# CLIMATE CHANGE ADAPTATION TECHNOLOGY NEEDS ASSESSMENT in ENERGY, AGRICULTURE, WATER, FORESTRY, TRANSPORT, HEALTH sectors of the REPUBLIC of MOLDOVA

Food and Agriculture Organization of the United Nations

GREEN CLIMATE FUND

# FOREWORD

The Republic of Moldova stands at a critical juncture in its development, where climate change adaptation is essential for safeguarding its economic, social, and environmental future. The country has aligned with the UNFCCC Parties in recognizing the significance of technology, following Article 10 of the Paris Agreement's Technology Framework, which emphasizes innovation, implementation, capacity building, enabling environments, collaboration, and stakeholder support.

As global weather patterns grow more erratic, Moldova adopted a strategic approach to climate adaptation, backed by technological innovation and coordinated policy efforts. Recognizing the technological needs for climate adaptation as a cornerstone of effective action, Moldova conducted a Technology Needs Assessment (TNA) in six priority sectors—Agriculture, Energy, Water, Forestry, Health, and Transport—during 2021-2023. In-depth sectoral assessments took an inclusive approach, guided by Sectoral Work Groups focused on enhancing resilience and promoting sustainable development in each area. The TNA was carried out as part of the second iteration of the National Adaptation Plan, funded by the Green Climate Fund and supported by UNDP and FAO UN Agencies.

The TNA process laid a robust foundation for integrating climate adaptation into sectoral planning, addressing existing adaptation gaps, and fostering systemic resilience in response to climate impacts. The identified and prioritised technological solutions aligned with Moldova's broader national and sectoral adaptation strategies, such as the *National Programme for Adaptation* (2023-2030), *Moldova 2030 Sustainable Development Strategy*, *Low Emission Development Programme* 2030 and *Nationally Determined Contribution 2.0 and 3.0* (under consultation*).* The outcomes of the TNA emphasised transformative adaptation, aiming to meet Moldova's adaptation needs by establishing resilient systems capable of responding to identified climate impacts, vulnerabilities, and risks in a timely manner, matching the anticipated pace of climate change.

The TNA process in Moldova followed a structured, three-stage approach to ensure a comprehensive understanding and prioritisation of adaptation technologies: Identification and *Prioritization of Adaptation Technologies; Barrier Analysis and Enabling Environment; Development of Technology Action Plans (TAPs)* followed by the identification of *Project Ideas* (Energy, Water, Forestry, Transport, Health and investment Concept Note (Agriculture). Sectoral TNA Reports offer a thorough exploration of the technological pathways that can facilitate effective climate adaptation across the prioritized sectors.

Climate adaptation TNA assessments form a vital component of Moldova's contributions to global adaptation efforts under the Paris Agreement, underscoring the country's commitment to strengthening resilience against climate-induced impacts.

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# CLIMATE CHANGE ADAPTATION TECNOLOGY NEEDS ASSESSMENT

# AGRICULTURE SECTOR

## Integrated Report (TNA, BAEF, TAPs) for the AQUACULTURE, HORTICULTURE, CEREALS, LIVESTOCK


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# TECHNOLOGY PRIORITISATION REPORT of the AQUACULTURE, HORTICULTURE, CEREALS, LIVESTOCK SUB-SECTORS

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| | |
|---|---|
| ADA | Austrian Development Agency |
| AEZs | Agro-Ecological Zones |
| CCAS | Climate Change Adaptation Strategy |
| CCCM | Climate Change Coordination Mechanism |
| DTU | Denmark Technical University |
| EBRD | European Bank for Reconstruction and Development |
| EPARD | European Neighbourhood Programme for Agriculture and Rural Development |
| FAO | Food and Agriculture Organization |
| GCF | Green Climate Fund |
| GCMs | Global Circulation Models |
| GD | Government Decision |
| GHG | Green House Gas Emissions |
| INDC | Intended Nationally Determined Contribution |
| LLT | long list of proposed adaptation technologies/practices |
| MAFI | Ministry of Agriculture and Food Industry |
| MCA | multi-criteria analysis methodology |
| NAP | National Adaptation Plan |
| NCCAP | National Climate Change Adaptation Programme |
| NCCC | National Climate Change Commission |
| NDA | National Designated Authority |
| NSARD | National Strategy for Agricultural and Rural Development |
| SAP | Sectoral Adaptation Plan |
| SAPARD | Special Accession Programme for Agriculture and Rural Development |
| SD | United States Dollar (currency) |
| SDGs | Sustainable Development Goals |
| SWG | Sectoral Working Groups |
| TAP | Technology Action Plan |
| TFS | Technology Fact Sheets |
| TNA | Technology Needs Assessment |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |

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# Executive Summary

Climate change is having a significant impact on Moldova, with the Agriculture sector being particularly affected by hazards such as drought, late frosts, rising mean temperatures, and altered precipitation patterns. These challenges are causing reduced yields and, in some areas, complete production losses, disproportionately impacting the rural population, which constitutes 60% of the country's total and relies heavily on agriculture for livelihoods.

Acknowledging the severity of these challenges, the Government of Moldova has enacted short- and mid-term adaptation plans to strengthen the resilience of key agricultural sub-sectors. To support these efforts, the Food and Agriculture Organization (FAO) conducted a Technology Needs Assessment (TNA) as part of the Green Climate Fund project *"Mainstreaming adaptation into planning processes to reduce vulnerability to climate change at local and central levels in Moldova's Agriculture Sector (Ag. SAP).*

The first iteration of the Technology Needs Assessment (TNA) in Moldova, implemented under the UNEP Project (2011–2013), delivered substantial benefits. A key achievement was the identification and prioritization of environmentally friendly green technologies to support climate adaptationin agariculture at sector level. International initiatives, such as the Special Accession Programme for Agriculture and Rural Development (SAPARD), the European Neighbourhood Programme for Agriculture and Rural Development (EPARD), the World Bank's Competitive Agriculture in Moldova Project (MAC-P, 2015), the ADA/UNDP NAP1 project, and the Inclusive Rural Economic & Climate Resilience Programme, provided critical support for sustainable land management practices and national climate change adaptation planning.However, despite these efforts, significant gaps persisted, particularly in knowledge transfer and methodological support, which hindered the widespread adoption of climate adaptation technologies by farmers. Over time, the combined effects of climate change and outdated agricultural practices exacerbated risks to agricultural sustainability, including a 30–50% loss in soil fertility, high input costs, and unprofitable crop production in local and regional markets.Scaling up green technologies and achieving transformative impacts requires a stronger conducive business environment supported by robust policies, innovative business models, and diverse financial instruments to unlock access to finance for agricultural SMEs. Recognizing these challenges, the second iteration of TNA for Climate Change Adaptation prioritised the agriculture sector and was implemented under the FAO/GCF project as part of Moldova's NAP2 process to address these critical gaps and enhance resilience in the sector.

The TNA process focused on identifying and prioritizing technologies that enhance agriculture's resilience to climate change. This was achieved through vulnerability assessments and extensive consultations with stakeholders, including government ministries, FAO national and international experts, academia, and research institutions. The assessments revealed two broad categories of climate impacts: a)systemic, gradual, and extensive changes caused by shifting climatic patterns, and b)extreme events characterized by localized impacts and increasing unpredictability.

The TNA identified Aquaculture, Cereals, Horticulture, and Livestock as the most relevant agricultural sub-sectors impacted by climate change. Using a multi-criteria analysis methodology (MCA) developed by UNEP-DTU, the selection process evaluated the environmental, social, and economic co-benefits of proposed technologies, their alignment with national policies, and their contribution to adaptive capacity. National experts, supported by FAO's international advisors, proposed 8–19 technologies for each sub-sector were evaluated and prioritized through scoring and weighting exercises during stakeholder workshops. The top

three technologies with the highest overall scores were prioritized for implementation for each subsector. The results provide a targeted pathway to inform enhanced National Adaptation Plans (NAPs) and ensure that Moldova's agriculture sector is equipped to address the risks a changing climate poses.

**Adaptation Technologies by Sector**

**Aquaculture sub- Sector**

**Use of lakes with complex destination for growing fish for consumption in polyculture.** This technology optimizes fish production by introducing species that feed at different depths and substrates, reducing competition and enhancing productivity. Polyculture increases biodiversity and utilizes the natural trophic potential of water bodies like Dubasari and Costești-Stânca reservoirs, which are vulnerable to climate change impacts such as high temperatures.

**Increase the water flow in the ponds used for aquaculture.** This intervention addresses water deficits caused by obstructed riverbeds and clogged channels, including dredging supply channels and cleaning riverbeds to improve water flow. These measures prevent habitat degradation, reduce flooding, and ensure a stable water supply for aquaculture ponds.

**Fish protection system and ensuring food security in the conditions of climate change.** A fishery-biological inventory system monitors aquaculture operations and assesses impacts of climate change on water quality and fish health. The system supports disease prevention, genetic improvements, and sustainable production, restoring aquaculture resilience while maintaining aquatic biodiversity.

**Livestock sub-Sector**

**Increase of areas under irrigation for the production of feed.** Expanding irrigation infrastructure in northern and southeastern regions improves maize silage yields in drought years, ensuring sufficient feed for livestock. This intervention stabilizes feed availability, supporting cattle farms in areas prone to green fodder shortages.

**Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and the observance of the populated areas of the animals.** The design and reconstruction of farms with modern technology ensure animal welfare, energy efficiency, and biosecurity. These facilities incorporate automated climate control systems and EU-compliant standards, creating sustainable and climate-resilient livestock operations.

**Construction of platforms for the production of organic fertilizers.** Establishing 100 manure processing platforms enables the production of organic fertilizers, enhancing soil quality and productivity. This supports sustainable feed crop cultivation, contributing to long-term resilience in the livestock sector.

**Horticulture sub-Sector**

**High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency.** Advanced greenhouses with climate control and energy-efficient systems utilize renewable energy and biomass for heating and cooling. These facilities ensure year-round production, improve crop yields and protect against extreme weather events.

**Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.).** Renewable energy-powered drip irrigation systems maximize water and energy efficiency, reducing water usage while increasing crop yields. These systems are crucial for sustainable horticulture under changing climatic conditions.

**Hydroponics with recyclable solutions.** Hydroponic systems grow plants in nutrient-enriched water, optimizing resource use and reducing waste. Recyclable systems enable precise control of plant growth conditions, enhancing productivity and adaptability to climate variability.

**Cereals sub-Sector**

**Conservation agriculture (including no- and minimum tillage, continuous soil cover, etc) .**This approach minimizes soil disturbance, promotes continuous soil cover, and diversifies crops to enhance soil quality and water retention. It reduces erosion and improves resilience in cereal production.
**Climate-smart rotations, wheat predecessor programmes, and organic fertilizer production.** Incorporating legumes and grasses into rotations enhances soil organic matter and nitrogen fixation. This method reduces reliance on synthetic inputs, stabilizes yields, and supports adaptation to climate change.
**ANetwork of shelter belts, agroforestry, and ponds is needed to increase the humidity of the air.** Networks of shelter belts reduce wind erosion, increase soil moisture, and protect valuable topsoil. Combined with agroforestry and pond systems, these interventions boost farm productivity and environmental sustainability.

In general, the prioritization of technologies was driven towards very concrete and low-cost options rather than highly ambitious cutting-edge technologies at lower levels of development. Best practices and management options dominated the prioritization exercise in the aquaculture, livestock and cereals sub-sector, although not completely, with horticulture being the only sub-sector incorporating purely technological solutions among those prioritized at the end of the process. The reasons for this situation shall be further researched. In all prioritization exercises, technology capital costs have been a predominant factor for evaluation and scoring; although quantitative information has been difficult to find and supported by existing literature and proven sources, these received relevant attention from the National Consultants and the SWG members. Similarly, among co-benefits, economic indicators have made a determining contribution to the final prioritization and ranking of all technologies with high weights across the four sub-sectors. Economic impacts on agriculture are still the predominant concern for sectoral experts, reflected in the prioritization exercise. Financial exposure for a low-gain economic activity is clearly perceived as a barrier that influenced the prioritization, even before a proper barrier analysis – which has taken place separately as per TNA methodology – was carried out. Solutions, therefore, seem to be recognized as limited by financial feasibility rather than by lack of technological adequateness and performance, and structural deficiencies are the main cause of limitations on sub-sectors' performances.

# Chapter 1. Introduction

## 1.1 Background on the assignment and the TNA

A climate Technology Needs Assessment (TNA) is a process comprising a set of multi-stakeholder participatory activities leading to the identification and selection of climate technologies or practices most apt to reduce the impacts of climate change on agriculture in a specific context or country. The TNA can be further classified as "mitigation TNA" if the technologies/practices are aimed at reducing GHG emissions, or "adaptation TNA" if the technologies/practices are aimed at adapting to climate change.

In 2012, the Republic of Moldova carried out the first TNA in its agriculture sector[1]. That report targeted agriculture as a whole, without distinctions between the most vulnerable sub-sectors (e.g. livestock, oilseeds, etc.) and including both mitigation and adaptation actions. Ten years down the road, the climate impacts withstood by Moldova have increased in magnitude and urgent assessment of specific adaptation actions on most relevant sub-sectors of agriculture have become necessary, and furthermore, the technological landscape has changed rapidly making available new technologies to lessen the effects of the changing climate.

In the context of the GCF Readiness Programme project "Mainstreaming adaptation into planning processes to reduce vulnerability to climate change at local and central levels in Moldova's Agriculture Sector (Ag. SAP)" a specific outcome is dedicated to updating the previous TNA with an assessment of the key sub-sectors of agriculture and most advanced and yet to be fully deployed technologies for key sub-sectors of agriculture. The TNA will result in a Climate Change Adaptation Technological Framework that illustrates clearly medium- and long-term objectives and related actions to support a transformational change of the agriculture sector, through improved techniques, practices, and technologies of its main sub-sectors in Moldova.

**Objective and Outputs of this TNA**

The specific outputs of the TNA will be 1) a Technology Action Plan with clear roles and implications for implementing the prioritized technologies, and 2) a Concept Note for a project to implement the most promising prioritized technologies in Moldova 3) a prioritised set of technologies, which forms sector level technological portfolio in support to climate change adaptation investment intervention in agricultural sector of Moldova.

The objective of the TNA in the Republic of Moldova is to identify the most urgent climate vulnerabilities for key sub-sectors of agriculture and prioritize a set of innovative technologies and practices to adapt the Moldovan agriculture sector to the impacts of climate change. This is the second iteration of the TNA for adaptation in agriculture in Moldova and builds on the previous work carried out in this area by analysing complementary practices in key sub-sectors. The selection of the most relevant sub-sectors is the result of a critical analysis of the relevance of each sub-sector to the economy and rural development of the country, and the susceptibility of each sub-sector to observed and historical impacts of climate change. The impacts, in turn, have been disaggregated into extreme events (e.g. droughts, floods) and long-term gradual changes in patterns (e.g. precipitation changes, average temperature gradients, etc.) in order to differentiate between practices for short-term adaptation versus long-term adaptation.
Moldova suffered from flash floods events in 2008 and 2010, whereas severe droughts took place in 2003, 2007, 2012, and most recently from autumn 2019 to late spring 2020. The long-term changes in climatic conditions have been forecasted for mean temperatures to increase, and precipitation patterns change towards dryer summers especially in the southern region.

[1] https://tech-action.unepccc.org/tna-database/?fwp_tna_database_type=tna_report&fwp_tna_reports_region=moldova

**The TNA process**

There are various official methodological approaches that have been validated by recognized institutions and Organizations, including FAO, UNEP and others. TNA is a mature process which has evolved over the 15 years that it has been used: developed initially in the context of GEF-founded UN-Environment project, the methodology has been used by several other partners as a publicly available tool to guide evaluations of technology and practices needed to mitigate or alleviate climate change-related problems. Thanks to the information they provide about the potential, ability, and scale of climate change technologies, TNAs can play a unique role in the implementation of Nationally Determined Contributions and NAPs. For example, UNEP-CCC developed a clear and updated methodology, and provides guidance on how to carry it out for both mitigation and adaptation needs.

Another relevant piece of work in the field of TNA has been produced by the collaboration between FAO and the European Bank for Reconstruction and Development (EBRD) that, in 2017, developed a methodology to assess market readiness of climate technologies for the agrifood sector. This work has been one result of the strategic partnership between FAO and EBRD which produced several tools and instruments to foster investments in sustainable and modern agriculture.

The TNA methodology used in this study stems from the UNEP-DTU methodology, which is used as the main reference tool, with the addition of specific aspects that concern the water-energy-food nexus, developed by the FAO-EBRD methodology.

In light of the above, this study involved the following steps:

The identification of the key sub-sectors of agriculture that have the greatest relevance in the context of climate change adaptation needs in Moldova. *Cereals, horticulture, livestock and aquaculture* have been identified as key sub-sectors of agriculture to target in this TNA as a result of a consultation process with sectoral working groups (SWG). Firstly, an assessment of climate vulnerabilities for each sub-sector has been carried out. As a result, national experts produced a long-list of technologies for each sub-sector (8 – 15 technologies each), subsequently these have been prioritised using a Multi-criteria Analysis (MCA) approach developed by UNEP-DTU for TNAs and to which Stakeholder Working Groups participated actively. The MCA is a decision-making tool that allows the prioritisation of technologies considering several concurring aspects at once and weighing the relative importance of each of them in a harmonised system. Through the MCA, technology options are listed and ranked (prioritised) based on a scoring and weighting system.

Concerning the trade-offs that may occur as a consequence of the selection of a certain technology over another, the water-energy-food (WEF) nexus considerations are made to address the trade-offs. Traditionally, water, energy, and food–related challenges have been addressed individually, leading to unpredictable impacts across sectors and scales for livelihoods and the environment. The WEF Nexus approach contributes to anticipating potential trade-offs and synergies, setting an opportunity for stakeholders to design, appraise and prioritise integrated response options that are viable across different sectors.

The prioritisation delivered 3 – 4 technologies and best practices for each relevant sub-sector to which a barrier analysis was applied. Stakeholders, with the support of the TNA Team, understood the technologies being proposed and expressed their opinion on a number of criteria to rank these options. The outcome of the TNA is a set of prioritised practices and technologies for each sub-sector that will be used as the basis for the Technology Action Plan (TAP). The TAP will set the basis for implementation of the most promising technologies.

## 1.2 Existing national stakeholders and policies related to technological innovation, adaptation to climate change and development priorities.

The Republic of Moldova's medium- and long-term adaptation goal is to reach a sustainable social and economic development resilient to the impact of climate change by establishing a strong enabling environment for a coherent and effective adaptive action with mitigation benefits, integrating climate risk into investment decision- making and business planning, while remaining socially inclusive and sensitive to gender impacts of climate change.

As such, the national adaptation framework contributes to the country's sustainable development priorities embodied in the "National Development Strategy: Moldova 2030" (2019) and to the overarching adaptation goal of the Paris Agreement to enhance adaptive capacity and resilience, to reduce vulnerability, with a view to contributing to sustainable development, and ensuring an adequate adaptation response in the context of the goal of holding average global warming below 2 $^{o}$C and pursuing efforts to keep it below 1.5 $^{o}$C.

In the Republic of Moldova, climate change adaptation planning and implementation is a shared responsibility and requires involvement by line Ministries of the Government, their subordinated agencies, local public authorities, private sector, and civil society. The nature of involvement varies across these stakeholders.

***Relevant public stakeholders***

The **Ministry of Agriculture and Food Industry (MAFI)** is the state authority vested with the power to develop and promote policies and strategies addressing climate change, environmental protection, rational use of natural resources and biodiversity conservation; to identify priorities; to develop and promote national programs and action plans which address such priorities; coordinate relevant actions and monitor their implementation in the best way; to promote the state policy and determine the priority directions of climate change and environmental research and development; to ensure international collaboration in climate change and environmental protection; to collect, systematise and manage own information database in support to own activities; to ensure maintenance and optimization of the sector information system, other environment and climate-related responsibilities.

The **Ministry of Environment** of Moldova is responsible for implementation of international climate change and environment related treaties to which the Republic of Moldova is a Party (including the United Nations Framework Convention on Climate Change).

The **National Climate Change Commission (NCCC)** chairs the Climate Change Coordination Mechanism (CCCM) in cross-sectorial coordination of all climate-related components: adaptation, GHG emissions and mitigation and is to be operationalized through a dedicated Government Decision. The purpose of the multi-stakeholder CCCM is to foster dialogue, coordination, collaboration and coherence among sectors, leverage and oversight the reporting on climate change planning and actions by all stakeholders. The established multi-stakeholder partnership is foreseen to contribute to a common understanding in climate planning, improved rationality and effectiveness of policy making, to facilitate the implementation of climate action, to have contribution to the sustainability of climate governance. Cross-sectorial coordination will also enhance the transparency in the implementation of prioritised adaptation measures.

The NCCC is a permanent formalised body with the highest representation of key stakeholders: sectorial ministries, NGOs, academia, research, private sector, taking into consideration gender balance through including representatives of women's associations and considering gender equality and social inclusion in all supervising activities of NCCC. Such organisational structure of NCCC comprises actors of horizontal, inter-sectorial planning and of vertical integration, with the representation of below sectorial/national level, thus ensuring a multi-level framework with interactions between government and civil society representatives. The NCCC will have a Secretariat as a technical executive body. At the sector level, the NCCC is supported by the sectorial administration in charge of the development of sector-specific climate change enabling environment and reporting on climate action, establishing working groups or nominating focal points. Technical Committees on specific thematic areas will be established ad-hoc when the need for advanced thematic expertise will be required, in particular during the consideration of donor project proposals. Such needs will be met by the recruitment of mitigation or adaptation experts. The Commission will also coordinate previously initiated actions, which have not been completed under the Kyoto Protocol. Through the proposed structure of the CCCM, the Republic of Moldova overcomes the issue of limited integration and connectivity between levels, which is an impediment to the effective decision-making process in adaptation and mitigation. A dedicated Government Decision (GD) enacted the Climate Change Coordination Mechanism on 24 July 2020 (GD 444).

***Relevant policies***

Relevant national policies related to technological innovation, adaptation to climate change and development priorities include: the **Climate Change Adaptation Strategy (CCAS)**and its implementation Action Plan, provides for an integrated vision of the Republic of Moldova's development opportunities and the ability to respond in a resilient way to the impact of climate change. The objectives of the CCAS are oriented towards increasing the country's capacity to adapt and respond to actual or potential climate change effects and it is underpinned by an in-depth study of future climate risks and their impacts on vulnerable sectors. The CCAS and its implementation Action Plan serve as an umbrella strategy that creates an enabling environment for Central and Local Public Authorities to integrate CCA and risk management into existing and future strategies through a range of sectorial and local actions. The sectorial approach in climate change adaptation in the Republic of Moldova is prevailing at the current stage of the country's development, while cross-sectorial and sub-national approaches are becoming increasingly important. Some sectors are already implementing adaptation actions, while others need more support in adaptation planning and implementation.

While the objectives stated in the CCAS are still valid, the associated Action Plan covers the timeframe 2014-2020.

The **Paris Agreement** was ratified by the Republic of Moldova in June 2017. Its Intended Nationally Determined Contribution (INDC) was submitted in September 2015 and subsequently updated in March 2020 (NDC 2), with a more ambitious emissions reduction goal until 2030.

Within the framework presented above, Moldova submitted its **second NDC** in March 2020. The adaptation component, as a forward-looking document, incorporates country's adaptation priorities that derive from the in-force policy documents, such as the Climate Change Adaptation Strategy and the Action Plan for its implementation (2014), as well as from the Fourth National Communication to the UNFCCC (2018), and from a number of national level policy documents covering cross-sectoral socioeconomic areas and sector-specific development documents of the national priority sectors: agriculture, water resources, human health, forestry, energy and transport. Adaptation priorities in Moldova's NDC pose relevant emphasis on technology transfer needs and make a direct link to the TNA process. Technology transfer is considered a priority for all sectors of the economy tackled in the NDC, thus first and foremost for agriculture. The NDC lays down all steps of the TNA for CCA, starting with the prioritisation to the screening of barriers, and finally to the proposition of a Technology Action Plan and related concept note for a major international funding opportunity.

The adaptation component in the NDC is built upon the experience gained from the implementation of the first cycle of the **National Adaptation Plan (NAP-1) (2014-2017)** that is presented in the document, and from the planning perspectives of the NAP-2 that is to be implemented in two tracks:

a) National Adaptation Plan, covering Water Resources, Human Health, Forestry, Energy and Transport.
b) Agriculture Sectoral Adaptation Plan (Ag.SAP).

In support to climate action, the adaptation component incorporates cross-sectorial and sector-specific adaptation actions and measures to be implemented, along with identified adaptation investment priorities based on the review of national and sectorial development policies and plans, and the outcomes of an extensive consultation process, including stakeholders from all sectors and levels of governance, in particular, central public authorities and local public authorities, climate-related institutions and agencies, along with private sector, civil society, academia and women associations and youth NGOs representatives.

During the first phase of National Adaptation Planning (NAP-1), the Climate Change Adaptation Strategy and its Action Plan until 2020 were developed and adopted by GD No 1009/10.12.2014. It laid down the first national strategic framework aiming to advance the climate change resilience of the Republic of Moldova's social and economic development. NAP-1 has assessed the vulnerability of the key economic sectors and six were identified for priority climate adaptation action, namely: agriculture, water resources management, health, forestry, energy and transport. The NCCAS 2020 was adopted as an umbrella policy document intended to create the enabling environment for the identified vulnerable sectors to "mainstream" climate change adaptation and risk management into existing and future sectoral strategies. The Strategy was subsequently supported by long-term financial planning (developed by the World Bank), including estimated cost of inaction and recommended adaptation investments per sector.

The **National Strategy for Agricultural and Rural Development (NSARD) for the 2023-2027 timeframe** (approved by the Government Decision of 17.02.2023) incorporates proactive action responsive to both increased frequency of climate extremes and incremental and cumulative climate changes. The new strategy is a document that represents the vision and priorities of the Government of the Republic of Moldova to stimulate competitiveness in the agri-food sector, to focus on value chains, to protect the environment and to increase resilience to climate change. It aims to strengthen food security and safety, to ensure a better life in rural communities. The document defines four general strategic objectives, which aim to strengthen the potential of the agricultural sector resilient to climate change, promote smart, efficient, and sustainable agricultural practices, develop the local market as well as supporting sustainable rural socio-economic development.

The national **Programme for conservation and increase of soil fertility for the years 2011-2020** provides a plethora of measures to restore the productive role of agriculture in the Moldovan society through several objectives. These include actions at the landscape level, such as increased development of forest strips and buffer zones around agricultural lands and water basins, afforestation of grassland lands affected by landslides, as well as nature-based approaches to increase productivity of the land such as expansion of new vineyards and orchards, promotion of intercropping (e.g. cultivation between rows of vineyards and orchards of annual crops) to prevent soil erosion, which will also have an impact on carbon sequestration and the reduction of greenhouse gas emissions and several others. The programme provides measures that directly or indirectly contribute to achieving the overarching goal of making agriculture more sustainable and more resilient.

The NAP-1 policy document was fit for its purpose, but the short implementation timeframe between 2015 and 2020 was not sufficient to deliver tangible progress towards the overall goal of reaching a sustainable social and economic development of the country, making it resilient to the harmful climate change impacts. During this period a number of new developments have occurred, which need to be reflected in updated national strategic planning.

Among these developments, relevant to climate change policy are:

- **National Development Strategy (NDS)** – "European Moldova 2030" is a strategic document that outlines Moldova's poverty reduction strategy and long-term development vision. The strategy establishes ten general objectives that aim to bring Moldova closer to the European Union standards, while recognizing that climate change poses risks and opportunities and that these need to be assessed as part of Moldova's development agenda. The National Development Plan (NDP) operationalizes the national development strategy over a three-year period. The NDP 2023-25 includes a climate change perspective.
- Adoption in 2015 of the **global Sustainable Development Agenda 2030** and its 17 Sustainable Development Goals (SDGs). Drawing on the global Agenda, the National Development Strategy (NDS)

"Moldova 2030" was approved at the end of 2018, outlining the strategic vision and the main goals that will drive the growth of the national economy and society over the next decade.

- The governmental and administrative reforms undertaken by the Republic of Moldova in 2017 have introduced substantial changes in the central public administration, which required new institutional arrangements for the management and coordination of climate-related policy and measures. The functions of the National Designated Authority (NDA) were taken up by the Ministry of Agriculture, Regional Development and Environment in 2017. A Climate Change and Air Quality Unit was established within the Ministry, and the former Climate Change Office was incorporated into the public institution "Environmental Project Implementation Unit" established in 2019.
- New governmental structure and re-establishment of the Ministry of Environment as a stand-alone institution, following the snap elections in Moldova held on 11 July 2021, inevitably affecting the decision-making process in a cross-sectoral policy area as climate change (mitigation and adaptation).

In light of these developments, time has come to engage in a second phase of the NAP process in the Republic of Moldova (NAP-2) and to upgrade accordingly the national climate change adaptation framework. **The purpose of the National Climate Change Adaptation Programme (NCCAP) until 2030** is to build on the umbrella Adaptation Strategy until 2020 and to transit from planning to action by enhancing the sectoral "streamlining" of adaptation measures, while ensuring synergy with the existing planning documents in both climate adaptation and disaster risk management policy areas.

To that end, the scope of six vulnerable sectors is kept, but the timeframe of adaptation measures is extended until 2030 to cover the national development agenda embedded in "Moldova 2030", the sustainable development goals committed under this Agenda, as well as the updated NDC submitted by the Republic of Moldova under the Paris Agreement in 2020 – all with an implementation horizon until 2030. The Action Plan accompanying the Adaptation Programme describes, per each sector, which adaptation actions should be taken, showing potential budget consequences and sources, foreseen duration and expected results, performance indicators and responsible institutions. The NCCAP 2030 for agriculture lays down the vulnerabilities of the country to the impacts of climate change and their expected socio-economic implications for agriculture in Moldova. The reference sub-sectors of agriculture used for the selection of adaptation actions is based on cereals, livestock, horticulture, and permanent crops, including thus grapevines and fruits. The NCCAP 2030 also touches upon the water sector and several interesting actions can be shared with agriculture and specifically with aquaculture. Concerning agriculture per se, the NCCAP 2030 foresees the following actions to adapt to climate change the Moldovan agriculture sector:

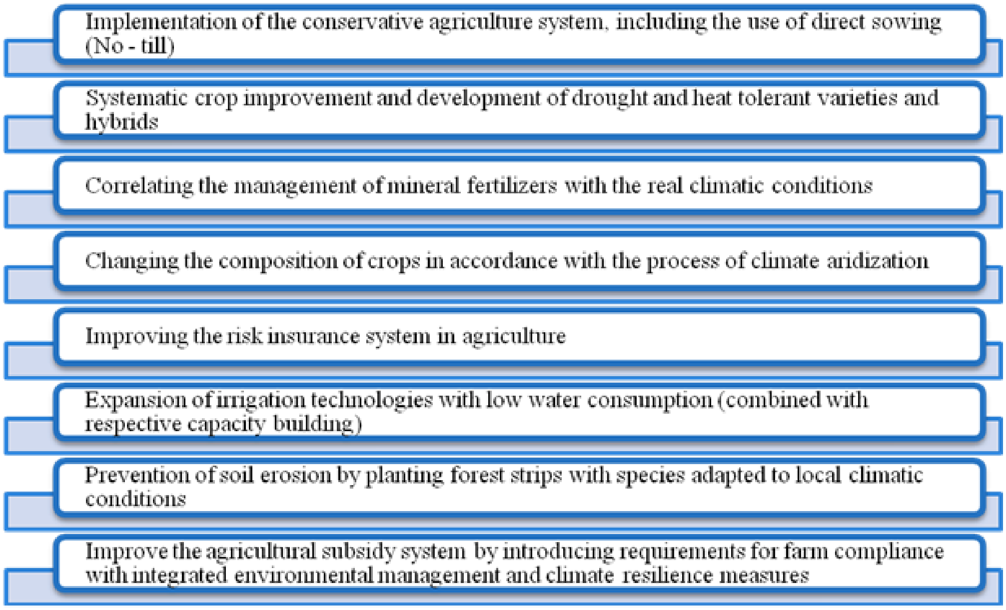



*Figure 1-0-1 Climate change adaptation measures recommended for the Agriculture sector (Source: NCCAP until 2030)*

The NCCAP 2030 foresees predominantly risks for the agriculture sector but also some opportunities, provided that investments and appropriate technologies are put in place. Interestingly, the policy act also includes an estimate of the potential costs of inactivity against climate change, based on World Bank studies, identifying such value as around USD 34 million per year.

Last but not least, the NCCAP 2030 also highlights the additional sectors that will require close attention for the implementation of adaptation (and to an extent also mitigation) strategies and actions, including Forestry, and Energy. These two sectors, in addition to the aforementioned water sector, need to be treated holistically in accordance with Agriculture to yield reciprocal maximum benefits in terms of adaptation.

## 1.3 Vulnerability assessment of agriculture in the country

The impacts and vulnerabilities reported by national experts have been evaluated and compiled to represent a distilled overview of the situation in Moldova within which the TNA process will unfold.

Literature research on existing official projections presented useful insights on the overall climate vulnerabilities in Moldova, which was subsequently complemented for each sub-sector by the research carried out by the national experts.

The three representative concentration pathways considered (RCP 2.6, 4.5 and 8.5) project similar temperatures in the near-term decades +0.9 - 1.1°C over the Republic of Moldova (RM) geographical territory. Only starting around the 2050s the three emissions scenarios produce temperature patterns distinguishable from each other. This is due to both the big inertia of the climate system, and also due to the time taken for the full climate effects of greenhouse gas emissions to be observed, along with the different emission scenarios to produce large differences in greenhouse gas concentrations.

Annual changes for temperatures are very homogeneous over the RM's Agro-Ecological Zones (AEZs). By the 2080s, the rate of warming is higher under the RCP8.5, on the average it reaches +4.6°C; medium under the RCP4.5, +2.4°C, and smaller under the RCP2.6 scenarios, ensembles average would be +1.3°C.

All models reviewed agree that for the three future periods (2016–2035, 2046–2065 and 2081–2100) an increase in winter temperatures is expected, as compared to the 1986–2005 baseline period. The warming would be higher during winter up to +4.6°C in the Northern AEZ, but in Central and Southern AEZ's temperature rise will be up to +4.2°C according to the RCP8.5. RCP2.6 reveals less intense warming over the

RM's AEZs from +1.2 to +1.4°C. The corresponding results from the RCP4.5 scenario show intermediate intense differences in temperature increase. Estimates of simulations from the RCP4.5 scenario show that the warming will be quite uniform +2.5-2.6°C by 2081-2100 throughout all AEZs.

Summer warming is found to be even higher than the winter one, however, the spatial distribution of the changes is quite different. The strongest temperature rise occurs over Southern and Central AEZs. The ensemble, driven by RCP8.5, estimates that the RM AEZs will experience the most significant warming during summer, from +5.9 in the Northern AEZ up to +6.1°C over the Southern AEZ by 2100. The pattern of change derived from the RCP2.6 scenario is quite similar, but the magnitude of change is lower, from +1.3 to +1.5°C. The corresponding results from the RCP4.5 show medium intensity differences in temperature increase. Estimates of simulations from the RCP4.5 ensembles show that the warming will be quite uniform, +2.9°C, by 2081-2100 overall RM's AEZs. Projections of Future Changes in Annual and Seasonal Precipitation: The RCP8.5 and RCP2.6 project a slight precipitation increase of about 0.6-2% over all of the RM's AEZs by 2016-2035 time period. Conversely, according to RCP4.5 a slight decrease in precipitation from 1.5% to 2% is projected for Northern and Central AEZs in comparison to the reference period (1986-2005). Annual changes in precipitation became much more differentiated over the RM's AEZs by 2100. The multi-model projections from the RCP8.5 show that the RM's AEZs would show a general annual decrease in precipitation varying from 9.9% in Northern AEZ to 13.4% in Southern AEZ. Conversely, according to RCP2.6, a moderate increase in precipitation from 3.1% in Northern AEZ to 5.1% to Southern AEZ by 2100 is projected. The corresponding results from the RCP4.5 show a moderate increase in precipitation from 1.6% to 3.6% only in Central and Northern AEZs by 2100 relative to the reference time period 1986-2005.The ensemble averages for the three RCP scenarios show that precipitation reductions will be much more extended in the Republic of Moldova during summer and autumn. The drying conditions are expected to characterise all the country's regions.

The Climate Risk Assessment report (FAO, 2022) carried out in the context of the Ag.SAP project offered most up-to-date climate projections based on Global Circulation Models (GCMs) for climate impacts in Moldova under the same reference RCP scenarios. These indicate homogeneous temperature changes throughout the country. By 2100, mean temperatures are projected to increase by 1.3°C under RCP 2.6, by 2.4°C under RCP 4.5, and by 4.6°C under RCP 8.5. Mean temperatures are projected to increase at a faster rate over the winter months, particularly in the northern areas. Conversely, during the summer months, higher increases in temperature are projected in southern and central areas, increasing by 1.3°C (RCP 2.6) to 5.9°C (RCP 8.5) in the north and by 1.5°C (RCP 2.6) to 6.1°C (RCP 8.5) in the south by 2100.

The Climate HAzard Toolbox (CHAT) developed at FAO shows a high level of model agreement in the sign of the climate change signal for precipitation, both in total annual and seasonal rainfall. For total annual rainfall, precipitation is likely to experience a slight increase (0-20mm) and a decrease (10-30mm) under RCPs 2.6 and 8.5, respectively by the end-century (2070-2099).

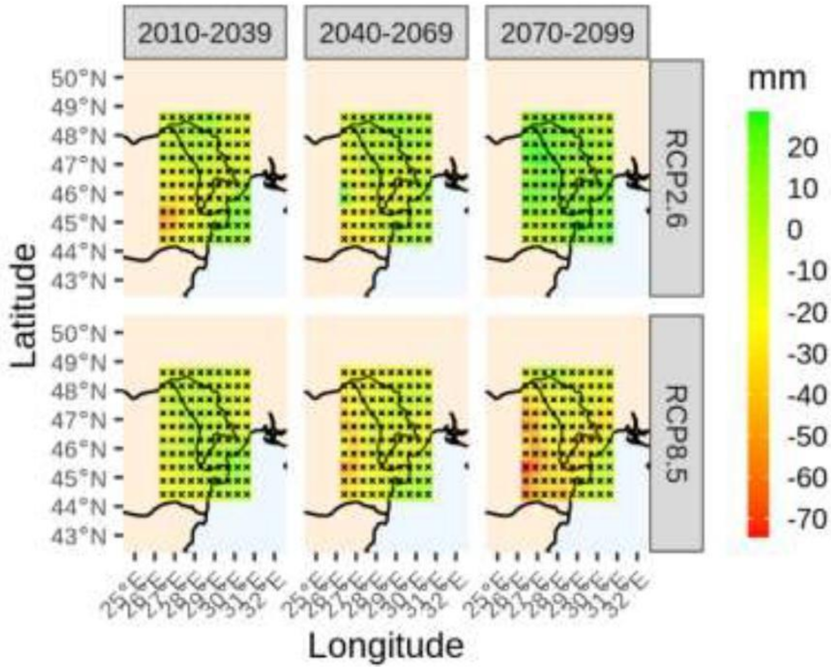
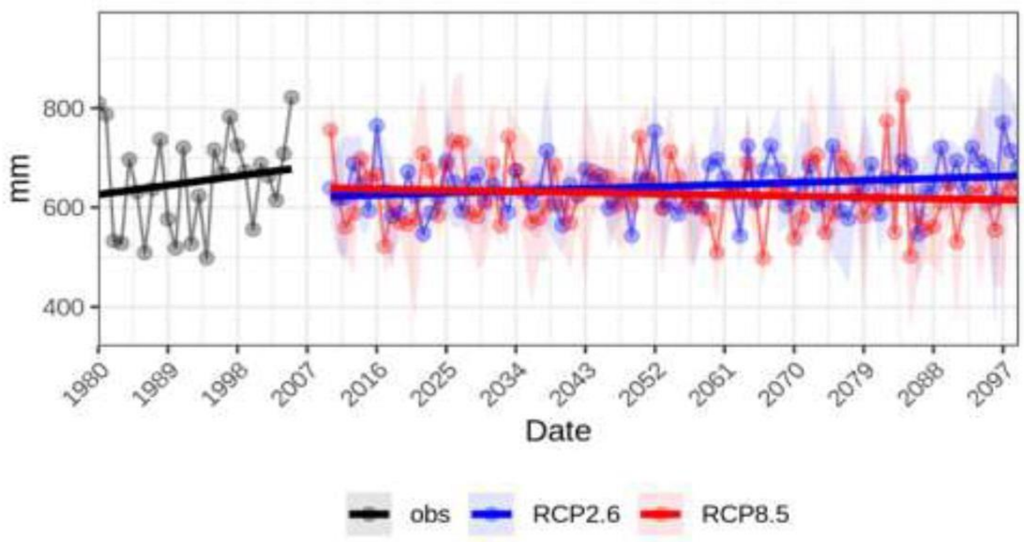



*Figure 1-0-2 Projected total annual precipitation until year 2099 in Moldova (FAO, 2022).*

Depending upon the RCP of reference used however, interannual precipitation patterns differ significantly, therefore underlining considerable difficulties and lack of data time series to project such changes until 2100.

Overall precipitations in Moldova are expected to increase under RCP 2.6 by 20mm (represented graphically below by the 0.46 slope of the trend line in blue) whereas under RCP 8.5, the trend is reversed (slope -0.27 for a decrease by the end of the century of approximately -10 to -30 mm).




| | slope | p.value |
|---|---|---|
| obs | 2.06 | 0.43 |

| | slope | p.value |
|---|---|---|
| RCP2.6 | 0.46 | 0.02 |

| | slope | p.value |
|---|---|---|
| RCP8.5 | -0.27 | 0.29 |

*Figure 1-0-3 Interannual rainfall variability and total annual rainfall under RCPs 2.6 and 8.5 (FAO, 2022).*

Concerning extreme events, the number of very hot days (Tmax>30ºC) per year may increase by 10 to 15 days under RCP 2.6 and up to 20 to 45 days under RCP 8.5 by the end-century (2070-2099). In addition, the number of tropical nights (Tmin>20ºC) may increase by more than 50 days under RCP 8.5 by the end-century (2070-2099), mostly along the nearby locations to the Black Sea. The number of heavy rainfall events (pr. >20mm/day) per year may increase by 0.5 days under RCP 2.6 and by 0.75 to 1.5 days under RCP 8.5 by the end-century (2070-2099). The number of dry days (pr. <1mm/day) per year may increase by 2 to 4 days under RCP 2.6 and by 10 days under RCP 8.5 by the end-century (2070-2099).

Climatic stressors and vulnerabilities have been mentioned and supported by evidence to a varying degree by national and international experts. There are two broad categories of impacts of climate change on the sub-sectors of agriculture in Moldova. These are 1) extensive, gradual and perpetual impacts due to systemic changes in climatic patterns; and 2) extreme events, characterised by localised impacts not associated with a specific change in climatic pattern but rather to increased frequencies and unpredictability.

These vulnerabilities, in turn, can give way to a) direct impacts on agriculture sub-sectors; or b) indirect impacts on agriculture sub-sectors.

Moreover, a classification of whether impacts are the predominant cause of an alteration of specific indicators of the performance of each sub-sector, or a concurrent cause (which adds up to mismanagement, or other unsustainable practices) has been provided by the sub-sector.

The main extensive and perpetual impacts included in the various reports reviewed for this summary are:

1. Increased mean temperatures.
2. Change in precipitation patterns.

These take place every year along a trend-like path that has been abundantly documented.

The main extreme events detected in the various studies have been listed:

| Climate vulnerability | Years during which event(s) occurred |
|---|---|
| **Drought** | 1990, 1992, 1994, 1996, 2000, 2001, 2003, 2007, 2012, 2015, 2020 |
| **Extreme high temperature events** | 2005, 2012, 2019 |
| **Floods** | 1994, 1997, 1999, 2002, 2005, 2008, 2010 |
| **Storms and hailstorms** | 1994 and 2000 |

*Table 1.0.1 Climate vulnerability of Moldova since 1990*

These have been detected for individual years, but with increasing frequency. To an extent, high frequency extreme events (such as drought for instance) are showing the beginning of a trend. In fact, if drought events are recorded every year for a sufficient timeseries, these will become part of the mutated climatic pattern as a consequence of climate change.

The aforementioned climate impacts affect the various sub-sectors of agriculture in Moldova in similar ways.

For the **cereals sector**, droughts and heat waves have been identified as the main source of distress and direct consequences on productivity have been highlighted. On the other hand, indirect impacts of climate change have been reported, as climate change exacerbates the suffering condition of various features of the sector by unsustainable management practices in cereal production. Indirect contribution of climate change to vulnerable features of the cereal sub-sector in Moldova encompasses soil quality loss, and increased pests and weed infestations. These were reported to have worsened over recent years as a constant trend, rather than on an extreme event basis. Precipitations, nationwide, have actually increased although in specific climatic stations in the central and southern part of the country a marked decrease in precipitation has been documented. Interestingly, the yields of winter wheat in Moldova have shown a parabolic trend from the 60's to present times. In fact, yields have initially increased due to the use of inputs and farming practices but the productive capacity of these farms peaked around the end of the 1980's to start a decline to levels comparable to the beginning of the agricultural reforms, though with much higher input levels than before. Nature-based solutions, such as conservation agriculture, are key to adapt the sector to the existing conditions and regain productivity. The role of rotations and their correct management is also highlighted as a pivotal aspect of the sustained productivity of the land.

Low diversity of crops, improper crop rotations along with excessive moldboard plow and prevalence of mineral fertilizers, especially nitrogen, without organic fertilizers, are contributing to the deterioration of soil fertility. The integral index of soil fertility is soil organic matter. During the last 100 years the stocks of soil organic matter on arable soils of Moldova have decreased by 50-60 %. As a result, soils became more compact, more vulnerable to water and wind erosion, and to droughts, more susceptible to pests, diseases, and weeds. Compacted soils have a lower water penetration capacity which is leading simultaneously to water erosion and a higher vulnerability to drought.

The correct rotations also have an important role in contributing or limiting increased pests and weed infestations, and due consideration has been given by the National Consultants to this aspect. That being said, for the cereal sector the contribution of global warming to the reduction of soil fertility in yield decrease can only be estimated as a concurrent cause and its extent and quantification remains difficult. However, NCs reports confirm that actions to improve soil quality and particularly soil organic carbon content is a necessary adaptation action, which also offers mitigation co-benefits.

Climate change acts both directly and indirectly **on the livestock sector**. These changes primarily affect the need **for feed and water for animals**. Both high temperatures, drought, and low temperatures (especially spring frosts), hailstorms, floods have quite serious consequences for the animal feed production sector. Likewise, climate change has a strong negative impact both on the productivity of animals, but also on their health and reproductive capacity.

During periods of drought, most **forages** have a low nutritional quality. Thus, in these feeds, especially in cereals, the amount of digestible protein (the most expensive component) decreases, this in turn influences the level of essential amino acids, which decrease dramatically. It is also influenced by the starch content, which is the most important source of energy in cereals, especially corn, which is widely grown and used as feed in Moldova. At the same time, the concentration of cellulose increases, which has fewer nutritional characteristics, especially for monogastric (poultry, pigs).

It should be noted that the impact of climate change on sub-sectors is different. **Cattle and sheep production** are the most affected sectors. First of all, the drought affects the grazing animals. Pigs and poultry, on the other hand, are less affected, as they are practically less dependent on free grazing and small-scale, low-input management, as in the case of ruminants. During 2020, drought the number of cattle has decreased by at least 30%, mostly due to the lack of fodder. At the same time, the number of poultry and pigs (at the industrial level) did not suffer considerably, as it was possible to import grain from abroad (Serbia, Romania, Ukraine). Industrial production can be less affected as in cattle feeding and it is possible to supply the farm with feed reserves for a period of at least 2 years.

**Water** is one of the critical development factors for livestock. It is necessary to take into account not only the quantity but also the quality of the water used for watering animals, as this is also a source of the spread of diseases in animals (it may contain bacteria, parasites, pesticide residues, etc.). Water is needed for irrigation, forage production and for watering animals. The most affected by the insufficiency of surface water is the sheep farming sector of Moldova which uses surface water (lakes, ponds) for watering. Climate change affects this sector not only by drastically reducing the amount of forage through grazing due to drought but also limiting the amount of surface water used to water these animals. Thus, in recent years, due to climate change and the improper management of surface water, the sources of water supply have decreased constantly.

Grazing sheep and cattle are the most exposed to climate impacts. These animals usually use open water sources (lakes, rivers, ponds, etc.), which in recent years the country faces the reduction or even loss of these water sources (due to the lack of precipitation and persistent hydrological drought). Another major problem is that for the last 20 years, the water bodies have not been cleaned and are muddy. The continued lack of state policy and specialized programs in this area lead to catastrophic effects, especially for the livestock sector (sheep and cattle breeding). Poultry and pig farms use water from deep wells (150-250 m), which currently provide the necessary amount of water.

A direct impact of climate change is on **animal welfare and productivity**. Both low and higher temperatures than thermal comfort have a negative effect on the health status and reproductive indices of animals. Poultry is the most sensitive to ambient temperatures. They are affected by low temperatures, especially the youth (for them, the thermoregulation system sticks or does not work enough, so it is essential to ensure the temperature in the youth breeding halls according to the technological recommendations). Similarly, for adult birds (especially broiler chickens), high temperatures above 33 $^0$C cause serious problems, including their death. The highest temperature in the Republic of Moldova was recorded in 2012 and was 42 $^0$C.

Cattle, pigs and sheep are more resistant to temperature fluctuations but sensitive to high temperatures.

Increased temperatures (both mean annual and daily maximum) are also a co-factor in the spread of disease and pathogens, which affect grazing animals already weakened by the low nutritional value of forage. The quality of fodder obtained from plants that have developed under conditions of high temperatures and insufficient water is low because the composition of these fodder is predominantly cellulose and not proteins, starch or sugar. For this reason, the energy level of the fodder and its digestibility decreases considerably.

Despite all the above, the response policies of the Republic of Moldova on climate change are insufficient, and their impact is not felt in the agricultural sector and especially in the livestock sector. In 2013, two Government Decisions were approved and in 2018 one on climate change, namely:

GD No. 779 of 04.10.2013 for the approval of the Regulation on drought management planning; GD No. 887 of 11.11.2013 for the approval of the Regulation on flood risk management; GD No. 590 of 21.06.2018 regarding the approval of the Conception of the reform of the national system for managing, preventing, and reducing the consequences of floods.

However, these normative acts have a general character and may have a less direct impact on the agricultural sector and especially on the livestock sector.

At the same time, in recent years, a series of other normative acts on veterinary health have been approved, which partially reflect the necessary conditions for animal welfare. These normative acts indicate the necessary conditions for the protection of animals, including the impact of climate change. Namely: LAW No. 50 of 28.03.2013 regarding official controls to verify compliance with legislation on animal feed and food products and with animal health and welfare rules; G.D. No. 793 of 22.10.2012 for the approval of the Sanitary-Veterinary Norm regarding the protection and well-being of animals during transport. (Council Regulation (EC) 1/2005 of 22 December 2004); G.D. No. 859 of.07.2008 regarding the approval of the Sanitary-Veterinary Norm regarding the minimum criteria for the protection of pigs intended for breeding and fattening, and others. All these normative acts are European Union regulations transposed into national legislation.

Nowadays, in Moldova, farmers do not pay the necessary attention to ensuring animal welfare conditions. Very often farms are rehabilitated from the old ones and the worst is when their destination is changed without considering the requirements for the animals. Another problem is that even the newly built ones do not always respect needed conditions, one of the problems being both the lack of clear regulations established for animal welfare and the chronic lack of financial sources. In recent years, there were no grant programs aimed at modernizing the livestock sector and the subsidy policy was incomplete, which led to a slowed-down development of the sector. In the last 3 years, this has been changed into a positive, moreover, for the first time since 2023 the ceiling for the livestock sector, including constructions and equipping has increased up to 10 million lei (for the cattle sector by 12 million), this will lead to faster sector development.

Modern poultry farms are equipped with cooling systems however, not all farms have this technology, and periodically these farms experience considerable losses. Likewise, some pig and cattle farms use cooling systems that are much simpler than those used in poultry farms.

The technological interventions in the livestock sector have strong adaptation potential and even an appreciable mitigation potential. This is especially true in the context of manure management, which has important implications concerning the return of organic carbon to soils (key for the adaptation to water stresses of cereals and other plant-production types, including forage). Increased temperatures then, are also a co-factor in the spread of diseases and pathogens, which affect grazing animals already weakened by low nutritional value of the forage.

Generally, Moldova has favourable climate conditions and relief for **horticulture crop production.** The country's soils have a high level of fertility in the northern region and a medium level of fertility in the central and southern regions. However, the country is subject to climate hazards that often become calamities such as droughts, late spring frosts, hail, and floods with a destructive impact on crop production. Due to these frequently experienced climate calamities, many land plots are losing their natural fertility and require rehabilitation. If the soil protection issue is ignored and its deterioration advances due to the continued use of outdated farming technologies and a failure to adopt new environmentally friendly practices that increase crop resistance and help adapt to the impacts of climate change, the whole horticulture production will have a significant decline. For these reasons, it is vital to identify those practices and technologies that will be responsive to the consequences of climate impacts, vulnerabilities, and risks.

The gradual, but high impact of climate change on the horticulture sector occurs due **to the increase in the mean annual temperature**. For the period (1945-2020) this increase changed from +9.25 $^{o}$C to +11.4 $^{o}$C (by +2.15 $^{o}$C, or by +0.0287 $^{o}$C annually). Consequently, the trend of increasing annual temperatures in the last 45 years (1975-2020) was: +2,45 $^{o}$C (+0,054 $^{o}$C per 1 year), including for the last 20 years (2000-2020): by +1,80 $^{o}$C (or +0.09 $^{o}$C per year), but the last 10 years (2011-2020): by +0.94 $^{o}$C (or +0.094 $^{o}$C per year), i.e. 1.74 times more intensive compared to the average indicator. The increase in temperatures leads to the shortening of the vegetation period of horticultural crops and thus to the reduction of their productivity.[2]

Concurrently, **the amount and the pattern of precipitation change**, which could be seen in the amount of atmospheric precipitation. During the last 35 years (1985-2020) a decrease in the amount of atmospheric precipitation was recorded: from 576 mm to 538.0 mm (or by -1.09 mm annually). The decline in the annual precipitation from 544.2 mm (multiannual average) by -141.5 mm, (-26.0%), led to a decrease in the level of

[2] https://gov.md/sites/default/files/document/attachments/subiect-03-nu-864-maia-2022.pdf

productivity by -0.04 t/ha (-0.93%) of the vine and -0.27 t/ha (or -0.0104 t/ ha for every -1.0% of precipitation) for fruit crops. The changes in the amount of precipitation concurrently with the uneven distribution of precipitation and increase in temperature produce a complex and severe negative impact on crop production, and many horticultural crop varieties do not withstand these impacts. The decrease in the photosynthetic production of crops (t/ha for every +100 °C) was recorded.[3]

One of the most drastic climatic hazards the horticulture sector (along with the whole agri-sector of Moldova) has to face is **drought**. Because of the open field production, along with the small irrigated area (12.9 thousand ha) of horticulture crops, it is highly exposed to climatic factors._For instance, 7 out of the 10 warmest years in Moldova's history occurred within the past two decades. Historically, Moldova has experienced droughts once every 3 to 10 years depending on the geographic location in the country. In 2007, Moldova suffered the worst drought in its recent history, affecting 80 percent of the country's territory and roughly 135,000 people, causing estimated losses of about US$1.0 billion. The recent 2020 drought caused a drop of over 26 percent in agricultural production and had a significant socio-economic impact, with almost 20 percent of overall job losses.

**Abundant rains** (coming as heavy rains and river flash floods) can compensate for insufficient moisture in the soil, but in some periods of vegetation of horticultural crops, they bring great losses. In the flowering phenophase, it prevents their pollination, thus the percentage of flower attachment is reduced. Another negative effect of heavy rains is when horticultural crops reach maturity, the quality of the fruits is reduced by diluting the cell juice, which subsequently cracks them. These fruits will be prone to dehydration and fungal diseases.

**Hail** produces a climatic risk which, although not very often encountered on the territory of the Republic of Moldova, can have an immediate negative impact on large areas of crop production. The maximum frequency of this hazard happens during the warm period of the year and impacts horticultural crops in different stages of their development, affecting the smooth development of their biological cycle. A single case of hail in a critical phase of plant development is enough for the entire crop to be compromised.

Being located in the southeast of the continent, the Republic of Moldova territory is crossed by several trajectories of cold air masses that produce frosts. When the advection of cold air is determined by anticyclones from the western and central parts of Europe, the northern and western half of the country is affected by **frosts.** According to the multiannual average data, the spring frosts occur on April 5-21, close to the time when the daily average air temperature exceeds 10°C (the beginning of the active vegetation of agricultural crops). Frosts cause considerable damage to fruit crops during the flowering period. The probability of frost damage to apricot flowers and fruit is on average 15-40%, and for other fruit crops - up to 15%. Late spring frosts after the bud break are a particular danger for the vine. The probability of the appearance of these frosts on the territory of the republic is 10-30% years. Late spring frosts are particularly dangerous for heat-loving vegetables: potatoes, tomatoes, peppers, eggplants, and others are the most demanding in terms of heat. Frosts with an intensity of 0-1C could lead to their crushing.[4]

The **autumn frosts** also could be a high danger for crop production. On average, at ground level, it is reported on in the first half of October, while for the air, in the second half of the same month. However, in some years, on-the-ground frosts are possible even in the first decade of September, while air frost - is in the second decade of September. These affect the harvests of late-ripening horticultural crops and prevent obtaining quality harvests.

The natural hazards can have a severe impact on horticultural production, with average annual losses from hydrometeorological hazards comprising about three percent of gross domestic product. The impact of

3

4 https://old.meteo.md/newsait/inf280407.htm

natural hazards is particularly severe on the rural population of Moldova, which accounts for 60 percent of the population and is highly dependent on agriculture.

Despite the presence of climatic risks within the country, economic actors in the horticultural industry play a crucial role in generating employment and income in rural areas. Leveraging certain competitive advantages such as favourable geographical positioning, climatic conditions, and the opportunities presented by the Association Agreement between the Republic of Moldova and the European Union, including the Deep and Comprehensive Free Trade Area, as well as the availability of relatively inexpensive labour and government subsidies, the horticultural sector has experienced remarkable growth in terms of both scale and output.

Despite the willingness to modernise and develop the sector, the state does not have enough measures, sources and levers to support the sector that is increasingly affected and not only by climatic conditions. Given the prolonged impact of food instability, it is crucial to implement immediate actions that foster and enhance the country's horticulture sector. To achieve this, there is an urgent requirement for the implementation of contemporary technologies that are adaptable to climate change, while also being readily accessible and feasible within a short timeframe.

To effectively enhance the present condition of the horticultural industry, it is essential to acknowledge potential risks, including:

- the sector's reliance on conventional markets.
- decreased access to water resources for irrigation due to climate change and unfair management of transboundary waters.
- losses resulting from extreme fluctuations in climatic conditions.
- decreased availability of labour in the horticultural sector due to competition from other sectors of the economy and emigration.[5]

The aforementioned factors render the agricultural sector susceptible to instability, resulting in uncertain incomes for both farmers and the entire nation. To mitigate this vulnerability and enhance resilience in the face of climate change, a set of technologies has been suggested as part of the Technology Needs Assessment (TNA) for the horticulture sector.

**Aquaculture** in the Republic of Moldova is currently experiencing modest growth and remains vulnerable to political uncertainty, weak administrative capacity, bureaucratic interests, higher feed prices, mineral fertilizers, adverse weather conditions and climate vulnerability, so adaptation is to be prioritised within the national policy framework.

The impact of climate change on aquaculture is affecting fish production and supply, as well as the livelihoods of communities, fish consumers and the country's food security and this impact is expected to increase.

Climate change affects the aquaculture sub-sector mostly through temperature changes in both water and air, the pattern of precipitation, wind speed and heat waves and especially by extreme weather events (drought).

Existing climate variability significantly influences the aquaculture sector directly threatening the sector production through the influence on the biological productivity of water bodies (lakes and ponds) varies and depends on the specific climatic conditions of the fishing areas and the biological characteristics of the cultured species, resulting from the implemented technology (population formulas, densities , feed recipes, disease treatments, etc.).

[5] https://docs.google.com/document/d/12VxtB2XR91NNXQcrQwoEs1eQ6_BqQTPN/edit

Extreme events impact both on sector production and its infrastructure, with increased risks of disease, parasitic infections, and harmful algal blooms, threatening the whole sector production.

Climate change has direct and indirect impacts on aquaculture in the short and long term.

The direct impact includes changes in water availability, temperature changes, water level changes, as well as an increase in the frequency of extreme weather phenomena:

a) droughts,

b) reduction of water availability by decreasing the flow rate and water level.

The vulnerability of water bodies used for fishing purposes to climate change is very high. The assessment of water bodies confirms the supposition that aquaculture sector vulnerability may increase with different degrees depending on climate scenario and the fishing areas. Due to the acute effects of climate change a large water deficit is occurring. The decrease in water flow leads to changes in the size, depth and trophic potential of water bodies, and changes in water level account and ultimately reduce the area available for aquaculture and determine the vulnerability of the ecosystem.

In this context, many water basins used in aquaculture, during the summer of 2019 -2020 y.y., also in subsequent years, especially in the central and northern fishing areas, have changed their shape or dried up entirely against the background of the lack or change in precipitation dynamics. The acceleration of the evaporation phenomenon and frequent droughts affected around 780 water basins. Excluding 2021 y, during the last 3 years about 255 ponds have dried up, most of them located in the districts of Nisporeni, Glodeni, Telenești, Ungheni, Fălești, Cantemir located in all 3 fishing areas.

Given that the streams of small rivers that capture and feed the ponds have exhausted their capacity to capture and discharge water as the springs are blocked and dammed and their beds are silted up and overgrown with aquatic vegetation. Considering this negative impact, there is a need to update the watershed management schemes of small rivers, so as to take into account the effects of climate change (decreasing water resources, increasing water demand).

b) the increase in temperature leads to the degradation of water quality.

Prolonged high temperatures cause severe evaporation in lakes and ponds and affect the physiological processes of fish, thereby affecting reproduction, fry survival, production and yield. The long periods of drought that disrupt the growth technology applied with an impact on the production achieved. The much milder winter months that increase the risk of pathological conditions and so of high temperatures will lead to increased rates of decomposition and eutrophication of ponds and changes in water quality including a reduction in dissolved oxygen levels that require substantial additional investment to manage (costs associated with aeration).

Most fish species are sensitive to variations in water temperature that directly influence dissolved oxygen content and the occurrence of eutrophication, the water being "choked" due to decaying algae that depletes oxygen from it, as well as other parameters of water quality with impact on fish growth and development. That is why forced aeration is required, which is carried out at night when photosynthesis processes are limited.

c) increase in damages caused by droughts (fish mortality).

Aquaculture is highly affected by droughts, the damage of which could be partially avoided through property insurance, however, in Moldova insurance companies do not work in the aquaculture sector. In the absence of a compensation system as it exists in the agricultural policy, farmers alone bear all the losses and damages due to droughts. In the summer of 2007, with an extreme drought followed by water temperatures of up to 32 °C, which caused the dissolved oxygen level to drop to 1-2 mg/l and the massive development of algae, these circumstances led to fish mortality in a series of fishponds in the districts of Ungheni, Nisporeni, Călăraşi, Făleşti, Taraclia. As a result of the droughts, about 780 ponds have dried up in recent years. In these cases, climate change causes the reduction of fish production by inducing the reduction of the areas used in aquaculture. On the other hand, climate change will lead to a change in the composition of cultivated species. This change may cause long-term effects on the diversification of the assortment of fish production. Longer droughts will increase competition from other sectors, thus limiting the areas and volume of fish production.

Farmers should be able to cope with the climate impacts by selecting species that are best suited to changing temperatures. Additional financial resources will also be needed to protect some farms from droughts resulting from erratic rainfall to improve management capacity and adaptability.

The main drought impacts are:

Economic

- Reduction of fish production and financial activities that depend on the sector.
- Unemployment caused by the decrease in production.
- Damages as a result of the reduction of available water in the supply system and/or water bodies.
- Pressures from financial institutions (high risk of loans, decreases in capital, etc.).

Environment

- Decrease in the availability and quality of water.
- Damage to ecosystems, biodiversity, and the occurrence of diseases (generated by the availability and quality of water, etc.).
- Losses in complex and natural lakes (with effects on fish farming, etc.).

Social

- Damages in terms of public health and safety, as a result of affected water quality.
- Increasing social inequity, by unequally affecting different socio-economic groups.
- Occurrence of tensions between the public administration and the affected groups.
- Changes in political perspectives.
- Inconveniences as a result of water use rationalization.
- Effects on the course of life (unemployment, doubts about the future, loss of property).

Climate change imposes new challenges on aquaculture, especially with implications on the population, for which fish is an important source of food and ensures food security following the increase in the volume of fish from aquaculture and the supply of local fish products on the domestic market. The effects of climate change on aquaculture establish the need to make decisions about risk reduction and the development of sustainable aquaculture. Thus, climate variability and change need to be addressed emerging from the sector's activities, by developing and promoting a mitigation action plan and adaptation measures. As a result of the decrease in the volumes of water available in certain aquaculture farms, it will be necessary to change the structure of cultivated species and in the absence of water, they will be used for other activities, such as agriculture, animal breeding, hunting, etc.

The most important effects expected to result in the aquaculture sector in the Republic of Moldova due to climate change are increased temperatures above the optimal range of tolerance, changes in the precipitation regime and extreme phenomena - drought.

The large water deficit recorded in the lakes and ponds used in aquaculture places the Republic of Moldova in the category of countries with insufficient water and with an increased risk of the impact of climate change. The negative consequences of climate change, especially in the increased incidence of heat and drought require governance to implement some adaptation practices and support policies to help and strengthen fish farms to reduce the threats posed by climate change to aquaculture and capitalize on the opportunities to invest in coherent and convergent risk reduction and adaptation measures to anticipate and reduce the impact of extreme events. Following the change in climatic conditions, it is expected that the frequency, duration and location of these phenomena will change, therefore aquaculture in the Republic of Moldova must move from reactive management after the occurrence of the extreme phenomenon - drought to the proactive reduction of climatic risks and hazards.

Reducing the vulnerability of the aquaculture sector requires the application of well-planned adaptation measures to the effects of climate change, which must take into account government structures and must not accentuate economic and social inequality. Their effectiveness depends on strengthening the capacity to respond to changes, as well as including measures to respond to these changes in policy documents.

The analysis of the regulatory framework of the aquaculture sector revealed weaknesses of both the administrative and legislative frameworks, requiring modifications of the legal framework to strengthen the enabling environment of the aquaculture sector and align it with EU standards:

- ➔ development and adaptation of the law on aquaculture - separate regulation of aquaculture and recognition as a separate branch with mainstreaming into it of climate resilience and adaptation.
- ➔ Government financial support in carrying out inventory, mapping and crediting of water basins (assessment of hydrological, hydrochemical, and biopotential indices) in order to identify the vulnerability and risks of water resources at the water body . To establish a register in order to establish the production units operating in aquaculture and the number of users of water for aquaculture and monitor the number of taxpayers.
- ➔ elaboration of normative acts for inclusion in the state subsidy system producers of juveniles for stocking, and fish for consumption, along with scientific institutions in aquaculture.
- ➔ participatory approach of state and profile institutions by updating and implementing the Action Plan of the National Program for Consolidation and Development of the Aquaculture Sector in the Republic of Moldova for 2020-2030 with the incorporation of CCA measures.
- ➔ create one national entity bringing together all relevant authorities with aquaculture responsibilities to facilitate and coordinate work on planning and monitoring activities, national and sectoral policies on support for implementing climate-related measures preventing and mitigating the impact of climate change on economic and social activities.
- ➔ ensuring registration and issuing environmental authorization for special use of water for all water basins in the country (according to art. 23 para. (1) of the Water Law nr. 272 of 23.12.2011). Currently, only 785 ponds have environmental permits for special water use.
- ➔ elaboration of fisheries and biological substantiations (FPB) for water bodies, taking as basis inventory, mapping and crediting (assessment of hydrological, hydrochemical indices, trophic potential) and classification according to existing climatic conditions of water bodies (aquaclimatic districting) in fisheries areas of Moldova, in order to predict water availability in ponds, allowing farmers to adapt to existing climate changes.
- ➔ ensuring the necessary budgetary provisions for monitoring the health status of fish by carrying out complex investigations (ichthyopathological, hydrochemical, hydrobiological) of production areas and promoting aquaculture with a high level of protection of the environment, animal health and welfare, as well as public health and safety – elaboration of the sanitary veterinary passport of the aquatic basin.
- ➔ undertaking policy reform, improving the regulatory and governance process, transparency and accessibility in the aquaculture sector will allow increasing farmers' capacity to respond to the effects of climate change by identifying, mapping and crediting fisheries areas at the national level by productivity classes for aquaculture, will contribute to increasing aquaculture production and increasing environmental benefits and services.

To reduce the vulnerability of the aquaculture sector to the impact of climate change, the following measures are necessary:

- Using existing vulnerability and risk assessment results and conducting new studies and assessments as appropriate;
- Strengthening the capacity to monitor and forecast climate changes, applying forecasts to prevent potential disasters;
- Promoting the development and improvement of the efficiency of interventions regarding damage recovery and management of the aquaculture sector;
- Strengthening the quality climate-related education;

- Elaboration of criteria based on the findings of vulnerability and adaptation analyses for prioritizing women's needs in terms of climate change adaptation and mitigation actions.
- Improving the use of new fish production technologies in vulnerable farms.
- Developing the capacity to implement policies and technological innovations to address the adaptation of the aquaculture sector to the effects of climate change.
- The deployment of technologies for the development and rehabilitation of the infrastructure of the ponds by carrying out the cleaning works of the water supply channels to respond to the negative effects of climate change.
- Create policies and study profiles and promote the implementation of adaptation measures at the farm and community level, including strengthening the partnership between government, development partners and the private sector.
- Based on the above analysis, we propose a set of technologies that will contribute to climate resilient and adaptive development of aquaculture sector of Moldova.

A number of common to all sub-sector challenges hamper the efficiency and productivity of the country's agricultural sector.

**Water resources**. The total available water resources in the country amount to 5.6 $km^3$, including 4.3 $km^3$ of surface water and 1.3 $km^3$ of groundwater. The main groundwater reserves are located in deep confined aquifers, whose natural recharge capacity is limited. Irrigation has been considered a valuable measure to mitigate drought risk, increasing yield by 25–50% in normal years, while avoiding losses in drought years. Irrigated land has diminished drastically compared to the Soviet period, due to the ageing and deterioration of the equipment, the rising cost of energy for the pumps, the farm restructuring process – older pumping systems not adapted to the new size of plots – and the overall collapse of the agriculture sector since the 1990s. Water resources for agriculture are scarce, and irrigation infrastructure is almost non-existent among small scale farmers (high costs especially). Due to the uncontrolled use of water from wells and short boreholes for irrigation in households and small farms, the water table depth in these aquifers has dramatically increased, leading to the depletion of aquifers in many regions of the country.

**Water quality.** Even though water resource quality has improved since 1990, some of the inner rivers, especially in the southern region, have high salt content, making waters unsuitable for direct use. Moreover, water quality in wells does not comply with the national standard for drinking water due to excessive water hardness and concentration of nitrates. Approximately 12% of the total population has no access to potable water, which is primarily polluted by nutrient runoff from farm fields, storage and use of manure, agrochemicals, and waste. This was found to have impacts on all sub-sectors of agriculture and predominantly on ***aquaculture and livestock***.

**Erosion.** Water and wind erosion are on-going processes that cause significant damages to agriculture in Moldova. About 43% of the agricultural land is eroded to some degree, with about 6.4% considered highly eroded (up to 30 tons of soil loss per hectare). The eroded area increases by about 7,700 ha per year on average. Landslides are most common during winter and spring months, as a result of increased rates of precipitation, snow melt, and soil saturation, and can be triggered by intensive agriculture and deforestation that lead to compaction, subsidence, and rising groundwater. This was found to have impacts on all sub-sectors of agriculture and predominantly on ***cereals and horticulture, and indirectly on livestock (feed production)***.

**Forest cover and illegal logging.** Moldova is the least forest-covered country in Europe. The inadequate forest management in the past caused a decline of forest quality, increased vulnerability to pests and diseases, and decrease in biodiversity. Despite afforestation activities conducted between 2002 and 2008, the country still has a very low level of forest cover (12% of the country's land area), which explains in part the frequency and severity of soil erosion, flood, and landslide events. This was found to have impacts predominantly on ***cereals and aquaculture.***

**Overgrazing.** The unauthorised and often uncontrolled grazing has a negative impact on pastures. The area under improved pastures is six times lower than the number of livestock heads in Moldova (625,000 heads), which increases pressure on improved pastures. Clearly this affects the ***livestock sector***.

**Social and economic vulnerability**. Overall poverty rates in Moldova have decreased significantly, from 26% in 2008 to 11.4% in 2014. Yet, Moldova remains one of the poorest countries in Europe and faces challenges in sustaining the progress. Poverty is most severe in rural areas. Low wages, limited numbers of jobs, natural hazard shocks, and poor infrastructure and livelihood conditions in rural areas have led to rural-urban migration. Moldovan labour markets contributed to a decline of poverty, but mostly through productivity increases rather than job creation – in fact, employment has steadily declined. Some sub-sectors of agriculture, especially those most reliant on labour, have been more affected, like the case of ***livestock***. All ***other sub-sectors***, to varying degrees, have been affected too.

**Technological investments and added value.** Between 1995 and 2007, the total area of orchards and vineyards decreased by 30% and 20% respectively, while the grain land area increased from 50% of the total area of crops in 1994 to 65% in 2004. These developments are a consequence of farmers' decreasing incomes, since they cannot finance needed investments in higher value-added crops. High value-added crops require more sophisticated technologies and better protection against unfavourable climate conditions. This socio-developmental aspect impacted predominantly the ***horticulture and livestock sectors.***

## 1.4 Sector selection

An attentive review of the main sub-sectors of agriculture that should be targeted in the context of the TNA is key to determining the areas of focus for the project and the consequent technical and administrative arrangements. A pre-screening has been carried out during the initial phases of the TNA, based on two main resources: FAOSTAT and the World Bank Climate Smart Agriculture programme. In addition, the results of the climate vulnerability assessment carried out by National Consultants were reviewed by the TNA Team. Following these two steps, such pre-screening has been discussed with the National Steering Committee and has represented the basis for the final selection of a manageable number of sub-sectors to be targeted in the context of this TNA. Once the sub-sectors have been identified, Sectoral Working Groups (SWG) for each sub-sector were formed. Later, these groups met with the respective sectoral National Consultant to evaluate the Long List of Technologies and the related Technology Factsheet and carry out the prioritisation exercise (see Chapter 3).

| **Crop** | **Surface (ha)** |
|---|---|
| **Maize** | 420,490 |
| **Sunflower seed** | 373,989 |
| **Wheat** | 300,341 |
| **Grapes** | 114,123 |
| **Barley** | 51,025 |
| **Apples** | 50,434 |
| **Soybeans** | 26,471 |
| **Rapeseed** | 24,148 |
| **Potatoes** | 22,533 |

| | |
|---|---|
| **Walnuts, with shell** | 20,947 |
| **Plums and sloes** | 19,975 |
| **Beans, dry** | 16,134 |
| **Sugar beet** | 12,989 |
| **Peas, dry** | 8,631 |
| **Onions, dry** | 6,418 |
| **Sorghum** | 6,351 |
| **Cucumbers and gherkins** | 5,834 |
| **Peaches and nectarines** | 5,606 |
| **Watermelons** | 4,838 |
| **Vegetables** | 4,667 |
| **Tomatoes** | 4,439 |
| **Pumpkins, squash and gourds** | 4,125 |
| **Cherries** | 4,071 |
| **Garlic** | 4,044 |
| **Cherries, sour** | 3,757 |
| **Apricots** | 3,599 |
| **Pears** | 2,403 |
| **Carrots and turnips** | 2,310 |
| **Strawberries** | 2,056 |
| **Chillies and peppers, green** | 1,928 |
| **Cabbages and other brassicas** | 1,751 |
| **Peas, green** | 1,655 |
| **Raspberries** | 1,120 |
| **Oats** | 1,072 |
| **Quinces** | 1,001 |

*Table 1.0.2 Main crops cultivated in Moldova, by harvested area in 2019 (FAOSTAT).*

In terms of harvested area, major crop groups/sub-sectors of agriculture can be identified from recent FAOSTAT data. Clearly the cereals sub-sector is prominent in the country and so is the oilseed market. A first question that raises from this analysis is linked to the degree of adoption of crop rotations in the Republic of Moldova, and the characterization of the rotations.

The fruits and nuts sector (horticulture, to an extent) is also a relevant share of the harvested area in Moldova and is dominated by grapes and apples, and to a lesser extent by walnut production.

Vegetables, including tomatoes and several other summer crops also interest considerable surface areas, though in light of their strong seasonality it remains to be further understood what the land use during unfavourable seasons is.

The livestock sector also emerges as a relevant sub-sector of agriculture in Moldova.

Lesser emphasis, at least in terms of production, is linked with aquaculture.

Stakeholder discussions supported by official reports and national policies have highlighted the relevance of the following sub-sectors of agriculture as the key targets for the TNA:

a. **Cereals:** wheat, barley, and maize are key food crops produced in Moldova. The assessment carried out estimated that these crops cover the majority of the agricultural land in the country and make up the majority of the production of agricultural commodities (source FAOSTAT, 2022). Wheat and Maize are the two most common crops in Moldova by surface area, with about 17 and 22% of total harvested agricultural land respectively, cumulatively making up to one third of all arable land in the country. Their productivity levels are rather low, especially if compared to neighbouring Ukraine. Soil quality in Moldova is decaying, and the cultivation of these annual crops through tillage and erosion deplete the organic carbon content of the soils. Cereals are often cultivated in rotation with oilseeds, especially sunflower, and this crop should also be considered to the extent possible in this assessment for many reasons. Firstly, because the demand for this crop as well as the demand for wheat and maize, already very relevant in the context of agriculture in Moldova, is expected to rise in the coming years as a consequence of the conflict in Ukraine, largest producer and exporter of both cereals and oilseeds in this geographical area. Such increased demand is expected to drive both cereals and vegetable oil prices up, as in part has already been observed, generating a supply response in those areas where this cropping system is known and practiced. Secondly, sunflower production shares several limitations and is affected by similar climate-induced constraints as the aforementioned cereals, and most importantly, several technological advances may apply to both crops seamlessly. Decoupling cereals and oilseeds therefore seem inconsiderate, and the TNA will mention technologies and practices that could apply to both cereals and oilseeds when possible.

b. **Horticulture**: fruit and vegetable production in Moldova consists of many horticultural products and makes up a relevant share of the GDP of the Agriculture sector. Apples and grapes, but also walnuts, are among the woody plants most commonly cultivated in the country and their products are consumed in both domestic and export markets. Tomato, beets and many other vegetables are also produced to a large extent during specific growing seasons, nevertheless these represent an important part of the agricultural activities carried out in specific regions of the country. Climate change is expected, among other things, to reduce crop yields across the three agro-ecozones by 10–30% by 2050 (relative to 2013 yields), considering no adaptation measure and given the current water challenges (World Bank, 2019). However, higher temperatures could shift grape cultivation towards the country's northern border and may improve grape quality, by increasing sugar content, which could significantly boost wine quality. Apples, however, are more likely to be impacted mainly negatively by these climate change-induced effects. Although the share of national arable land cultivated with tomatoes and apples is low (0.3% and 2.9% respectively) these crops have high added value and relatively competitive productivity, but late frosts and hail events have been causing growing concerns for a sustainable future of the sub-sector.

c. **Livestock**: a study on the literature available on impacts of climate change on livestock sector was carried out by National Consultants in the context of the TNA and the results indicate that the sub-sector will be affected negatively by the warming climate and water scarcity. The general results of the study were that, relative to the baseline, the probability of choosing beef cattle and chickens will decline with rising temperatures, but that the probability of selecting dairy cattle, goats, and sheep will increase. Income per animal is also expected to decline across all livestock types, but most dramatic changes are already being observed for beef cattle, goats, and chickens. A model-based study mixed with literature trends showed a fall in income due to lower body weight gains for all livestock types with a temperature increase of 2.5°C compared to last century's values. Rising temperatures, in general, lead to a response to reduce the predicted number of beef cattle and chickens on each farm, but increase the number of the other livestock types, especially free grazing animals. Drought and water stresses, however, are responsible for a decrease in pasture's availability and quality, especially protein. This is why actions to adapt to these changes are essential also for the livestock sector.

d. **Aquaculture**: The Republic of Moldova is rich in retained water resources. Comparing the size of the country and the total area of water reservoirs and ponds, it has the largest resources of artificial waterbodies among the countries of Central and Eastern Europe. The water reservoirs and ponds are owned by public local authorities, irrigation associations, the State and private owners. However, despite the large availability of water bodies, aquaculture remains below its potential. The established aquaculture farms may face growing challenges to express their potential as expansion and even maintenance of the current levels is being hindered by impacts of climate change. These issues apply also to fishery, both commercial and recreational. The disappearance of sturgeons and other valuable species has been influenced by human factors as the conditions of breeding, feeding and growth of fishes have changed considerably. These consist mainly in the use of water resources for irrigation and the pollution of waterbodies with untreated wastewater of agricultural and industrial enterprises discharged pesticides, herbicides, and other chemicals into the remaining waterbodies. Increasing temperatures, especially in summer, have changed the composition of the fish fauna of Moldova, due to lower concentrations of dissolved oxygen into the water. Although this sub-sector does not have a monolithic relevance in terms of national GDP, the importance for local populations of farmers and for the overall biodiversity conservation of aquatic species in Moldova, led to the inclusion of this sub-sector among those receiving improved technological options to cope with the impacts of climate change.

After the preliminary definition of the sub-sectors considered in the TNA, the TNA team begun the process of formation of Sectoral Working Groups. These include sector specific experts, in addition to stakeholders that have an overarching role in all sub-sector (e.g. energy stakeholders, water stakeholders, etc.). Experts were recruited based on a Terms of Reference drafted by the TNA Team to clearly show the roles and responsibility of the Sectorial Working Groups and expectations from their members (see Annex 1).

# Chapter 2. Institutional arrangement for the TNA and the stakeholder involvement

The TNA is the result of a set of interactions between the TNA team and the facilitators of the process. The TNA Team is composed by the TNA Coordinator, a technical officer belonging to FAO, National and International technical consultants, and the Sectoral Working Groups. In addition, the TNA team is enriched by the presence of a National TNA Committee, composed of representatives from relevant ministries, academia, private and the civil society. The facilitators are key figures that contribute to the decision-making process but are not in the driving seat of the TNA. They are members of the Steering Committee, FAO, and stakeholders.

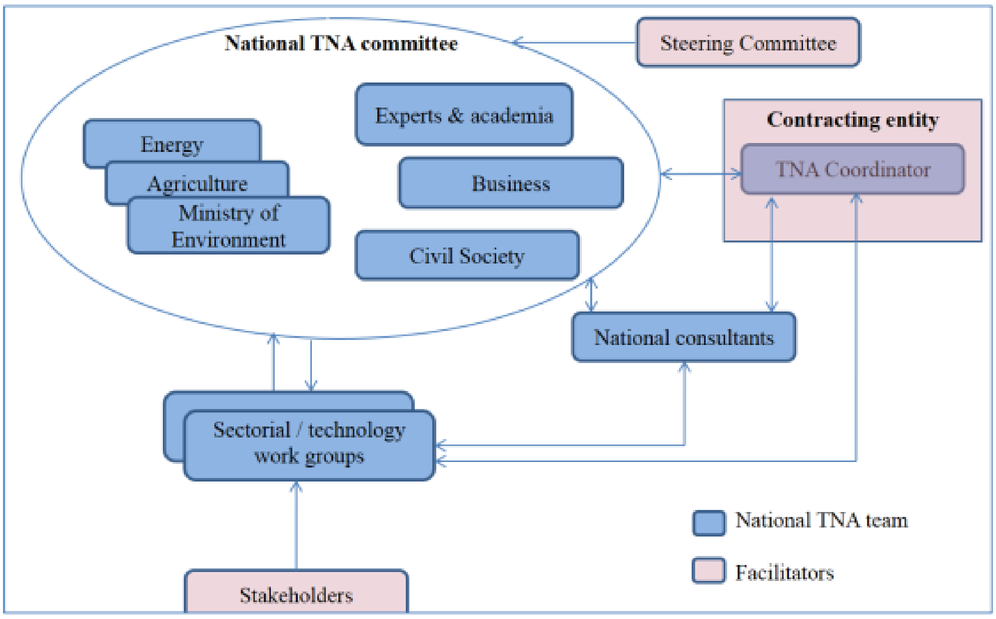



*Figure 2-0-1. Institutional Arrangements for TNA process. Source: UNFCCC Draft paper on aligning technology needs assessments process with the national adaptation plans process*

## 2.1 National TNA team

**The National TNA Coordinator**

The TNA Coordinator is responsible for the day-to-day management of the overall TNA process. This role will involve providing vision and leadership for the action, facilitating communication tasks with the National TNA Committee members, National and International Consultants and stakeholder groups, forming networks, directing data collection, and the coordination and communication of all work products (UNEP DTU, 2019). The TNA Coordinator's skills should include familiarity with the relevant technological aspects in addition to leadership and management.

**National and International Experts**

Technical experts (or consultants) are a crucial element of the TNA process. National consultants belong to universities or research institutes based in the country. International consultants belong to International Organizations or consulting firms. The role of national consultants is to conduct most data collection and analytical work for the TNA process. International consultants have documented long lasting experience assessing climate change impacts on agriculture, the TNA process and possibly FAO's procedures. Their role is to directly interact with national consultants and coordinate in depth technical aspects related the TNA with them. They report to the TNA Coordinator.

According to UNEP DTU (2019), national TNA consultants can be tasked with the following:

- organizing stakeholder consultations.
- identifying and prioritizing technologies for the specific sector through a participatory process with the broad involvement of relevant stakeholders.
- preparing deliverables, including the intermediate and final reports.
- preparing working papers and other TNA-related documents as may be required to ease the consultative process.
- harnessing inputs from stakeholders during meetings and workshops, among others
- participate in capacity-building workshops.

- work in close partnership with the TNA Coordinator to facilitate communication within the national TNA Team (coordinator, consultants, sectoral working groups), engage with stakeholders, form networks, and coordinate and communicate all deliverables.

**Working Groups**

The Working Groups can be set up on either a sector-specific or a technology basis in a way that makes sense to local needs and conditions. The typical composition of these groups includes representatives of government departments with responsibility for policy formulation and/or regulation; private- and public-sector industry representatives; delegates from utilities and regulators; and representatives of technology suppliers, finance, technology end-users (e.g., households, small businesses, farmers) and technology experts (e.g., from universities, consultants, etc.). These working groups should contribute their technical expertise and input into technology prioritization, the barrier analysis, and ideas or inputs for the enabling framework for a given technology and/or sector.

**The National Steering Committee**

The National Steering Committee is the key body guiding the TNA process. The National Steering Committee should be comprised of members responsible for policymaking from all the relevant ministries, as well as key stakeholders from the private sector. Their role is to provide high-level guidance to the national TNA team and help secure political acceptance for the TAP. As such, it is envisaged that the National Steering Committee should meet a handful of times, first when the TNA team has been established and the priority sectors have been selected, and then again towards the end of the process once the TAP has been finalized.

**National Stakeholders and Facilitators**

This is a fundamental aspect of the TNA process. Sufficient time should be set aside, and effort made by the National Coordinator and National TNA Committee to ensure that the TNA process is a truly stakeholder-driven process. Everybody who has an interest in or is affected by the TNA process or by its results should be considered a relevant stakeholder. It is important to ensure that the stakeholder consultation process is gender-sensitive in both process and content. This means that the perspectives of both women and men need to be sought during consultation to ensure that both have an opportunity to voice their opinions. Sceptical and critical persons or groups should be invited to join the national stakeholder groups. Their presence and participation are very important firstly due to the enhanced transparency of the process itself (as well as transparency perception of the civil society), and the quality and completeness of the action plan proposed at the end of the TNA will be enhanced by their contribution to the process. water stakeholders, etc.).

## 2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

After the preliminary definition of the sub-sectors considered in the TNA, the TNA team formed Sectoral Working Groups (SWG). The SWG included experts and stakeholders with specific knowledge in climate-related impacts and on various sub-sectors of agriculture, in addition to stakeholders that have an overarching role in all sub-sectors (e.g. energy stakeholders, water stakeholders, etc.). Stakeholders have been recruited based on a Terms of Reference drafted by the TNA Team to clearly show the roles and responsibility of the Sectorial Working Groups and expectations from their members (see Annex II).

The TNA Team identified stakeholders involved in the mitigation and adaptation expertise and were brought onboard based on clear Terms of Reference (see Annex II). Firstly, the identification of those who are directly impacted by the climate change in the area of interest: Ministry of Environment, Ministry of Agriculture and Food Industry, Institute of Biotechnology in Animal Husbandry and Veterinary Medicine, State Commission on Plant Varieties Testing, National Agency for Rural Development, Institute of Pedology, Agrochemistry and

Soil Protection, as well as the council of Local Authorities of Moldova. Moreover, research institutes and the State Agrarian University were also brought onboard, as was the case in previous iterations of the TNA exercise. Representatives of the Gender Public Association are also part of the SWG. This initial group of stakeholders was requested to suggest other stakeholders who have interest in promoting technology transfer and are concerned of future climate change impact. Other stakeholders have been identified, including those in national institutions who have a direct opportunity to support the technology transfer process, such as the Agency for Modernization and Development of Agriculture. Concerning financial implications of the introduction of advanced technologies for adapting to climate change, representatives of national financing institutions have also been enrolled as SWG members. Overall, then, the SWG is composed by a varied ensemble of planners and decision makers, sectoral planners and key stakeholders at the local and national levels resulting in a balanced mix of representatives of ministries, persons with strong political background, business representatives, sectoral experts, and scientists.

## 2.3 Consideration of Gender Aspects in the TNA process

Women and men often have distinct roles and duties that vary depending on the situation and country, which affects how they use and obtain access to technologies. These technologies can have different impacts on women and men. Factors such as age, ethnicity, physical and mental abilities, urban or rural living environments, as well as the cultural norms and values of their society, can affect the responsibilities and activities of women and men. These differences must be recognized and properly addressed to ensure that everyone has equal opportunities. To achieve this, it is necessary to identify and address any inequalities that exist, including ensuring equitable access to resources and opportunities.

Gender mainstreaming is a process that will help TNA country teams integrate gender issues into their assessments at all levels:

- understand how gender roles, responsibilities and inequalities can affect the effectiveness of the TNA process and the sustainability of its outcomes.
- design and implement inclusive technology projects in such a way as to close gender gaps in the transfer and implementation of climate-related technology so that both women and men benefit equally from outcomes.

Having a good gender balance among stakeholders and ensuring gender representation in sectoral working groups is crucial. After the participatory process for prioritising sectors, the TNA team will choose consultants who are skilled and knowledgeable in gender issues for each of the prioritized sectors.

Before the technology factsheets are produced, TNA teams will review existing planning documents and their preparation. It is important that the gender-related background assessment is fully integrated into the sector background study to be conducted as part of the TNA. Prior to creating the technology factsheets, the TNA teams will evaluate the planning documents and their development process. It is crucial that the gender-related background assessment is integrated thoroughly into the sector background study, which will be conducted as part of the TNA. If this process involves desktop analysis by utilising existing analyses, national planning or strategy documents, then the analysis should include information about gender targets and goals.

The TNA process will involve engaging with relevant stakeholders, and to ensure that the stakeholder consultation process is both gender-sensitive in process and content. This involves two key elements: a) ensuring that both women and men are given the opportunity to express their views during the consultation process, and b) treating gender issues as an integral part of both sector and technology selection. By including these elements in the stakeholder consultation process, the TNA team will ensure that gender perspectives are taken into account and that the needs and concerns of both women and men are properly addressed.

Effective gender-mainstreaming in the context of climate change adaptation projects requires planning and resources to ensure that general principles are translated into action. Several gender-responsive actions could be carried out in the context of a TNA Assessment including the following:

- Analysis of the differential impacts of proposed interventions on women and men respectively.
- Full recognition of women's and men's different needs, based on consultations that purposely seek advice from both women and men.
- Recognition of the respective potential of women and men to play an active role in contributing to climate change adaptation.
- Recognition of the need to tackle institutional barriers that limit women's participation in climate change mitigation and adaptation planning and implementation.
- Recognition of the potential of women and men to participate in technology transfers.
- A focus on context-specific gender-mainstreaming that is anchored in local systems.

Therefore, the first action to put in place is a research and analysis of possible different impacts that a given intervention may have on women and men. A study of those agricultural activities carried out predominantly by women is one example of this analysis. An example in Moldova is linked to small scale animal husbandry, as well as the horticulture sector, which are the two sub-sectors where women are involved in the production cycle. Cereals and aquaculture see a lower presence of women, however, because the climate vulnerabilities highlight shared impacts on each sub-sector of agriculture in Moldova, the analyses of impacts on women engaged in whichever agricultural activity as opposed to men will be valid across the board.

**Gender issues in the agriculture sector in Moldova and considerations in the context of the TNA prioritisation.**

Small scale farming dominates agriculture in Moldova. Majority of agricultural holdings (99.6%) do not have legal status but are operational. In the agricultural census holdings without legal status (meaning they were not formally registered as farming enterprises) include "registered peasant households, farmers/entrepreneurs and other types of households" and the vast majority of these holdings produce crops, horticulture or livestock (94 percent or 848,637 holdings).

The agricultural census provides sex-disaggregated data and information on the main gender gaps in agriculture, but it covers only just over 900,000 individuals, of which approximately 320,000 were led by women. It does not capture information about the numerous rural households and informal agricultural enterprises engaged in agriculture. Additionally, a very large proportion of smallholders and family farms engage in agriculture for subsistence and may not keep records of agricultural production. This makes it difficult to track gender-based information on indicators such as crop yields and harvests or income from selling agricultural products.

The sex-disaggregated data from the agricultural census provides valuable insights into women's ownership of agricultural land, both in legal and family farming entities. However, women still constitute a minority of farmers, regardless of whether the holding has legal status. In the Republic of Moldova, women own or manage slightly more than one-third of agricultural holdings, but they are better represented as holders of unregistered farms. This suggests that farming as a profession is still uncommon for women. Moreover, women have control over only 19 percent of the total land area, despite heading just over a third of agricultural holdings. This difference represents more than 1.3 million hectares of land. In holdings without legal status, where most women are represented as farmers, they own less than a third of the agricultural land. These data suggest that although there are no legal barriers to women's land ownership, men still control the title and tenure over agricultural land in the Republic of Moldova.

A large part of the arable land in the country is dedicated to cereals and industrial crops. Large farms are widely specialized in low-value crops (including cereals, oilseeds [sunflower, rapeseed], and industrial crops [sugar beet, soybeans]). As there is greater availability of machinery in agricultural enterprises, they produce the majority of fodder crops. Additionally, smallholders and family farms dedicate a significant portion of their seeded areas to cereals and leguminous crops, followed by industrial crops.

Moreover, small-scale farms are the main producers of labour-intensive crops with high added value (such as fruits, nuts, grapes, open-field vegetables, zucchinis, and potatoes). The agricultural census indicates that there are minimal differences in the vegetable production patterns between farms run by women and those run by men. The most significant difference is that farms run by women produce industrial crops on 18 percent of their arable land, while male-run enterprises use 26 percent of their arable land for this purpose.

The fact that women use a smaller portion of land for industrial crops is linked to factors such as their limited access to machinery and equipment and the fragmentation of their land parcels. Farms run by women are slightly more involved in vegetable production.

Studies on selected value chains reveal gender-based differences in crop and horticulture production work. Women typically hold lower-value positions in value chains and perform minimally mechanized physical activities, such as seed sowing, planting seedlings, weeding, hoeing, harvesting in greenhouses, manually spraying small plots with pesticides and chemicals, as well as some selling of agricultural products in small outdoor spaces. In contrast, men perform work that largely relies more on mechanization, including spraying large plots with pesticides and chemicals, irrigating, and operating agricultural equipment. Men also have greater involvement in transportation, processing, marketing, selling, and exporting of plant products.

Women mainly perform informal seasonal work in crop harvesting, sorting, and packaging agricultural products. They also process plant products, often on-farm, and rarely occupy higher management or technical positions (accounting, finance, or marketing), positions that are associated with higher salaries.

While women are underrepresented in leadership positions and management roles, they are more equally represented in some value chains. For instance, in the apple growing and processing value chain, women are involved at all levels, from family farmers to large commercial producers, processors, and exporters. However, men still dominate in industry leadership, middle management, and exporting roles. In the berry production value chain, including strawberries, raspberries, and currants, women make up the majority of the workforce, representing between 70 and 75 percent of the workforce along the chain. They are involved in seasonal harvesting as well as growing and managing processing companies. The potential for women to establish and manage their berry farms is also high because the required land plot is relatively small. Investments in primary production, cold chain and post-harvest handling infrastructure, irrigation, and extension services can increase the export potential for berries.

The sub sector of cultivated medicinal and aromatic plants is currently underdeveloped but has been recognized as a potential value chain for women to participate in cultivation, processing (including essential oil distillation), and marketing of these products, provided that there are significant investments made in each stage of production. (Chemonics International Inc., 2017b)

Women farmers own less than 12% of all machinery and equipment, and their ownership of harvesters, seeders, cultivators, and plows is less than 10% for each type. This is due to the fact that women farmers engage more in crop production and horticulture on smaller plots. This limitation has significant effects on the type and scale of farming that women can undertake.

Smallholders, especially women, have limited access to cold storage facilities and post-harvest handling equipment. This leads to women processing the products at home, resulting in higher spoilage rates and limited opportunities for higher-value segments such as processing and export. Women dominate at the lower-value stages of stone fruit, table grapes, and open field vegetable value chains, while men occupy management and export-oriented roles. Women also represent most of the workers in nut processing facilities. Women farmers own less machinery and equipment, limiting the type and scale of farming they can undertake.

National policy in the Republic of Moldova does not adequately recognize the role of women in fisheries and aquaculture. Women's participation in fish farming is generally low in Eastern Europe, likely also the case in

Moldova. Women's involvement is often limited to secondary processing and marketing, which is underdeveloped in Moldova. As most locally produced fish are sold live or partially processed, few women are employed in fish farming, but more may be involved in sales. State support and training should be provided to improve fish enterprises and attract women's entrepreneurship to this subsector.

For the development and prioritisation of climate change adaptation technologies in agriculture the following key determinants of gender implications in agriculture sector in Moldova have been considered:

- Differences in the crops and value chains that women typically participate in. Women are more involved in labour-intensive crops with high added value, such as fruits, nuts, grapes, open-field vegetables, zucchinis, and potatoes. However, they face limitations due to their limited access to machinery and equipment, fragmentation of their land parcels, and limited access to cold storage facilities and post-harvest handling equipment. This point will be considered in the context of the prioritization of technologies for the Horticulture sub-sector.
- Studies have shown that women typically hold lower-value positions in value chains, and their work is minimally mechanized. To address this, investments in primary production, cold chain, post-harvest handling infrastructure, irrigation, and extension services can increase the export potential for crops such as berries, which have a relatively small land plot requirement and high potential for women to establish and manage their farms.
- Women farmers own significantly less machinery and equipment, limiting the type and scale of farming they can undertake.
- National policy in the Republic of Moldova should adequately recognize the role of women in fisheries and aquaculture, where their involvement is currently limited to secondary processing and marketing. State support and training should be provided to improve fish enterprises and attract women's entrepreneurship to this subsector.
- Technological options introduced should be accompanied by trainings and capacity development, specifically targeting women groups and associations. Introducing these technologies is expected to generate a demand for skilled jobs in the agricultural sector, especially for women living in rural areas – if properly trained - this will enable access to non-traditional jobs and bring social development.

# Chapter 3. Technology prioritisation for Aquaculture

## 3.1 Adaptation Technology Options for Aquaculture and their Main Adaptation benefits

The TNA team and the aquaculture expert proposed 15 technological options for adaptation to climate change in the context of aquaculture in Moldova.

Table 3.1.1 presents the long list of proposed adaptation technologies/practices (LLT) in the aquaculture sector, categorized by climate impact.

For each technology, the following aspects will be presented:

- adaptation needs,
- description of the technology option, and
- expected adaptation benefits based on simplified Technology Factsheets.

Detailed information about technologies is presented in the annexed Technology Fact Sheets prepared for each prioritized technology.

| Climate Hazard | Climate Impacts | Priority technologies/practices |
|---|---|---|
| Increased temperatures above the optimal tolerance range | Eutrophication, stress to temperate-climate fish species | 1. Technology of complex capitalization of the trophic potential through interspecific polyculture. |
| | | 2. Restoration and conservation of the genofond populations of native fish of culture |
| | | 3. Fish protection system |
| | | 4. Mapping and crediting of the trophic potential |
| | Lower dissolved oxygen content, decreased productivity | 5. Ensuring the food security of fish for consumption in fish basins in the conditions of climate change |
| | | 6. Pond Shading |
| | | 7. Water aerators |
| Change in the precipitation regime | Reduced recharge of ponds and lakes, floods, sedimentation | 8. The use of lakes with complex destination for growing fish for consumption in polyculture |
| | | 9. An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology. |

| | | |
|---|---|---|
| Increased frequency of extreme phenomena - drought | Water level reduction in ponds and lakes, stress to fish, low oxygen content | 10. Increasing the production capacity by restoring, modernizing and arranging the ponds for complex use dried up. |
| | | 11. Technology for feeding cyprinids |
| | | 12. Relevant risk management tools to support subsidies and implementation of an aquaculture credit facility |
| | Complete dry-out of waterbodies | 13. Creation of the climate change information system and knowledge platform in the field of aquaculture. |
| | | 14. Development, implementation and monitoring of comprehensive plans for the management of freshwater aquaculture |
| | | 15. Rainwater Catchment Systems |

*Table 3..0.1 Long-list of proposed adaptation technologies (or practices).*

## 3.2 Criteria and process of technology prioritisation

The effects of climate change on the aquaculture sector of Moldova are expected to be largely fish-specific due to the influence of local factors. The analysis of the sector's most critical vulnerabilities are the increased water temperatures above the optimal tolerance range, the changes in the precipitation regime and extreme drought phenomena.

Taking into account the physical and biological properties of fisheries areas in the Republic of Moldova and their socio-economic importance, Technology Fact Sheets (TFS) have been drawn up in consultation with the sectoral working group members and stakeholders and a long list containing 15 technologies for adapting the aquaculture sector to climate change have been identified by the TNA team following a participatory approach. The technologies proposed are therefore classified into three groups (A. B. and C.) by climate change-induced impact:

**A. Damage from increased temperatures above the optimal tolerance range.**

1. Technology of complex capitalization of the trophic potential through interspecific polyculture.
2. Restoration and conservation of the genofond populations of native fish of culture.
3. Fish protection system and ensuring food security in the conditions of climate change.
4. Mapping and crediting of the trophic potential and the climatic rayoning of the water basins.
5. Ensuring the food security of fish for consumption in fish basins in the conditions of climate change.
6. Pond Shading,
7. Water aerators.

**B. Damage because of changing the precipitation regime.**

8. The use of lakes with complex destination for growing fish for consumption in polyculture.
9. An intervention to increase the water flow in the ponds used for growing fish in polyculture according to continuous technology.
10. Rainwater Catchment Systems.

**C. Damage due to extreme drought phenomena.**

11. Increasing the production capacity by restoring, modernizing and arranging the ponds for complex use dried up.
12. Technology for feeding cyprinids.
13. Relevant risk management tools to support subsidisation and implementation of the aquaculture credit facility.
14. Creation of the climate change information system and knowledge platform in the field of aquaculture.
15. Development, implementation and monitoring of comprehensive plans for the management of freshwater aquaculture.

Simplified TFS have been developed for each technological option in the long list of technologies and underwent prioritization using the tools of multi-criteria analysis. The Aquaculture Expert (National Consultant) proposed an initial set of prioritization criteria, as well as potential starting scoring and weighting of each. In the context of several sectoral working group meetings the cohort of participants reached consensus on the scoring and weighting for each criterion for each of the 15 technologies. For each technology, the following elements have been considered:

- Description of the technology, how it is implemented and how it facilitates adaptation to climate change.
- Possible Costs and Benefits (environmental, social, economic, etc.);
- Knowledge and monitoring requirements.
- Institutional and organizational requirements.
- Gender dimension.
- Obstacles and opportunities in the implementation process.
- Actual case of application.

**Determination of criteria**

When determining and establishing the criteria for evaluating priority of a given technology option, costs and potential co-benefits have been considered. The National Consultant in collaboration with the TNA team formulated the criteria, the Sectoral Working Group of livestock experts determined the scoring and weighting for each criterion. Each technology received a score for each criterion. The weightings for each criterion were allocated taking into account the relative importance of the criterion.

**Criteria selected:**

***Cost - 15% of total weight***

Cost to set up and operate the technology (annual operational costs and maintenance).

1. Cost to set up:
   - Necessary Financial Resources (CAPEX costs);
2. Annual operational costs (OPEX costs).
3. Maintenance expenses (Maintenance costs).

***Economic co-benefits - 21% of total weight***

1. Improving farmer income and ability to reinvest.
2. Maintaining the sector as economic activity.
3. Trigger private investment:
   - Trigger private investment.
   - Protection for infrastructure.

*Social co-benefits - 10%*

The indicators used for scoring were the:

- New jobs.
- Increased wages.
- Gender impacts.

*Environmental co-benefits - 19%*

1. Contribution of the technology to protect and sustain ecosystem services.

2. Rational use of water resources:

- Reducing water scarcity.
- Reduction of surface losses of water bodies.
- Surface recovery.
- Concrete results of protection of water bodies in a short space of time.

*Climate change adaptation co-benefits - 15%*

1. Improvement of Resilience to Climate Change:

- Extent the technology will contribute to reduce vulnerability to climate change impacts on aquaculture.
- Ability to adapt to the effects of climate change.
- The potential of the technology to demonstrate tangible and concrete results of protection of water bodies in a short space of time.

*Alignment to National policies and priorities and replicability potential - 20%*

1. Public policy documents.

2. Available resources.

3. Institutional capacities:

- Considerations for the implementation of technology.
- Education.
- Improve awareness.
- Opportunities for research

| **Major Criteria** | **Criteria Description** | **Sub-criteria** | **Criterion weight, %** |
|---|---|---|---|
| **Costs, 15 %** | CAPEX | | **6** |
| | Annual operational costs | | **4** |
| | Maintenance expenses | | **5** |
| **Economic Co-benefits,**<br>**21 %** | Improving farmer income and ability to reinvest | | **10** |
| | Maintaining the sector as | | **5** |

| | | | |
|---|---|---|---|
| | economic activity | | |
| | Trigger private investment | | **6** |
| | | Trigger private investment (4) | |
| | | Protection for infrastructure (2) | |
| **Social, 10 %** | New jobs | | **5** |
| | Increased wages | | **5** |
| | Recreational areas value | | |
| **Environment,**<br>**19 %** | Contribution of the technology to protect and sustain ecosystem services | | **7** |
| | Biodiversity and Landscape value | | |
| | Rational use of water resources | | **12** |
| | | Reducing water scarcity (4) | |
| | | Reduction of surface losses of water bodies (5) | |
| | | Surface recovery (3) | |
| **Climate related 15 %** | Improvement of Resilience to Climate Change | | **15** |
| | | Extent the technology will contribute to reduce vulnerability to climate change impacts (8) | |
| | | Ability to adapt to the effects of climate change (4) | |
| | | The potential of the technology to demonstrate tangible and concrete results of protection of water bodies in a short space of time (3) | |
| **Alignment to National policies and priorities and replicability potential 20 %** | Public policy documents | | **4** |
| | Available resources | | **5** |
| | Institutional capacities | | **11** |
| | | Considerations for the implementation of technology (3) | |
| | | Education (2) | |
| | | Improve awareness (3) | |

| | | | |
|---|---|---|---|
| | | Opportunities for research-based (3) | |
| | | | **100** |

*Table 3.0.2 Criteria and sub-criteria used in technology prioritisation of the aquaculture sector.*

## 3.3 Results of technology prioritization

The technologies were selected following the Multi Criteria Analysis (MCA), based on their potential to reduce vulnerability to climate change, and social, economic, and environmental co-benefits as well as taking into account capital and operational costs.

The technology prioritization followed the TNA Multi-criteria analysis manual, edited by UNEP-DTU. Each technology from the Long List of Technologies was accompanied by simplified Technology Fact Sheets (see Annex III). National Consultants received training on the MCA process during two dedicated training workshops, and prioritization Excel spreadsheets were prepared by the TNA team and distributed to the SWG members together with simplified Technology Factsheets for all technological options included in the LLT.

Out of the total 15 technologies from the LLT, the 3 highest scoring ones were prioritized. These are:

1) Technology of complex capitalization of the trophic potential through interspecific polyculture.
2) An intervention to increase the water flow in the ponds used for growing fish in polyculture according to continuous technology.
3) Fish protection system and ensuring food security in the conditions of climate change.

The MCA matrix below shows the scoring for each of the technologies and each of the relevant costs and co-benefits considered for the Aquaculture sub-sector.

**ACVACULTURĂ**

| Matricea de punctaj (Pentru fiecare criteriu, scorurile trebuie să varieze de la 0 la 100) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Beneficii | | | | | | | | | | | Altele | | |
| | Costul | | | Economice | | | | Sociale | | | De mediu | | | legate de climă | Instuâionale/Implementate | | Politice |
| Denumirea tehnologiei | Costul de configurare | Costuri operaționale anuale | Cheltuieli pentru întreținere | Îmbunătățirea veniturilor fermierilor și a capacității de a reinvesti ability to reinvest | Menținerea sectorului ca activitate economică | Productivitatea | Declanseaza (Provocarea) investitii private | Noi locuri de munca | Cresterea salariilora | Valoarea zonelor de agrement | Contribuția tehnologiei la protejarea și susținerea serviciilor ecosistemice | Biodiversitatea și valoarea peisajului | Utilizarea rațională a resurselor de apă | Îmbunătățirea rezilienței la schimbările climatice(• În măsura în care tehnologia va contribui la reducerea vulnerabilității la impactul schimbărilor climaticechange impacts) | Documente de politici publice | Resurse disponibile | Capacități instituționale |
| *1. Tehnologie de valorificare complexa a potențialului trofic prin policultura interspecifica* | 75 | 79 | 71 | 74 | 67 | 80 | 50 | 20 | 30 | 0 | 70 | 80 | 80 | 50 | 60 | 50 | 80 |
| *2. Refacerea și conservarea geno-fondului populațiilor peștilor de cultura autohton* | 83 | 87 | 79 | 80 | 70 | 84 | 66 | 30 | 30 | 0 | 75 | 78 | 80 | 55 | 65 | 67 | 85 |
| *3. Sistemul de protecție a peștilor și asigurarea securității alimentare în condițiile schimbărilor climatice* | 97 | 97 | 97 | 84 | 75 | 84 | 90 | 35 | 40 | 0 | 85 | 80 | 86 | 65 | 55 | 55 | 85 |
| *4. Cartarea și bonitarea potențialului trofic și raionarea acvaclimatică a bazinelor acvatice* | 88 | 85 | 91 | 78 | 64 | 78 | 76 | 25 | 24 | 0 | 78 | 75 | 85 | 61 | 60 | 58 | 75 |
| *5. Asigurarea securității alimentare a peștelui de consum prin menținerea stării de sănătate a materialului piscicol în bazinele piscicole în condițiile schimbărilor climaterice.* | 92 | 94 | 90 | 77 | 73 | 80 | 90 | 30 | 30 | 0 | 83 | 80 | 85 | 65 | 69 | 55 | 80 |
| *6. Umbrirea iazurilor* | 70 | 74 | 60 | 65 | 60 | 70 | 56 | 15 | 20 | 0 | 67 | 74 | 90 | 70 | 50 | 30 | 50 |
| *7. Sisteme de aerare a apei* | 78 | 78 | 78 | 70 | 59 | 79 | 83 | 10 | 19 | 0 | 70 | 70 | 70 | 74 | 50 | 30 | 50 |
| *8. Utilizarea lacurilor cu destinație complexă pentru creșterea peștelui de consum în policultură* | 96 | 97 | 95 | 84 | 75 | 80 | 90 | 35 | 40 | 0 | 85 | 82 | 85 | 77 | 68 | 60 | 84 |
| *9. O intervenție de mărire a debitului de apă în iazurile utilizate pentru creșterea peștelui în policultură după tehnologia continuă* | 97 | 97 | 97 | 84 | 75 | 82 | 90 | 35 | 38 | 0 | 85 | 76 | 90 | 78 | 65 | 40 | 80 |
| *10. Creșterea capacității de producție prin refacerea, modernizarea și amenajarea iazurilor de folosință complexă secate.* | 89 | 91 | 87 | 72 | 66 | 78 | 65 | 10 | 28 | 0 | 70 | 74 | 80 | 65 | 56 | 57 | 84 |
| *11. Tehnologie pentru alimentația ciprinidelor* | 90 | 94 | 86 | 71 | 74 | 80 | 70 | | 29 | 0 | 77 | 73 | 80 | 69 | 60 | 60 | 85 |
| *12. Instrumente relevante de gestionare a riscurilor care să sprijine subvenționarea și implementarea mecanismului de creditare în acvacultură.* | 86 | 89 | 83 | 68 | 65 | 75 | 55 | 20 | 26 | 0 | 65 | 70 | 73 | 64 | 59 | 55 | 82 |
| *13. Crearea sistemului de informații privind schimbările climatice și platforma de cunoștințe în domeniul acvaculturii.* | 80 | 81 | 79 | 74 | 65 | 75 | 60 | 25 | 20 | 0 | 75 | 78 | 77 | 70 | 62 | 50 | 79 |
| *14. Elaborarea, punerea în aplicare și monitorizarea unor planuri cuprinzătoare de gestionare a acvaculturii de apă dulce.* | 91 | 91 | 91 | 72 | 68 | 78 | 63 | 27 | 21 | 0 | 78 | 75 | 65 | 74 | 64 | 56 | 79 |
| *15. Sisteme de recoltare a apelor pluviale* | 84 | 84 | 84 | 69 | 62 | 77 | 50 | 25 | 20 | 0 | 80 | 70 | 90 | 80 | 55 | 40 | 50 |

*Table 3.0.3 MCA matrix on scoring for each of the technologies and each of the relevant costs and co-benefits considered for the Aquaculture sub-sector.*

The second part of the MCA matrix (below) shows the weighted scoring for each of the technologies considering the relative weight of the various criteria considered for the Aquaculture sub-sector.

| Decision Matrix: Weighted Scores | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Beneficii | | | | | | | | | | Other | | | |
| | Costs | | | Economice | | | | Social | | | De mediu | | | legate de climă | Institutionale/Implementate | | Politice | |
| | Costul de configurare | Costuri operaționale anuale | Cheltuieli pentru întreținere | Îmbunătățirea veniturilor fermierilor și a | Menținerea sectorului ca activitate economică | Productivitatea | Declanșează (Provocarea) investitii private | Noi locuri de munca | Cresterea salariilora | Valoarea zonelor de agrement | Contribuția tehnologiei la protejarea și susținerea | Biodiversitatea și valoarea peisajului | Utilizarea rațională a resurselor de apă | Îmbunătățirea rezilienței la schimbările climatice(• În | Documente de politici publice | Resurse disponibile | Capacități institutionale | Total score |
| *1. Tehnologie de valorificare complexa a potențialului trofic prin policultura interspecifica* | 450 | 316 | 355 | 370 | 335 | 400 | 300 | 100 | 150 | 0 | 350 | 320 | 800 | 750 | 240 | 250 | 880 | 6366 |
| *2. Refacerea și conservarea geno-fondului populațiilor peștilor de cultura autohton* | 498 | 348 | 395 | 400 | 350 | 420 | 396 | 150 | 150 | 0 | 375 | 312 | 800 | 825 | 260 | 335 | 935 | 6949 |
| *3. Sistemul de protecție a peștilor și asigurarea securității alimentare în condițiile schimbărilor climatice* | 582 | 388 | 485 | 420 | 375 | 420 | 540 | 175 | 200 | 0 | 425 | 320 | 860 | 975 | 220 | 275 | 935 | 7595 |
| *4. Cartarea și bonitarea potențialului trofic și raionarea acvaclimatică a bazinelor acvatice* | 528 | 340 | 455 | 390 | 320 | 390 | 456 | 125 | 120 | 0 | 390 | 300 | 850 | 915 | 240 | 290 | 825 | 6934 |
| *5. Asigurarea securității alimentare a peștelui de consum prin menținerea stării de sănătate a materialului piscicol în bazinele piscicole în condițiile schimbărilor climaterice.* | 552 | 376 | 450 | 385 | 365 | 400 | 540 | 150 | 150 | 0 | 415 | 320 | 850 | 975 | 276 | 275 | 880 | 7359 |
| *6. Umbrirea iazurilor* | 420 | 296 | 300 | 325 | 300 | 350 | 336 | 75 | 100 | 0 | 335 | 296 | 900 | 1050 | 200 | 150 | 550 | 5983 |
| *7. Sisteme de aerare a apei* | 468 | 312 | 390 | 350 | 295 | 395 | 498 | 50 | 95 | 0 | 350 | 280 | 700 | 1110 | 200 | 150 | 550 | 6193 |
| *8. Utilizarea lacurilor cu destinație complexă pentru creșterea peștelui de consum în policultură* | 576 | 388 | 475 | 420 | 375 | 400 | 540 | 175 | 200 | 0 | 425 | 328 | 850 | 1155 | 272 | 300 | 924 | 7803 |
| *9. O intervenție de mărire a debitului de apă în iazurile utilizate pentru creșterea peștelui în policultură după tehnologia continuă* | 582 | 388 | 485 | 420 | 375 | 410 | 540 | 175 | 190 | 0 | 425 | 304 | 900 | 1170 | 260 | 200 | 880 | 7704 |
| *10. Creșterea capacității de producție prin refacerea, modernizarea și amenajarea iazurilor de folosință complexă secate.* | 534 | 364 | 435 | 360 | 330 | 390 | 390 | 50 | 140 | 0 | 350 | 296 | 800 | 975 | 224 | 285 | 924 | 6847 |
| *11. Tehnologie pentru alimentația ciprinidelor* | 540 | 376 | 430 | 355 | 370 | 400 | 420 | 0 | 145 | 0 | 385 | 292 | 800 | 1035 | 240 | 300 | 935 | 7023 |
| *12. Instrumente relevante de gestionare a riscurilor care să sprijine subvenționarea și implementarea mecanismului de creditare în acvacultură.* | 516 | 356 | 415 | 340 | 325 | 375 | 330 | 100 | 130 | 0 | 325 | 280 | 730 | 960 | 236 | 275 | 902 | 6595 |
| *13. Crearea sistemului de informații privind schimbările climatice și platforma de cunoștințe în domeniul acvaculturii.* | 480 | 324 | 395 | 370 | 325 | 375 | 360 | 125 | 100 | 0 | 375 | 312 | 770 | 1050 | 248 | 250 | 869 | 6728 |
| *14. Elaborarea, punerea în aplicare și monitorizarea unor planuri cuprinzătoare de gestionare a acvaculturii de apă dulce.* | 546 | 364 | 455 | 360 | 340 | 390 | 378 | 135 | 105 | 0 | 390 | 300 | 650 | 1110 | 256 | 280 | 869 | 6928 |
| *15. Sisteme de recoltare a apelor pluviale* | 504 | 336 | 420 | 345 | 310 | 385 | 300 | 125 | 100 | 0 | 400 | 280 | 900 | 1200 | 220 | 200 | 550 | 6575 |

*Table 3.0.4 MCA matrix on weighted scoring for each of the technologies for the Aquaculture Sector.*

The results of the MCA exercise are presented in Table 3.5 (below).

| **Technology option** | ***MCA Score*** | ***Priority ranking*** |
|---|---|---|
| *1. Technology of complex capitalization of the trophic potential through interspecific polyculture.* | 6370 | **XII** |
| *2. Restoration and conservation of the genofond populations of native fish of culture* | 6647 | **VII** |
| ***3. Fish protection system and ensuring food security in the conditions of climate change*** | **7287** | **III** |
| *4. Mapping and crediting of the trophic potential and the climatic rayoning of the water basins* | 6642 | **VIII** |
| *5. Ensuring the food security of fish for consumption in fish basins in the conditions of climate change* | 7050 | **IV** |
| *6. Pond Shading* | 5983 | **XV** |
| *7. Water aerators* | 6151 | **XIV** |
| ***8. The use of lakes with complex destination for growing fish for consumption in polyculture*** | **7466** | **I** |
| ***9. An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology.*** | **7331** | **II** |
| *10. Increasing the production capacity by restoring, modernizing and arranging the ponds for complex use dried up.* | 6539 | **IX** |
| *11. Technology for feeding cyprinids* | 6858 | **V** |
| *12. Relevant risk management tools to support subsidisation and implementation of the aquaculture credit facility* | 6251 | **XIII** |
| *13. Creation of the climate change information system and knowledge platform in the field of aquaculture.* | 6464 | **XI** |
| *14. Development, implementation and monitoring of comprehensive plans for the management of freshwater aquaculture* | 6686 | **VI** |
| *15. Rainwater Catchment Systems* | 6537 | **X** |

*Table 3.0.5The result of technology prioritisation.*

The results of the multicriteria analysis prioritized the top three technologies that the sectoral working group deemed having the highest overall potential for aquaculture in Moldova. A subsequent analysis was an estimation of the degree of application of all technologies in the long list in Moldova. Overall, aquaculture in Moldova is practiced as a low-tech activity, thus unsurprisingly most technological options included in the LLTs was found to be scarcely implemented in the country. Stakeholders during the SWG consultations stressed the need to foster the implementation of the more mature technologies in order to develop a climate-resilient aquaculture sector. A barrier analysis will be carried out and technological action plans developed for these priority technologies will be developed to reflect the need for such technological actions in the sector.

| **Technology option** | **Current degree of implementation in Moldova** | | | |
|---|---|---|---|---|
| | Unapplied | Weak | Medium | High |
| *1. Technology of complex capitalization of the trophic potential through interspecific polyculture.* | | | X | |
| *2. Restoration and conservation of the genofond populations of native fish of culture* | | X | | |
| *3. Fish protection system and ensuring food security in the conditions of climate change* | X | | | |
| *4. Mapping and crediting of the trophic potential and the climatic rayoning of the water basins* | X | | | |
| *5. Ensuring the food security of fish for consumption in fish basins in the conditions of climate change* | | X | | |
| *6. Pond Shading* | X | | | |
| *7. Water aerators* | X | | | |
| *8. The use of lakes with complex destination for growing fish for consumption in polyculture* | | X | | |
| *An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology.* | X | | | |
| *Rainwater Catchment Systems* | X | | | |
| *Increasing the production capacity by restoring, modernizing and arranging the ponds for complex use dried up.* | X | | | |
| *12. Technology for feeding cyprinids* | | X | | |
| *13. Relevant risk management tools to support subsidisation and implementation of the aquaculture credit facility* | X | | | |
| *14. Creation of the climate change information system and knowledge platform in the field of aquaculture.* | X | | | |

| | | | | |
|---|---|---|---|---|
| *15. Development, implementation and monitoring of comprehensive plans for the management of freshwater aquaculture* | X | | | |

*Table 3-6 The state of the current implementation of the technologies in the country.*

Only 5 technology options out of 15 proposed have resulted to be somewhat present in Moldova, although their presence is considered weak, and interestingly the SWG prioritized three technologies included in such group. This might be due to the increased familiarity of SWG members with these technologies since they are available already in the country, or vice versa, their existence in Moldovan aquaculture may be a sign of their effectiveness to adapt the sector to climate change. Further studies will be necessary to understand whether a correlation exists and what are its determinants.

## Summary description of the top three priority technology options for aquaculture in Moldova

**1. Use of lakes with complex destination for growing fish for consumption in polyculture.**

The loss of areas and the lower availability of water for aquaculture bring a change in the number and volume of ponds and lakes, as a consequence of increased evaporation, poor recharge and declining water quality. To maintain the same production levels in absolute tonnage of fish from the national aquaculture sector in this context may benefit from a more efficient and thorough exploitation of the residual water resources. By manipulating the species pool in aquaculture ponds and lakes, by introducing species feeding at different levels and on different substrates without competition within a given system, this technology option has the potential to increase productivity by unit of pond surface. Another activity related to the more efficient exploitation of resources is connected with the insufficient use of existing production capacities as a basis for restructuring and strengthening fish farms, the expansion, restoration, and modernisation of existing farms and the establishment of new aquaculture production capacities. Storage lakes are also available for use in aquaculture activities, however in the absence of financial support, these have not been put into production. With respect to the area set up for aquaculture, the production levels show low yields, which can be improved with the adoption of modern and innovative management practices. The decrease in the quantity of fish as a result of the drying up of the ponds and the increase of imports of fish, can be compensated by using storage reservoirs in which commercial fishing is currently prohibited under the legislative conditions, but not the practice of aquaculture.

Polyculture represents an aid to the rational use of the reservoirs Dubasari, Costești Stanca and Ghidighici Lake which are extremely vulnerable to the effects of climate change, by introducing additional native fish species. The reconstruction of the ichthyofauna of the lakes by choosing a complex polyculture system allows for the effective capitalization of the trophic potential of the basin as the main method of intensification and rational use of the natural productive potential. Changes in the annual rainfall regime in the recent past have a significant impact on water retention in lakes and create uncertainty of maintaining the necessary amount of water for aquaculture.

The availability of brood of various cyprinids to be introduced requires the development of local breeding capacity. Fish farms using this technology should seek financial means to cover the shortage of brood of perch, European catfish, and bream, thus contributing to developing national resilience to climate change. As climate change has a direct influence on the reproduction of these fish species, alternative techniques and/or the improvement of existing technologies for the artificial and natural reproduction of perch and bream are needed. Successful breeding is a major requirement in the climate change scenario of these fish species for aquaculture. The efficient management of the technology will allow to fully exploit the trophic resources of the reservoirs that are not used in aquaculture to increase a sustainable volume of fish production of about 10 thousand tons of fish per year and to restore the aquaculture's income increasingly lost due to climate change. Increasing native fish biodiversity, without the need for relevant feeding and disease control, will in turn restore aquatic biodiversity and improve aquaculture-related ecosystems. In this technology option, feed or other factors of production are not used, and only the available nutrients are used by polyculture.

Social co-benefits will include employment creation upstream (breeding) as well as downstream in the harvesting/fishing operations. To ensure that high stocking rates do not lead to decay of water conditions and competition among the species however, aquaculture practitioners need adequate capacity to monitor water parameters and intervene in case necessary with actions.

Polyculture has also key environmental co-benefits, by both providing support for biodiversity in ecosystems that integrate such exploitations, as well as by decreasing pressure on catch fishery resources in natural ecosystems. Improve the technologies for growing fish in polyculture that allow the exploitation of all trophic nieces of storage reservoirs in Moldova and the diversification of the species in order to increase the added value of the aquaculture production.

2. **Increase the water flow in the ponds used for aquaculture.**

The large water deficit recorded in the lakes and ponds used in aquaculture places the Republic of Moldova in the category of countries under water stress risk. The negative consequences of climate change, in particular the increased incidence of heat waves and recurrent drought, call for the implementation of adaptation practices and supportive policies to strengthen aquaculture farms' resilience to climate change. Structural interventions, in addition to operator's level interventions, should be considered as parts of an holistic approach to adaptation. Such structural and infrastructural interventions have been prioritized during the TNA process for the aquaculture sector in Moldova.

Riverbeds in most of the tributaries of the Prut river present abundant vegetation. Rainwater does not flow into the ponds efficiently, stagnates over the surface of the floodplains, with little infiltration, creating several puddles that later evaporate. Moreover, water storage channels in most water basins in Moldova are obstructed by debris and overgrown vegetation and subjected to clogging, which contributes to the decreasing volume of water reaching lakes and ponds.

To avoid the degradation of fish habitats it is necessary to restore waterflow towards these waterbodies, enhance the flow in supply channels by dredging them and maintaining their status overtime. Attentive hydrological planning, if coupled with activities to remodel and clean up riverbeds in the perimeter of aquaculture basins, will avoid flooding and reduce competition and conflicts between water users, including illegal practices such as restricting the stream's flow and the construction of unauthorized dams.

3. **Fish protection system and ensuring food security in the conditions of climate change**

The *fish protection system* is a set of measures aimed at improving the growth and wintering conditions of fish stocks in aquaculture basins through disease prophylaxis and the use of improved genetic material of the populations, while ensuring food security through case-specific actions. Increased high temperatures, changes in precipitation regimes, and extreme drought phenomena are having significant impacts on water quality, retention capacity, and ultimately fish health in aquaculture basins. To counter such a trend, it is necessary to elaborate a comprehensive, country-wide inventory of aquaculture activities through a *fishery-biological justification* (PFB). This inventory system for aquaculture water bodies has to survey and collect information of existing formally and informally established aquaculture activities, linked to specific cartography and hydrological determinants (e.g. hydrochemical indices, trophic potential, etc.) of aquaculture areas of Moldova. The PFB inventory will be instrumental to forecast and crucially monitor spatially impacts on water quality and availability in the water bodies, allowing farmers to adapt to the changes in the existing climate.

The PFB will allow to:

- determine the actual situation of the aquaculture sector and the impacts of climate change;
- identify the production units operating and the number of users of water for aquaculture;
- determine optimal and actual productivity levels and assess water scarcity and drought impacts on productivity;
- determine the size and coverage of ameliorative actions (e.g. cleaning the water supply channels of the ponds);
- plan and elaborate fish health protocols, including genetic pool needs, nutritional requirements, and disease prophylaxis.

Morbidity and mortality in fish, is often the consequence of eutrophication of the basins, and statistically truthfully reflects the state of health of the population, the intensity and quality of agricultural, industrial, urban, transport and other activity in the basin region [Meyer, Barklay, 1990]. Assessing the baseline status of aquaculture and monitoring overtime the determinants that might lead to decay in any of the key parameters of fish health is key to adapt to the impacts of climate change and improve the resilience of the sector.

The detailed TFS for the top three priority technological options and the full set of simplified TFS prepared are annexed in Annex III

# Chapter 4. Technology prioritisation for Livestock

## 4.1 Adaptation Technology Options for Livestock and their Main Adaptation benefits

The TNA team and the Livestock expert have proposed 14 technological options. Following the same analysis illustrated for aquaculture technologies before, the results are shown in Table 6.

Detailed information about technologies is presented in the annexed Technological Fact Sheet.

| Climate Hazard | Climate Impact | Priority technologies |
|---|---|---|
| Precipitation pattern changes | Decrease availability of feed | 1. Increasing areas under irrigation for feed production |
| | | 2. Creation and modernization of irrigation systems |
| | | 3. The use of drought-resistant feed varieties |
| | | 4. Optimizing livestock and poultry nutrition systems to fulfill their productive and adaptive potential, including the rational use of pastures |
| Increased average temperatures | Impact of more extreme temperatures on animal welfare and productivity | 5. Breeding and selection of breeds and hybrids of animals adapted to local soil and climate conditions. |
| | | 6. Improving and adapting to the requirements of livestock and poultry farming and maintenance systems. The construction of farms should be done based on projects developed by specialists in compliance with veterinary requirements. |
| | | 7. Energy efficiency. Thermal insulation of spaces where animals are kept, to ensure both protection from high temperatures and savings of heating costs. |
| | | 8. Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and observance of the placement surfaces. |

| | | |
|---|---|---|
| | | 9. Ensuring the necessary microclimate conditions through the construction and installation of cooling systems in spaces where animals are kept. |
| | | 10. Biogas systems to enhance manure management, reduce GHG emissions, and substitute fossil energy in livestock production |
| | | 11. Training of farmers on the effects of climate change on farm animals. |
| Increased incidence of extreme climatic events including droughts, floods, etc. | Lack or shortage of drinking water | 12. Ensuring access to water for animals |
| | | 13. Cleaning of water basins |
| | Increased disease spreading, outbreaks of severe disease, new diseases appearance | 14. Construction of platforms for the accumulation and storage of animal manure |

*Table 4.0.1 Long List of proposed adaptation Technologies in the Livestock sector.*

## 4.2 Criteria and process of technology prioritization

A similar approach as illustrated for aquaculture technologies was adopted. National Consultants received training on the MCA process during two dedicated training workshops, and prioritization Excel spreadsheets were prepared by the TNA team and distributed to the SWG members together with simplified Technology Factsheets for all technological options included in the LLT.

**Identification of priority technologies for climate change adaptation of livestock sector**

Over the recent years, Moldova's agricultural sector has been strongly affected by climate change, including the recurrent summer droughts, of which the most recent were in 2020 and in 2022. The main threats to the Livestock sector in Moldova are represented by increasing average temperatures, the changes in the precipitation regime, and the recurrence of extreme drought phenomena. The 2020 Drought Assessment the Government of Moldova estimated that about 20% of livestock might have been slaughtered in distress sales by households. Lower dairy herd numbers are indicative of de-stocking in response to lack of feed or loss of income. Taking into account the characteristics of the livestock sector in the Republic of Moldova and its socio-economic importance, a long list containing 14technologies for adapting the livestock sector to climate change was identified.

Simplified TFS have been developed for each technological option in the long list of technologies and underwent prioritization using the tools of multi-criteria analysis. The TNA Team (International + National Consultants) proposed an initial set of prioritization criteria, as well as potential initial scoring and weighting of each. In the context of several sectoral working group meetings, participants reached consensus on the scoring and weighting for each criterion for each of the 13 technologies.

**Determination of criteria**

Again, when determining and establishing the criteria for evaluating priority of a given technology option, costs and potential co-benefits have been formulated by National Consultant in collaboration with the TNA team, and the Sectoral Working Group of livestock experts determined the scoring and weighting for each criterion. The weightings for each criterion were allocated taking into account the relative importance of the criterion.

Along with the criteria described, following the proposals of the working group members, sub-divisions of the selected criteria have been added. Each option has been given a score against each criterion, considering the preference. Sub-criteria were based on expert opinions and the knowledge and experience of working group members.

***Costs - 18%***

Cost to set up and operate the technology, subdivided into annual operational costs and maintenance expenses, composed the relevant criteria for this category:

1. CAPEX costs.
2. OPEX costs.
3. Maintenance costs.

***Co-benefits:***

***Economic - 29%***

1. Improving farmer's income and ability to reinvest.
2. Diversification of quality and quantity of products.
3. Productivity.
4. Trigger private investments.

***Social - 12%***

The indicators used for scoring were the:

1. Employment (Jobs creation);
2. Increased wages.

***Environmental - 21%***

1. Contribution of the technology to protect and sustain ecosystem services;
2. Conservation of native breeds;
3. Rational use of soil resources.

***Climate related - 8%***

1. Improvement of Resilience to Climate Change:
    - ✓ Extent the technology will contribute to reduce vulnerability to climate change impacts.
    - ✓ Ability to adapt to the effects of climate change.
    - ✓ The potential of the technology to demonstrate tangible and concrete results of protection of water bodies in a short space of time.

***Other - 8%***

1. Alignment to National Policies;
2. Available resources in the country;
3. Institutional capacities.

| *Major Criteria* | *Criteria Description* | *Sub-criteria (Weight Factor)* | *Criterion weight, %* |
|---|---|---|---|
| **Costs, 18 %** | | Set up costs (CAPEX) | **6** |
| | | Annual Operational Costs | **6** |
| | | Maintenance Costs | **6** |
| | | | **18** |
| **Co-Benefits** | **Economic 29%** | Improving farmer's income and ability to reinvest | **10** |
| | | Diversification of quality and quantity of products | **5** |
| | | Productivity | **8** |
| | | Trigger private investments | **6** |
| | | | **29** |
| | **Social 12%** | Employment (Jobs creation) | **7** |
| | | Increased wages | **5** |
| | | | **12** |
| | **Environmental 21%** | Contribution of the technology to protect and sustain ecosystem services | **8** |
| | | Conservation of native breeds | **7** |
| | | Rational use of soil resources | **6** |
| | | | **21** |
| | **Climate related** | Climate changes (contribution to CC resilience) | **8** |
| | | | **9** |
| | | | **74** |
| **Other** | **Institutional/ Implementation** | Alignment to National Policies | **4** |
| | | Available resources in the country | **4** |
| | | Institutional capacities | **4** |
| | | | **12** |
| | | | **100** |

*Table 4.0.2. List of criteria and criteria weighting used for the prioritization exercise.*

## 4.3 Results of technology prioritization

The results of technology prioritisation are presented here, with a brief description of the selected technologies, and their benefits. Technology fact sheets (contents indicated in Annex III) for the technologies that are selected through technology prioritisation in Annex I of the report.

Out of the total of 13 technologies from the LLT, the 3 scoring the highest weighted value have been prioritized. These are:

1) **Increase of areas under irrigation for the production of feed;**
2) **Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and the observance of the populated areas of the animals.**
3) **Construction of platforms for the accumulation and storage of manure.**

## LIVESTOCK

| Climate Impact | Climate impact name | Technology code | Name of selected technologies | Cost to set up | Anual operational costs | Mentenance expences | Improving farmer income and ability to reinvest | Diversification of quality and quantity | Productivity | Trigger private investment | New jobs | Increased wages | Contribution of the technology to protect and sustain ecosystem services | Conservation of native breeds | Rational use of soil resources | Improvement of Resilience to Climate Change (i.e. to what extent the technology will contribute to reduce vulnerability to climate | Public policy documents | Available resources | Institutional capacities |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Scoring Matrix (For each criterion scores should vary from 0 to 100) | | | | | | | | | | | | | | | | |
| | | | | Costs | | | Benefits | | | | | | | | | | Other | | |
| | | | | | | | Economic | | | | Social | | Environmental | | | limate relate | stitutional | Implementati | Political |
| Climate Impact 1 | Damage to decrease in the amount of feed | T/M-1 | Increasing areas under irrigation for feed production | 25 | 30 | 30 | 60 | 60 | 90 | 90 | 80 | 80 | 70 | 80 | 90 | 90 | 30 | 30 | 30 |
| | | T/M-2 | Creation and modernization of irrigation systems | 20 | 25 | 25 | 60 | 50 | 80 | 80 | 80 | 80 | 60 | 60 | 80 | 80 | 30 | 30 | 30 |
| | | T/M-3 | The use of drought-resistant feed varieties | 50 | 50 | 50 | 60 | 60 | 75 | 60 | 60 | 70 | 60 | 60 | 80 | 80 | 30 | 30 | 30 |
| | | T/M-4 | Optimizing livestock and poultry nutrition systems to fulfill their productive and adaptive potential, including the rational use of pastures | 50 | 70 | 70 | 60 | 50 | 80 | 50 | 50 | 50 | 40 | 50 | 80 | 80 | 45 | 45 | 45 |
| Climate Impact2 | Damage of impact of low or high temperatures on animal welfare | T/M-5 | Breeding and selection of breeds and hybrids of animals adapted to local soil and climate conditions | 30 | 40 | 40 | 50 | 60 | 75 | 70 | 60 | 70 | 70 | 90 | 80 | 80 | 45 | 45 | 45 |
| | | T/M-6 | Improving and adapting to the requirements of livestock and poultry farming and maintenance systems | 20 | 45 | 45 | 60 | 60 | 80 | 50 | 50 | 80 | 60 | 50 | 80 | 80 | 30 | 30 | 30 |
| | | T/M-7 | Energy efficiency. Thermal insulation of spaces where animals are kept, to ensure both protection from high temperatures and savings | 10 | 45 | 45 | 70 | 70 | 85 | 60 | 50 | 80 | 60 | 50 | 80 | 80 | 45 | 15 | 45 |
| | | T/M-8 | Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and observance of the placement surfaces | 20 | 30 | 30 | 80 | 80 | 85 | 75 | 60 | 90 | 70 | 50 | 80 | 90 | 45 | 30 | 45 |
| | | T/M-9 | Ensuring the necessary microclimate conditions through the construction and installation of cooling systems in spaces where animals are | 10 | 25 | 25 | 70 | 70 | 90 | 60 | 50 | 80 | 60 | 50 | 80 | 80 | 45 | 20 | 45 |
| | | T/M-10 | Biogas systems to enhance manure management, reduce GHG emissions, and substitute fossil energy in livestock production. | 10 | 30 | 30 | 80 | 70 | 70 | 80 | 70 | 80 | 90 | 30 | 70 | 80 | 30 | 30 | 40 |
| Climate Impact 3 | Damage of lack or shortage of drinking water | T/M-11 | Ensuring access to water for animals | 10 | 10 | 10 | 80 | 80 | 90 | 70 | 60 | 80 | 80 | 60 | 80 | 80 | 30 | 10 | 20 |
| | | T/M-12 | Cleaning of water basins | 1 | 10 | 20 | 90 | 90 | 90 | 70 | 80 | 80 | 75 | 60 | 90 | 80 | 30 | 10 | 20 |
| Climate Impact 4 | Damage of greenhouse gas emissions on animal welfare | T/M-13 | Construction of platforms for the accumulation and storage of animal manure. | 30 | 40 | 40 | 70 | 70 | 80 | 60 | 60 | 80 | 90 | 50 | 85 | 70 | 60 | 30 | 40 |
| | | | **Scala de punctaj** | 50 | 60 | 60 | 70 | 70 | 80 | 60 | 60 | 80 | 70 | 50 | 50 | 60 | 60 | 50 | 60 |
| | | | ***Criterion weight*** | 6 | 6 | 6 | 10 | 5 | 8 | 6 | 7 | 5 | 8 | 7 | 6 | 8 | 4 | 4 | 4 |

*Table 4.0.3. Screenshot of the scoring matrix for the technological options selected for the livestock sub-sector.*

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Matricea deciziei: scoruri ponderate

| | | | Costuri | | | Beneficii – Economic | | | | Beneficii – Social | | Beneficii – De mediu | | | Legat de climat | Altele – Instituțional/Implementare | | Altele – Politic | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cost to set up | Anual operational costs | Mentenance expences | Improving farmer income and ability to | Diversification of quality and quantity | | Trigger private investment | New jobs | Increased wages | Contribution of the technology to protect and | Conservation of native breeds | Rational use of soil resources | Improvement of Resilience to Climate Change (i.e. to what extent | Public policy documents | Available resources | Institutional capacities | Scor total |
| Diminuarea cantității furaje pentru animale | T/M-1 | Increasing areas under irrigation for feed production | 150 | 180 | 180 | 600 | 300 | | 540 | 560 | 400 | 560 | 560 | 540 | 720 | 120 | 120 | 120 | 5650 |
| | T/M-2 | Creation and modernization of irrigation systems | 120 | 150 | 150 | 600 | 250 | | 480 | 560 | 400 | 480 | 420 | 480 | 640 | 120 | 120 | 120 | 5090 |
| | T/M-3 | The use of drought-resistant feed varieties | 300 | 300 | 300 | 600 | 300 | | 360 | 420 | 350 | 480 | 420 | 480 | 640 | 120 | 120 | 120 | 5310 |
| | T/M-4 | Optimizing livestock and poultry nutrition systems to fulfill their productive and adaptive potential, including the rational use of pastures | 300 | 420 | 420 | 600 | 250 | | 300 | 350 | 250 | 320 | 350 | 480 | 640 | 180 | 180 | 180 | 5220 |
| Impactul temperaturilor scăzute sau ridicate asupra bunăstării animalelor | T/M-5 | Breeding and selection of breeds and hybrids of animals adapted to local soil and climate conditions | 180 | 240 | 240 | 500 | 300 | | 420 | 420 | 350 | 560 | 630 | 480 | 640 | 180 | 180 | 180 | 5500 |
| | T/M-6 | Improving and adapting to the requirements of livestock and poultry farming and maintenance systems | 120 | 270 | 270 | 600 | 300 | | 300 | 350 | 400 | 480 | 350 | 480 | 640 | 120 | 120 | 120 | 4920 |
| | T/M-7 | Energy efficiency. Thermal insulation of spaces where animals are kept, to ensure both protection from high temperatures and savings of heating costs | 60 | 270 | 270 | 700 | 350 | | 360 | 350 | 400 | 480 | 350 | 480 | 640 | 180 | 60 | 180 | 5130 |
| | T/M-8 | Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and observance of the placement | 120 | 180 | 180 | 800 | 400 | | 450 | 420 | 450 | 560 | 350 | 480 | 720 | 180 | 120 | 180 | 5590 |
| | T/M-9 | Ensuring the necessary microclimate conditions through the construction and installation of cooling systems in spaces where animals are kept | 60 | 150 | 150 | 700 | 350 | | 360 | 350 | 400 | 480 | 350 | 480 | 640 | 180 | 80 | 180 | 4910 |
| | T/M-10 | Biogas systems to enhance manure management, reduce GHG emissions, and substitute fossil energy in livestock production | 60 | 180 | 180 | 800 | 350 | | 480 | 490 | 400 | 720 | 210 | 420 | 640 | 120 | 120 | 160 | 5330 |
| Insuficiența și lipsa apei potabile | T/M-11 | Ensuring access to water for animals | 60 | 60 | 60 | 800 | 400 | | 420 | 420 | 400 | 640 | 420 | 480 | 640 | 120 | 40 | 80 | 5040 |
| | T/M-12 | Cleaning of water basins | 6 | 60 | 120 | 900 | 450 | | 420 | 560 | 400 | 600 | 420 | 540 | 640 | 120 | 40 | 80 | 5356 |
| Damage of greenhouse gas emissions on animal welfare | T/M-13 | Construction of platforms for the accumulation and storage of animal manure | 180 | 240 | 240 | 700 | 350 | | 360 | 420 | 400 | 720 | 350 | 510 | 560 | 240 | 120 | 160 | 5550 |
| | | | | | | | | | | | | | | | | | | | |
| | | Criterion weight | 6 | 6 | 6 | 10 | 5 | | 6 | 7 | 5 | 8 | 7 | 6 | 8 | 4 | 4 | 4 | 92 |

*Table 4.0.4. Screenshot of the weighted score matrix for the technological options selected for the livestock subsector.*

The results of the prioritization exercise are summarized in the table below.

| *Name of the Technology* | *MCA Score* | *Priority ranking* |
|---|---|---|
| T/M-1. Increasing areas under irrigation for feed production | 5650 | I |
| T/M-2. Creation and modernization of irrigation systems | 5090 | X |
| T/M-3. The use of drought-resistant feed varieties | 5310 | VII |
| T/M-4. Optimizing livestock and poultry nutrition systems to fulfill their productive and adaptive potential, including the rational use of pastures. | 5220 | VIII |
| T/M-5. Breeding and selection of breeds and hybrids of animals adapted to local soil and climate conditions. | 5500 | IV |
| T/M-6. Improving and adapting to the requirements of livestock and poultry farming and maintenance systems | 4920 | XII |
| T/M-7. Energy efficiency. Thermal insulation of spaces where animals are kept, to ensure both protection from high temperatures and savings of heating costs. | 5130 | IX |
| T/M-8. Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and observance of the placement surfaces | 5590 | II |
| T/M-9. Ensuring the necessary microclimate conditions through the construction and installation of cooling systems in spaces where animals are kept. | 4910 | XIII |
| T/M-10. Biogas systems to enhance manure management, reduce GHG emissions, and substitute fossil energy in livestock production. | 5330 | VI |
| T/M-11. Ensuring access to water for animals | 5040 | XI |
| T/M-12. Cleaning of water basins | 5356 | V |
| T/M-13. Construction of platforms for the accumulation and storage of animal manure. | 5550 | III |

*Table 4.0.5 Results of the MCA exercise for prioritizing adaptation technologies.*

As shown in Table 4.5, there is a minimal difference in weighted scores between T/M-13 (5550 points) and T/M-5 (5500 points). This issue was addressed through the application of a sensitivity analysis. After discussions with stakeholders from the livestock sector with participation of the Ministry of Agriculture, additional factors were incorporated into the decision-making process. Key considerations included:

- **Environmental legislation requirements:** T/M-13 demonstrates stronger alignment with existing regulations on manure management and environmental protection.
- **Harmonization with EU directives:** As Moldova moves toward aligning its legislation with EU standards, ensuring compliance with environmental requirements is essential for the sustainable development of the livestock sector.

Taking these factors into account and acknowledging the significant influence of environmental requirements on the sector, it was determined that T/M-13 should take precedence over T/M-5. The final ranking, therefore, reflects both the weighted scores and the broader strategic priorities of the sector.

| ***No.*** | ***Name of the Technology*** | ***Scale of Application (Small, Medium or Large Scale)*** | ***Time Scale (Approx. number of years)*** | ***Potential for adaptation in the Time Scale*** |
|---|---|---|---|---|
| 1 | Increase of areas under irrigation for the production of feed | Large Scale | 3 years | Large |
| 2 | Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and the observance of the populated areas of the animals | Large Scale | 5 years | Large |
| 3 | Construction of platforms for the accumulation and storage of manure | Small Scale | 3 years | Medium |

*Table 4.0.6 Summary Table for Prioritized Technologies.*

The proposed adaptation technologies are not currently applied to a significant extent in Moldova, and stakeholders have stressed the need to expand the uptake of these technologies in order to develop a climate-resilient horticulture sector in the country. A barrier analysis will be carried out and technological action plans developed for these priority technologies will be developed to reflect the need for such technological actions in the sector.

| ***Name of the Technology*** | ***Current degree of application*** | | | |
|---|---|---|---|---|
| | ***Unapplied*** | ***Weak*** | ***Medium*** | ***High*** |
| T/M-1. Increasing areas under irrigation for feed production | | X | | |
| T/M-2. Creation and modernization of irrigation systems | | X | | |
| T/M-3. The use of drought-resistant feed varieties | | | X | |
| T/M-4. Optimizing livestock and poultry nutrition systems to fulfill their productive and adaptive potential, including the | | | X1 | |

| ***Name of the Technology*** | ***Current degree of application*** | | | |
|---|---|---|---|---|
| | ***Unapplied*** | ***Weak*** | ***Medium*** | ***High*** |
| rational use of pastures. | | | | |
| T/M-5. Breeding and selection of breeds and hybrids of animals adapted to local soil and climate conditions. | | X | | |
| T/M-6. Improving and adapting to the requirements of livestock and poultry farming and maintenance systems | | | X | |
| T/M-7. Energy efficiency. Thermal insulation of spaces where animals are kept, to ensure both protection from high temperatures and savings of heating costs. | | X | | |
| T/M-8. Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and observance of the placement surfaces | | X | | |
| T/M-9. Ensuring the necessary microclimate conditions through the construction and installation of cooling systems in spaces where animals are kept. | | | X | |
| T/M-10. Biogas systems to enhance manure management, reduce GHG emissions, and substitute fossil energy in livestock production. | | X2 | | |
| T/M-11. Ensuring access to water for animals | | X | | |
| T/M-12. Cleaning of water basins | X | | | |
| T/M-13. Construction of platforms for the accumulation and storage of animal manure. | | X | | |

*Table 4.0.7 Current degree of application of selected adaptation technologies.*

1. It is widely used in poultry and pig farms. Improvements are needed for cattle and sheep farms.

2. At the moment in Moldova there is a poultry farm, a pig farm and a beef cattle farm that have biogas systems.

All proposed technologies have found to be poorly applied already in Moldova, and the prioritization exercise, showing how the close ranking and relative score differences between the technology options presented is an index of the potential of all 13 technologies to make a difference in adapting the livestock sector to the impacts of climate change. Even though only the top three technologies from the prioritization process have been selected for in-depth evaluation and implementation in the Technology Action Plan, the remaining technologies were all deemed very relevant by the SWG members.

Below is a brief description of the top three technologies prioritized for the horticulture sub-sector in Moldova:

1. **Increase of areas under irrigation for the production of feed**

Expanding irrigation areas for forage crops, particularly maize silage, offers multiple advantages for addressing the challenges posed by climate change on food security and livestock farming in Moldova. Droughts, floods, and other extreme weather events have drastically reduced feed availability, directly impacting cattle populations and the rural economy. This proposed technology provides a sustainable solution by enhancing resilience to these climate impacts and gives multiple advantages:

**Increased yield stability.** By introducing irrigation systems, maise silage yields can significantly improve, particularly during drought years. Current yields of 30–40 tons/ha, which drop by 50% in dry conditions, can be raised to 25–35 tons/ha in drought years and up to 50 tons/ha in non-dry years when combined with modern agricultural practices such as crop rotation and fertilizer use. This ensures a consistent feed supply, mitigating risks associated with climate variability.

**Support for cattle farming.** Cattle farming, particularly dairy production, is highly dependent on silage, which constitutes the majority of daily feed for milking cows (25–30 kg/day per animal). Expanding irrigation systems to 5–15 thousand hectares in northern and southeastern Moldova, where cattle farms are concentrated, will address green fodder shortages and stabilize the sector against climate-induced feed scarcity.

**Optimised use of land and water resources.** The technology is proposed to be implemented into 2 stages. Stage I begins with a comprehensive feasibility study to identify water sources, calculate farm-specific water needs, and determine equipment and technology requirements. This ensures efficient resource allocation and minimizes waste.

**Enhanced climate adaptation.** The system will incorporate advanced technology, including automated equipment and IT systems, allowing farmers to remotely monitor soil and air humidity. These features enable precise irrigation during periods of need, ensuring optimal water use and reducing vulnerability to unpredictable weather patterns.

**Economic sustainability and automation.**The technology ensures maximum efficiency and reduces labour costs by equipping farms with modern irrigation machinery and IT-based control systems (Stage II). Automation enables real-time monitoring and adaptive management, enhancing the long-term viability of livestock farming under changing climatic conditions.

Reduced reliance on feed imports.Unlike poultry and pigs, cattle rely heavily on locally produced silage due to logistical challenges associated with importing feed. Increasing domestic production of maize silage ensures feed self-sufficiency, bolsters food security, and reduces reliance on external markets that may also face climate-related disruptions.

.

This proposed expansion of irrigation for forage crops will strengthen Moldova’s agricultural resilience, ensuring sustainable livestock production in the face of escalating climate challenges while supporting rural livelihoods and economic stability.

*Figure 4-0-1. Quality feed being fed to dairy cattle.*

2. **Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and the observance of the populated areas of the animals**

In the Republic of Moldova, most of the existing farms are rebuilt based on old farms, which were built before 1990. There are very few farms built from 0 in the last 10 years. Due to the high cost of design work, bureaucratic barriers to their approval and the lack of specialists in the field, most of the farms were rebuilt, rehabilitated, transformed from one type of farm to another type (for example, from cattle farm to poultry farm or vice versa). In most cases they were done without special technological projects to ensure animal welfare, thermal insulation (energy efficiency) and biosecurity of the farm.  Also, in most cases, not all the EU normative acts on animal welfare that have been or are to be harmonized in the Republic of Moldova have been considered. Within the framework of the technology, it is proposed to equip the existing halls with cooling systems to ensure the necessary microclimate conditions for animals (according to welfare requirements) and to develop standard design plans (technological design) for livestock farms (depending on the species).

For each species of animals, a different design plan will be drawn up:

For dairy cattle - 20, 40, 60, 80 and 100 animals.

For fattening pigs – 100, 300, 500, 700 and 1000 animals.

For laying birds – 20 000 and 50 000 poultry.

For broiler chickens – 25 000, 50 000, 75 000 and 100 000 poultry.

The design plan should contain the animal-specific technology plan ensuring biosecurity conditions and animal welfare in line with EU requirements. The project must also be developed according to the latest requirements on energy efficiency (thermal insulation) and maximum automation. Climate control and monitoring of all climate parameters inside the production halls (air circulation, $CO_2$ and $NH_3$ level, temperature, humidity). The design plan will be kept in AutoCAD and offered to farmers who will adapt them to the conditions of location of the farm or land (it will be framed in the conditions of the farmer's land and its necessity). This technological plan will be used as the basis for design on livestock farms, and the design companies will integrate it into the farm project by its specialists in resistance, communications, architecture, etc. These types of projects will primarily benefit small farmers, who have limited possibilities both financially and organizationally (specialized personnel).

*Figure 4-0-2.Adequate thermally insulated and heated animal shelter (small scale).*

**3. Construction of platforms for the accumulation and storage of manure**

It is proposed to build special platform places for storing manure on small and medium-sized farms in the country. In total, about 100 special platforms will be created (these will include special ones for cow, poultry and pig farms). It is proposed to use these platforms for the growth of earthworms . The resulting organic fertilizer will enhance soil health, significantly improving the yield of fodder crops. Additionally, fields fertilized with manure enriched by earthworms have shown greater resistance to drought, a critical adaptation measure in the face of increasing climate variability.

It is proposed to be done in 2 stages, the first - the design phase and the second - the construction. The design and construction of the platforms will be carried out according to special technologies depending on the species of animal and its physical consistency (liquid or solid). The same will be considered the volume depending on the production capacity of the farm, the possibility of expansion and the storage period.

These special platforms will be possible to collect and keep manure separated from wide debris (plastic, glass, etc.). As a result, it will be possible to use it later as an organic fertilizer for agricultural trains. It is proposed that the platforms are compact, to take up little space. At the same time, they must be designed to ensure the prevention of groundwater pollution. The storage of manure will take time and they will be able to be used as organic fertilizers for the agricultural sector.

Key climate adaptation benefits include preventing groundwater contamination through secure platform designs and enabling the efficient collection and storage of manure, free from debris such as plastic or glass. This ensures its later use as a high-quality organic fertilizer. Compact and space-efficient, these platforms will also reduce environmental risks, support sustainable agricultural practices, and enhance resilience to drought, a critical concern under changing climate conditions.

*Figure 4-3.Model platforms for the accumulation and storage of manure.*

# Chapter 5 Technology prioritisation for Horticulture

## 5.1 Adaptation Technology Options for Horticulture and their Main Adaptation benefits

The TNA team and the Horticulture expert have proposed 18 technological options.

Table 5.1 (below) presents the Long List of proposed adaptation Technologies (LLT) in the Horticulture sector, categorized following a consistent approach with other sectors.

Detailed information about technologies is presented in the annexed Technological Fact Sheets.

| Climate Hazard | Climate Impact | Priority technologies |
|---|---|---|
| Increased temperatures | Reduced productivity | 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency |

| | | |
|---|---|---|
| | | 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during summer |
| | Damage to leaves and plant parts. Difficult plant development | 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation |
| | | 4. Set up next-generation national horticulture breeding systems |
| | Biodiversity impacts on pests and beneficial fauna | 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests |
| | | 6. Pollinator's management, supporting and protecting natural bee colonies |
| Change in the precipitation regime and forms (e.g. hail) | Damage to plants as a consequence of hail, frost and sunburns | 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations |
| | Increased damage from pests | 8. Precision Agriculture including use of drones for pest and disease management |
| Extreme phenomena – drought | Water stresses and lack of irrigation water | 9. Rainwater harvesting systems |
| | Soil quality loss | 10. Soil moisture management through nature-based solutions including biochar, compost, green mulching |
| | | 11. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) |
| | | 12. Sustainable soil management in horticulture and fruit production |
| | | 13. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. figs, plums, pomegranate, etc.) |
| | Decreased resilience of existing horticulture plant-practice systems | 14. Hydroponics with recyclable solutions |
| | | 15. Promotion of biocontrol through the use of bacteria, fungi and oomycetes |
| | | 16. Technologies for seed quality leading to higher germination rate and increased yield capacity, |
| | | 17. Grafting nurseries for improved tomato production |

| | | |
|---|---|---|
| | | 18. Automation for crop production through digitalization and remote control via app |

*Table 5.0.1 The Long List of Technologies for the Horticulture sector.*

## 5.2 Criteria and process of technology prioritisation

The technologies were selected following an approach consistent to the previous sectors.

**Identification of priority technologies for climate change adaptation of horticulture.**

The effects of climate change on the horticulture sector are expected to be largely horticulture plants specific due to the influence of local factors.

The most important effects expected to result in the horticulture sector of Moldova due to climate change are the increased temperatures above the optimal tolerance range, the changes in the precipitation regime and the extreme phenomena (drought).

Considering the physical and biological properties of horticulture regions in the Republic of Moldova and their socio-economic importance, and based on horticulture development programs, the TFS data sheets have been drawn up in consultation with the sectoral working group and stakeholders and a long list containing 18 technologies for adapting the horticulture sector to climate change have been identified.

Subsequently, the technologies were listed according to the maturity, applicability, availability and acceptability of stakeholders for each technology and classified by two criteria into three groups both:

a) Classification by agricultural setting

b) Classification by climate impact

**a) Classification by agricultural setting:**

***1. Application of technology in protected agriculture (i.e. greenhouse farming, nurseries, etc.).***

| |
|---|
| 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency |
| 4. Set up next-generation national horticulture breeding systems |
| 14. Hydroponics with recyclable solutions |
| 15. Promotion of biocontrol through the use of bacteria, fungi and oomycetes |
| 16. Technologies for seed quality leading to higher germination rate and increased yield capacity |
| 17. Grafting nurseries for improved tomato production |

***2. Application of technology in open field horticultural settings.***

| |
|---|
| 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during summer |
| 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation |
| 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests |
| 6. Pollinator’s management, supporting and protecting natural bee colonies |
| 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations |

| |
|---|
| 8. Precision Agriculture including use of drones for pest and disease management |
| 9. Rainwater harvesting systems |
| 10. Soil moisture management through nature-based solutions including biochar, compost, green mulching |
| 11. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) |
| 12. Sustainable soil management in horticulture and fruit production |
| 13. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. apples, nuts etc.) |
| 18. Automation for crop production through digitalization and remote control via app |

| ***Climate Vulnerability*** | ***Climate impact*** | ***Technology Option*** |
|---|---|---|
| Increased temperatures | Long term productivity loss | 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency |
| | | 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during summer |
| | | 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation |
| | | 4. Set up next-generation national horticulture breeding systems |
| | | 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests |
| | | 6. Pollinator's management, supporting and protecting natural bee colonies |
| Change in the precipitation regime and forms (e.g. hail) | Late hail, late frost, drier summers-induced damage on fruit and vegetable | 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations |
| | Increased occurrence of pests, even out of offspring season | 8. Precision Agriculture including use of drones for pest and disease management |
| | | 9. Promotion of biocontrol through the use of bacteria, fungi and oomycetes |
| Extreme phenomena – drought | Water stress during fruiting season | 10. Rainwater harvesting systems |
| | | 11. Soil moisture management through nature-based solutions including biochar, compost, green mulching |

| ***Climate Vulnerability*** | ***Climate impact*** | ***Technology Option*** |
|---|---|---|
| | | 12. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) |
| | | 13. Sustainable soil management in horticulture and fruit production |
| | | 14. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. figs, plums, pomegranate, etc.) |
| | | 15. Hydroponics with recyclable solutions |
| | Decrease tomato production, quality, and profitability | 16. Grafting nurseries for improved tomato production |
| | | 17. Technologies for seed quality leading to higher germination rate and increased yield capacity |
| | | 18. Automation for crop production through digitalization and remote control via app |

*Table 5.0.2Classification of technological options by climate impact.*

Simplified TFS have been developed for each technological option in the long list of technologies and underwent prioritization using the tools of multi-criteria analysis. The TNA Team (International + National Consultants) proposed an initial set of prioritization criteria, as well as on potential initial scoring and weighting of each. In the context of several sectoral working group meetings, participants reached consensus on the scoring and weighting for each criterion for each of the 18 technologies.

***Determination of criteria***

A similar approach than for other sectors was adopted. The National Consultant in collaboration with the TNA team formulated the criteria, the Sectoral Working Group of livestock experts determined the scoring and weighting for each criterion.

***Criteria categories used in the prioritization process:***

Following the proposals of the working group members, significant sub-divisions of the selected criteria (weight factor) have been added. Each option has been given a score against each criterion. The weightings for each sub-criteria were allocated taking into account the relative importance of the criterion.

Sub-criteria were based on expert opinions and the knowledge and experience of working group members.

***Costs - 20%***

Cost to set up and operate the technology (annual operational costs and maintenance expenses), and human resources

1. CAPEX costs.
2. OPEX costs (excluding salaries);
3. As part of OPEX, human resources.

***Co-benefits:***

***Economic - 21%***

5. Profit for the enterprise.
6. Reinvestment potential and business development.
7. Profit for the state budget (taxes).

***Social - 21%***

The indicators used for scoring were the:

1. Employment (Jobs creation);

2. Specialists' qualification.

3. Resources of agri-food products, including horticultural products, for population (increased food security).

***Environmental - 21%***

1. The rational use of water resources.

2. Preventing and combating negative natural phenomena (drought, hail, frost, etc.);

3. Preventing and combating soil erosion.

4. Landscape preservation (fertility, soil structure, biodiversity, etc.).

***Climate related - 9%***

The indicator used was:

1. Improvement of Resilience to Climate Change:

- Extent the technology will contribute to reduce vulnerability to climate change impacts.
- Ability to adapt to the effects of climate change.
- The potential of the technology to demonstrate tangible and concrete results of protection of water bodies in a short space of time.

***Other - 8%***

1. Alignment to National Policies;

2. Available resources in the country.

| ***Major Criteria*** | ***Criteria Description*** | ***Sub-criteria (Weight Factor)*** | ***Criterion weight, %*** |
|---|---|---|---|
| **Costs, 20 %** | | The cost of technics, machines, maintenance, fuel and lubricants | **7** |
| | | The cost of materials (planting material, seeds, fertilizers, pesticides, herbicides) | **7** |
| | | Human resources | **6** |
| | | | **20** |

| *Major Criteria* | *Criteria Description* | *Sub-criteria (Weight Factor)* | *Criterion weight, %* |
|---|---|---|---|
| **Co-Benefits** | **Economic** | Profit for the enterprise | **8** |
| | | Reinvestment and business development | **7** |
| | | Profit for the state budget (taxes) | **6** |
| | | | **21** |
| | **Social** | Employment (Jobs creation) | **6** |
| | | Specialists' qualification | **6** |
| | | Resources of agri-food products, including horticultural products, for population | **9** |
| | | | **21** |
| | **Environmental** | The rational use of water resources | **8** |
| | | Preventing and combating negative natural phenomena (drought, hail, frost, etc.) | **6** |
| | | Preventing and combating soil erosion | **5** |
| | | The landscape preservation (fertility, soil structure, biodiversity etc.) | **2** |
| | | | **21** |
| | **Climate related** | Climate changes (contribution to CC resilience) | **9** |
| | | | **9** |
| | | | **72** |
| **Other** | **Institutional/ Implementation** | Institutional capacities and Development Policy | **5** |
| | | The available real resources (informational, financial, grants and other) | **3** |
| | | | **8** |
| | | | 100 |

Table 5.0.3 List of criteria and criteria weighting used for the prioritization exercise

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## 5.3 Results of technology prioritization

The results of technology prioritisation are presented here, with a brief description of the selected technologies, and their benefits. Technology fact sheets (contents indicated in Annex III) for the technologies that are selected through technology prioritisation should be put in Annex I of the report.

Out of the total of 18 technologies from the LLT, the 3 scoring the highest weighted value have been prioritized. These are:

1) **High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency;**
2) **Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.);**
3) **Hydroponics with recyclable solutions.**

## Horticulture

| | Costs | | | Benefits | | | | | | | | | | | Other | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Economic | | | Social | | | Environmental | | | | Climate related | Institutional/Implementation | |
| | The cost of technics, machines, maintenance, fuel and lubricants | The cost of materials (planting material, seeds, fertilizers, pesticides, herbicides) | Human resources | Profit for the enterprise | Reinvestment and business development | Profit for the state budget (taxes) | People employment (Jobs) | Specialists' qualification | Resources of agri-food products, including horticultural products, for population | The rational use of water resources | The preventing and combating negative natural phenomena (drought, hail, frost, etc.) | The preventing and combating of soil erosion | The landscape preservation (fertility, soil structure, etc.) | Climate changes (contribution to CC resilience) | Institutional capacities and Development Politcy | The available real resources (informational, financial, grants and other) |
| 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency | 30 | 40 | 50 | 90 | 80 | 80 | 60 | 90 | 90 | 90 | 70 | 80 | 60 | 90 | 90 | 90 |
| 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during summer | 70 | 80 | 70 | 40 | 40 | 30 | 40 | 30 | 30 | 80 | 80 | 90 | 80 | 80 | 40 | 40 |
| 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation | 50 | 30 | 40 | 90 | 90 | 90 | 50 | 90 | 80 | 70 | 40 | 20 | 20 | 90 | 90 | 90 |
| 4. Set up next-generation national horticulture breeding systems | 20 | 40 | 40 | 70 | 40 | 40 | 60 | 80 | 50 | 80 | 40 | 50 | 60 | 80 | 60 | 60 |
| 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests | 40 | 60 | 70 | 80 | 80 | 70 | 40 | 90 | 80 | 40 | 40 | 30 | 70 | 80 | 60 | 50 |
| 6. Pollinator's management, supporting and protecting natural bee colonies | 60 | 70 | 80 | 50 | 40 | 40 | 30 | 50 | 50 | 20 | 20 | 20 | 40 | 80 | 70 | 70 |
| 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations | 30 | 40 | 40 | 80 | 70 | 70 | 50 | 80 | 90 | 60 | 90 | 50 | 40 | 90 | 90 | 90 |
| 8. Precision Agriculture including use of drones for pest and disease management | 40 | 60 | 80 | 90 | 80 | 70 | 40 | 90 | 80 | 50 | 30 | 30 | 40 | 90 | 60 | 50 |
| 9. Rainwater harvesting systems | 30 | 60 | 50 | 80 | 80 | 70 | 50 | 70 | 70 | 90 | 80 | 50 | 80 | 60 | 60 | 50 |
| 10. Soil moisture management through nature-based solutions including biochar, compost, green mulching | 30 | 70 | 50 | 60 | 40 | 40 | 40 | 60 | 60 | 70 | 60 | 60 | 80 | 70 | 70 | 70 |
| 11. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) | 30 | 40 | 60 | 90 | 80 | 70 | 70 | 90 | 80 | 90 | 80 | 50 | 80 | 80 | 90 | 90 |
| 12. Sustainable soil management in horticulture and fruit production | 60 | 60 | 60 | 50 | 60 | 60 | 60 | 60 | 60 | 80 | 50 | 60 | 60 | 50 | 70 | 70 |
| 13. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. apples, nuts etc.) | 80 | 70 | 50 | 70 | 60 | 60 | 50 | 60 | 70 | 90 | 50 | 70 | 80 | 40 | 50 | 50 |
| 14. Hydroponics with recyclable solutions | 30 | 30 | 30 | 90 | 80 | 80 | 80 | 90 | 90 | 90 | 30 | 30 | 30 | 90 | 90 | 90 |
| 15. Promotion of biocontrol through the use of bacteria, fungi and oomycetes | 60 | 30 | 60 | 60 | 60 | 60 | 50 | 90 | 70 | 30 | 30 | 20 | 40 | 40 | 70 | 70 |
| 16. Technologies for seed quality leading to higher germination rate and increased yield capacity | 30 | 30 | 40 | 80 | 80 | 70 | 70 | 90 | 80 | 60 | 50 | 50 | 50 | 50 | 50 | 50 |
| 17. Grafting nurseries for improved tomato production | 40 | 50 | 40 | 70 | 70 | 60 | 70 | 90 | 80 | 60 | 50 | 50 | 50 | 50 | 60 | 50 |
| 18. Automation for crop production through digitalization and remote control via app | 40 | 30 | 50 | 80 | 70 | 70 | 80 | 90 | 80 | 80 | 60 | 60 | 70 | 60 | 90 | 90 |
| Scoring scale | 0=very high cost --> 100=very low cost | 0=very high cost --> 100=very low cost | 0=very high cost --> 100=very low cost | 0= Very low --> 100= Very high | 0= Very low --> 100= Very high | 0=very high cost --> 100=very low cost | 0= Very low --> 100= Very high | 0= Very low --> 100= Very high | 0=very high cost --> 100=very low cost | 0= Very low --> 100= Very high | 0=very high cost --> 100=very low cost | 0=very high cost --> 100=very low cost | 0= Very low --> 100= Very high | 0=Very Difficult -->100=Very Easy | 0=Very Difficult -->100=Very Easy | 0=Very Difficult -->100=Very Easy |
| Criterion weight | 7 | 7 | 6 | 8 | 7 | 6 | 6 | 6 | 9 | 8 | 6 | 5 | 2 | 9 | 5 | 3 |

*Table 5.0.4 Screenshot of the scoring matrix for the technological options selected for horticulture.*

| | Costs | | | Economic | | | Social | | | Environmental | | | | Climate related | Institutional/Implementation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | The cost of technics, machines, maintenance, fuel and lubricants | The cost of materials (planting material, seeds, fertilizers, pesticides, herbicides) | Human resources | Profit for the enterprise | Reinvestment and business development | Profit for the state budget (taxes) | People employment (Jobs) | Specialists' qualification | Resources of agri-food products, including horticultural products, for population | The rational use of water resources | The preventing and combating negative natural phenomena (drought, hail, | The preventing and combating of soil erosion | The landscape preservation (fertility, soil structure, etc.) | Climate changes (contribution to CC resilience) | Institutional capacities and Development Politcy | The available real resources (informational, financial, grants and other) | Total score |
| 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency | 210 | 280 | 300 | 720 | 560 | 480 | 360 | 540 | 810 | 720 | 420 | 400 | 120 | 810 | 450 | 270 | 7450 |
| 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during summer | 490 | 560 | 420 | 320 | 280 | 180 | 240 | 180 | 270 | 640 | 480 | 450 | 160 | 720 | 200 | 120 | 5710 |
| 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation | 350 | 210 | 240 | 720 | 630 | 540 | 300 | 540 | 720 | 560 | 240 | 100 | 40 | 810 | 450 | 270 | 6720 |
| 4. Set up next-generation national horticulture breeding systems | 140 | 280 | 240 | 560 | 280 | 240 | 360 | 480 | 450 | 640 | 240 | 250 | 120 | 720 | 300 | 180 | 5480 |
| 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests | 280 | 420 | 420 | 640 | 560 | 420 | 240 | 540 | 720 | 320 | 240 | 150 | 140 | 720 | 300 | 150 | 6260 |
| 6. Pollinator's management, supporting and protecting natural bee colonies | 420 | 490 | 480 | 400 | 280 | 240 | 180 | 300 | 450 | 160 | 120 | 100 | 80 | 720 | 350 | 210 | 4980 |
| 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations | 210 | 280 | 240 | 640 | 490 | 420 | 300 | 480 | 810 | 480 | 540 | 250 | 80 | 810 | 450 | 270 | 6750 |
| 8. Precision Agriculture including use of drones for pest and disease management | 280 | 420 | 480 | 720 | 560 | 420 | 240 | 540 | 720 | 400 | 180 | 150 | 80 | 810 | 300 | 150 | 6450 |
| 9. Rainwater harvesting systems | 210 | 420 | 300 | 640 | 560 | 420 | 300 | 420 | 630 | 720 | 480 | 250 | 160 | 540 | 300 | 150 | 6500 |
| 10. Soil moisture management through nature-based solutions including biochar, compost, green mulching | 210 | 490 | 300 | 480 | 280 | 240 | 240 | 360 | 540 | 560 | 360 | 300 | 160 | 630 | 350 | 210 | 5710 |
| 11. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) | 210 | 280 | 360 | 720 | 560 | 420 | 420 | 540 | 720 | 720 | 480 | 250 | 160 | 720 | 450 | 270 | 7280 |
| 12. Sustainable soil management in horticulture and fruit production | 420 | 420 | 360 | 400 | 420 | 360 | 360 | 360 | 540 | 640 | 300 | 300 | 120 | 450 | 350 | 210 | 6010 |
| 13. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. apples, nuts etc.) | 560 | 490 | 300 | 560 | 420 | 360 | 300 | 360 | 630 | 720 | 300 | 350 | 160 | 360 | 250 | 150 | 6270 |
| 14. Hydroponics with recyclable solutions | 210 | 210 | 180 | 720 | 560 | 480 | 480 | 540 | 810 | 720 | 180 | 150 | 60 | 810 | 450 | 270 | 6830 |
| 15. Promotion of biocontrol through the use of bacteria, fungi and oomycetes | 420 | 210 | 360 | 480 | 420 | 360 | 300 | 540 | 630 | 240 | 180 | 100 | 80 | 360 | 350 | 210 | 5240 |
| 16. Technologies for seed quality leading to higher germination rate and increased yield capacity | 210 | 210 | 240 | 640 | 560 | 420 | 420 | 540 | 720 | 480 | 300 | 250 | 100 | 450 | 250 | 150 | 5940 |
| 17. Grafting nurseries for improved tomato production | 280 | 350 | 240 | 560 | 490 | 360 | 420 | 540 | 720 | 480 | 300 | 250 | 100 | 450 | 300 | 150 | 5990 |
| 18. Automation for crop production through digitalization and remote control via app | 280 | 210 | 300 | 640 | 490 | 420 | 480 | 540 | 720 | 640 | 360 | 300 | 140 | 540 | 450 | 270 | 6780 |
| Criterion weight | 7 | 7 | 6 | 8 | 7 | 6 | 6 | 6 | 9 | 8 | 6 | 5 | 2 | 9 | 5 | 3 | 100 |

*Table5.0.5Screenshot of the weighted score matrix for the technological options selected for horticulture.*

The results of the prioritization exercise are summarized in the table below.

| *Name of the Technology* | *MCA Score* | *Priority ranking* |
|---|---|---|
| 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency | 7450 | I |
| 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during | 5710 | XIV |
| 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation | 6720 | VI |
| 4. Set up next-generation national horticulture breeding systems | 5480 | XVI |
| 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests | 6260 | X |
| 6. Pollinator’s management, supporting and protecting natural bee colonies | 4980 | XVIII |
| 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations | 6750 | V |
| 8. Precision Agriculture including use of drones for pest and disease management | 6450 | VIII |
| 9. Rainwater harvesting systems | 6500 | VII |
| 10. Soil moisture management through nature-based solutions including biochar, compost, green mulching | 5710 | XV |
| 11. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) | 7280 | II |
| 12. Sustainable soil management in horticulture and fruit production | 6010 | XI |
| 13. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. figs, plums, pomegranate, etc.) | 6270 | IX |
| 14. Hydroponics with recyclable solutions | 6830 | III |
| 15. Promotion of biocontrol through the use of bacteria, fungi and oomycetes | 5240 | XVII |
| 16. Technologies for seed quality leading to higher germination rate and increased yield capacity | 5940 | XIII |
| 17. Grafting nurseries for improved tomato production | 5990 | XII |
| 18. Automation for crop production through digitalization and remote control via app | 6780 | IV |

*Table 5.0.6 Results of the MCA exercise for prioritizing adaptation technologies.*

| No. | Name of the Technology | Scale of Application (Small, Medium or Large Scale) | Time Scale (Approx. number of years) | Potential for adaptation in the Time Scale |
|---|---|---|---|---|
| 1 | High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency | Large Scale | 3 years | Large |
| 2 | Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) | Small Scale | 5 years | Small |
| 3 | Hydroponics with recyclable solutions | Medium | 3 years | Large |

*Table5.0.7.Summary Table for Prioritized Technologies.*

The proposed adaptation technologies are not currently applied to a significant extent in Moldova, and stakeholders have stressed the need to expand the uptake of these technologies in order to develop a climate-resilient horticulture sector in the country. A barrier analysis will be carried out and technological action plans developed for these priority technologies will be developed to reflect the need for such technological actions in the sector.

| Name of the Technology | Current degree of application | | | |
|---|---|---|---|---|
| | Unapplied | Weak | Medium | High |
| 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency | X | | | |
| 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during | | X | | |
| 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation | X | | | |
| 4. Set up next-generation national horticulture breeding systems | X | | | |
| 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests | | X | | |
| 6. Pollinator’s management, supporting and protecting natural bee colonies | X | | | |
| 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations | X | | | |
| 8. Precision Agriculture including use of drones for pest and disease management | | X | | |

| Name of the Technology | Current degree of application | | | |
|---|---|---|---|---|
| | Unapplied | Weak | Medium | High |
| 9. Rainwater harvesting systems | X | | | |
| 10. Soil moisture management through nature-based solutions including biochar, compost, green mulching | X | | | |
| 11. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) | X | | | |
| 12. Sustainable soil management in horticulture and fruit production | | X | | |
| 13. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. figs, plums, pomegranate, etc.) | X | | | |
| 14. Hydroponics with recyclable solutions | | X | | |
| 15. Promotion of biocontrol through the use of bacteria, fungi and oomycetes | X | | | |
| 16. Technologies for seed quality leading to higher germination rate and increased yield capacity | X | | | |
| 17. Grafting nurseries for improved tomato production | | X | | |
| 18. Automation for crop production through digitalization and remote control via app | X | | | |

*Table 5.0.8 Current degree of application of selected adaptation technologies.*

Only 6 technology options out of 18 proposed have resulted to be somewhat present in Moldova, although their presence is considered weak. None of the prioritized technologies was found to be currently implemented to at least a medium degree of presence. Low tech greenhouse farming is rather popular but limited by its intimate performances, even more recently as a consequence of the changing climate. High tech greenhouse farming structures with enhanced climate control systems, including cutting edge technologies such as PCM panels and a number of other high-tech systems are not present to a large extent, but only a few examples – though very successful ones – exist in Moldova. Concerning hydroponics instead, at least one relevant case in Moldova was documented. During the following stages of this study, a mapping exercise of existing cases of such applications will be carried out by the relevant National Consultant to gain real-world information on both barriers and enabling factors for their diffusion in the country.

Below is a brief description of the top three technologies prioritized for the horticulture sub-sector in Moldova:

1. **High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency**

   Low-tech greenhouses are single-span pad and fan-cooled tunnels. The medium-tech greenhouses are tall, multi-span, glass-covered greenhouses with a soilless growing system, a heating system usually diesel or natural gas-fired, and a controllable shade screen. The Medium-tech greenhouses are also pad and fan-cooled. Modern High-Tech greenhouses are made of advanced thermal efficiency materials, including a plethora of different double or triple-glazed glass panels, or even cutting edge phase-change materials (PCM). These greenhouses use renewable energy systems to provide heat and cooling. Making best use of available agricultural residues (such as pruning waste, post-harvest waste biomass etc.) these greenhouses are equipped with biomass burners, that can dry and filter the exhaust gases to deliver only CO2 to growing vegetables. Hi-Tech greenhouses are also equipped with heat-pump air conditioning systems, and the structure can be completely sealed from the outside air. Because of this sealed environment, biogenic CO2 injection can be used to promote production and displace fossil fuels. PCM are highly innovative applications. As all breakthrough inventions these need demonstration also through pilots and different adaptations to the specific context. These have been created to mitigate high temperatures during hot periods (e.g. summer) as well as to release such heat during colder times (e.g. at night or during low sun irradiation). Coupled with rarefied air sandwiches of polycarbonated alveolar panel this technology can offer the best available thermal insulation of greenhouses. High-tech greenhouses also use proven yet innovative ancillary technologies, like climate control management systems based on Artificial Intelligence, the Internet of Things and Domotics controls. These allow data-driven management choices in greenhouse farming and result in higher productivity and cost-efficiency. increasing thermal efficiency and climate control inside greenhouses can have tremendous impacts on productivity and crucially diversification of products to be grown in the greenhouse year-round. Greenhouse farming can increase crop production because you can create the optimal climate conditions needed for plant growth and grow more plants per square foot than growing crops in an open field. Being in an enclosed space prevents crops from suffering damage from extreme climate-related events such as sudden increases or drops in temperature. It can also keep crops away from birds and other animals that may harm crops. Studies suggest that profits per crop per square foot can be two to three times as big when executing greenhouse farming instead of open-field agriculture when combining the practice with other approaches such as hydroponics. By utilizing resources more efficiently, you create less waste, which can translate into bigger profits. Greenhouses can prevent problems such as pests as well as provide more control against other diseases. The enclosed space can be restricted to only the essential staff, and fewer people going in and out means a lesser risk of bringing unwanted elements close to the crops. It also allows you to isolate problems should they occur. A greenhouse is a relatively independent climate-controlled space, allowing the growing crops all year-round instead of just seasonally. Even in the harsh winter cold or intense summer heat, high-quality crops can be grown, provided you have the necessary technology to create the right climate inside the greenhouse. Since outside conditions don't necessarily impact plants or workers, the greenhouse's protected environment provides a safe and stable working environment, this is particularly relevant for gender-sensitive considerations, as most harvesting of vegetables is carried out by women who sometimes work in strenuous conditions.

2. **Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.)**

Reliable, efficient, and environmentally friendly irrigation systems are needed to support sustainable intensification of agriculture in the context of adaptation to climate impacts in Moldova. Water and energy are important resources for economic and social development as well as for environmental integrity, while both are essential to irrigation. One approach for improving water use efficiency is to replace surface irrigation systems with more efficient pressurized (sprinkler and drip) systems to significantly reduce water application on the farm scale, thereby increasing water and land productivity, but also increasing energy and investment requirements. The energy used by pumping stations generates significant greenhouse gas (GHG) emissions, which then contribute to accelerating climate change, therefore modern irrigation systems necessarily need to rely on technologies that maximise both water use efficiency (e.g. drip irrigation) as well as energy efficiency. Maximizing water efficiency means finding the best combination of technologies and practices to return the highest water-use efficiency of crop production. This can happen both at national infrastructural level, as well as at farm level. At the national infrastructural level, monitoring and maintaining the hydraulic network is essential to avoid water leakages and losses before irrigation starts in the field. Technologies to update the national irrigation infrastructure include sensors and instrument to monitor pressures and identify potential losses, as well as improved valves and tubing junctions, made of flexible yet robust materials that have very long lifespans. Drip irrigation systems have higher capital costs than traditional systems, moreover, they require significant pumping power to operate. However, novel low-pressure drip irrigation systems can operate at 20 to 30 kPa. This pressure can be obtained by placing the irrigation tank or reservoir 3 meters above the height of the drippers. Drippers can also be buried into the soil to deliver more efficient water to the rootzone of the plants, this will increase the differential. At 25 kPa pressure an 8 liter per hour (lph) dripper will discharge about 3.4 lph. It is a good idea to use the 8 lph dripper as this will provide the maximum flow path size and be less resistant to clogging. Ideally the system should incorporate an inline filter, however this comes at a cost by creating a pressure drop as the filter traps contaminants. This is why it is advisable to use low-pressure drip irrigation systems always in conjunction with sedimentation tanks, so that particles will tend to settle in the bottom of the tank and if the outlet is above the sediment line filtering can be much less obstructive. The only downside to using gravity (low pressure) for drippers is that they can be more susceptible to clogging as the turbulent flow path is more laminar in performance. This should always be considered when using gravity pressure systems. When gravity pressure is not sufficient, or large filters are necessary, the low-pressure drippers can be hooked to a renewable energy powered pumping system. Small to large scale renewable energy plants can be deployed to sustain the irrigation facility. The electricity can be generated for instance by an Agri-photovoltaic systems as direct current (DC) and employed as such by DC pumps. When pumping power exceeds 10 kW, triphasic pumps are needed, thus specific inverters are needed but these can still be operated by PV or other renewable energy systems. At the field level, drip irrigation is a powerful technology that can reduce water consumption by 20-40% while increasing crop yield by 20-50% compared to surface irrigation or sprinklers, depending on the crop grown. Drip irrigation can enable farmers to grow crops under conditions where they otherwise could not and adapt to the impacts of climate change. Drip also allows farmers to grow a wider array of crops, increase crop yield, and save on labour and fertilizer costs.

**3. Hydroponics with recyclable solutions**

Hydroponics is a method of growing plants in water, or in an inert media, without soil and using mineral nutrient solutions in a water solvent to supply complete nutrition for plant growth. Hydroponics can give precise control over plant growth parameters which can lead to yield and quality improvement. In principle, nutrient solutions used in hydroponics can either be reused or discarded. Nowadays, the cultivation of leafy vegetables, medicinal herbs, and other plants with pharmaceutical value are commercially grown under recycled hydroponics with controlled environments. In recycled hydroponics, nutrient solutions passed through the growing medium are collected into a reservoir and reused repeatedly. In this system, both water and mineral nutrients are used efficiently and therefore minimizes the wastage of fertilizer and the environmental damage. Hydroponic systems are commonly associated with high-tech greenhouses or other controlled environment agriculture (CEA) facilities. Additional control overgrowth parameters is ensured by using artificial grow lights, such as light-emitting diodes (LED), climate control and nutrient dosing with real-time measurements. Hydroponics may however be challenged by the accumulation of root exudates that affect plant growth and reduce crop yield and quality. Lower growth and yield performance of several crops including lettuce, strawberry, several leafy vegetables, and ornamentals have been reported in recycled hydroponics. There are two main types of recycled hydroponics systems: the Nutrient Film Technique (NFT) and the Deep Flow Technique (DFT).

# Chapter 6 Technology prioritisation for Cereals

## 6.1 Adaptation Technology Options for Cereals and their Main Adaptation benefits

The TNA team and the cereals expert have proposed 18 technological options for adaptation to climate change.

Table 6.1.1. presents the Long List of proposed adaptation Technologies (LLT) in the cereal sector, categorized using a similar approach as for the other sectors. Detailed information about technologies is presented in the annexed Technological Fact Sheet of each prioritized technology from the Final Long List of adaptation technologies.

| Climate Hazard | Climate Impact | Priority technologies |
|---|---|---|
| Precipitation pattern changes | Soil quality decay | 1. Climate-smart rotations and wheat predecessor programmes |
| | | 2. Conservation agriculture (including no- and minimum tillage, continuous soil cover, etc) |
| | | 3. Soil C monitoring at farm and landscape level |
| | | 4. Network of shelter belts, agroforestry, and ponds for increasing the humidity of the air |
| Increased incidence of extreme climatic events including droughts, floods, etc. | Increased rates of soil organic matter mineralization | 5. Including perennial legumes and grasses in farm mosaics |
| | | 6. Integration of crops and animals for recycling of nutrients in each crop rotation |
| | | 7. Increased production and use of organic fertilizers and amendments (e.g. compost, biochar, green manure) |
| | | 8. Improve soil structure by increasing the input of carbon in soil and reduced rates of mineralization |
| | Increased water stress | 9. Real-time wireless soil moisture monitoring system |
| | | 10. In-vitro isolated pollen methods to obtain and use double haploid lines in plant breeding |
| | | 11. Integrated Pest Management |

| | | |
|---|---|---|
| Increased average temperatures | Increased pest outbreaks and virulence, increased weed infestations | 12. Integrated Nutrient Management |
| | | 13. Application of anthlers culture and „in vitro" isolated pollen methods to obtain and use double haploid lines in plant breeding |

*Table 6.0.1 Long List of proposed adaptation Technologies (LLT) in the cereal sector.*

## 6.2 Criteria and process of technology prioritisation

**Identification of priority technologies for climate change adaptation of cereal sector**

Over the last 20-25 years, Moldova, as well as other areas of the Planet, have experienced decreasing yields of main staple crops such as winter wheat. Long-term field experiments on Chernozem Soils in Balti steppe of Moldova have confirmed this trend. Modern technologies for growing winter wheat have been simplified in the period of intensive use of inexpensive industrial inputs, such as chemical fertilizers and pesticides.

A misconception began to dominate, in most former Soviet countries – and elsewhere - that by using more chemical inputs it would be possible to achieve ever growing yields at ever growing economic margins. As a result, crop rotations became shorter and simpler with domination of profitable crops, but with complete negligence of the level of soil quality and long-term considerations of productive capacity of the land. Along the same lines, also ecosystem services provided by the soil have been overlooked.

Taking in consideration the preponderant role of soil organic matter (SOM) in yield determination, the stocks of this key component of the soil (and thus of soil organic carbon – SOC) have decreased significantly and relentlessly starting with the privatization of land in Moldova. The substitution of perennial herbaceous crops from crop rotations with annual crops, and the drastic reduction of organic fertilizer's application in favour of mineral fertilizers has resulted in long-term stresses to the balance of the soil and the rhizosphere. Oversaturation of the structure of sowing areas with annual row crops doesn't allow room for proper crop rotations, where winter cereal crops are sown after early harvested predecessors (mixture of both annual and perennial legumes and grasses). In this scenario of anthropic disturbance to soil dynamics through monocropping and extreme input use, the resilience of soils to additional stresses posed by climate change, has become evident through decreased yields and poor quality of the produce.

As a result, in drought conditions winter wheat crops are suffering as a consequence of unnatural soil moisture deficit, especially, in deeper soil layers. More and more often farmers are starting to consider additional intensification techniques, including irrigation of winter wheat, to reduce the negative impacts of drought. Such short-sighted solution would likely deliver a decent crop over the short term, but it is proven that over time the consequences of irrigation on chernozem soils are negative and unforeseeable because of high content of salts in water and because of the intensification of decomposition of soil organic matter under the influence of irrigation in the conditions of insufficient application of carbon with fresh organic residues.

Plowing is increasing soil compaction in the crop rotations with the lack of perennial herbaceous crops capable of improving soil structure. Irrigation of such compacted soils is worsening both soil erosion and deficit of soil moisture in areas where it is being applied. A paradigm shift in soil quality management for cereals production is necessary in Moldova to cope with the existing sustainability issues of Business-As-Usual. Improving soil management practices together with more sustainable technologies is the key objective of the TNA for the cereals sub-sector. With this goal in mind, the selection of the Long List of Technologies looked at providing long term solutions to SOC loss, decreased water retention capacity of the soils, increased susceptibility to pests and diseases and the loss of agricultural biodiversity that the country is facing.

Taking into account the characteristics of the cereals sub-sector in the Republic of Moldova and its socio-economic importance, a long list containing 13 technologies for adapting domestic grain production to climate change was identified.

Simplified TFS have been developed for each technological option in the long list of technologies and underwent prioritization using the tools of multi-criteria analysis. The TNA Team (International + National Consultants) proposed an initial set of prioritization criteria, as well as on potential initial scoring and weighting of each. In the context of several sectoral working group meetings, the cohort of participants reached consensus on the scoring and weighting for each criterion for each of the 13 technologies. The same elements as for other sectors were taken into account.

**Criteria categories used in the prioritization process:**

Similarly, as for other sectors, the prioritization decisions were based on the following evaluation criteria (and sub-criteria):

***Costs - 21%***

Cost to set up and operate the technology, subdivided into annual operational costs and maintenance expenses, composed the relevant criteria for this category:

1. CAPEX costs;
2. OPEX costs;
3. Maintenance costs.

***Co-benefits:***

***Economic - 21%***

1. Maintaining the sector as economic activity.
2. Productivity.
3. Trigger private investments.

***Social - 24%***

The indicators used for scoring were the:

1. Employment (Jobs creation);
2. Increased wages;
3. Recreational value.

***Environmental - 27%***

1. Contribution of the technology to protect and sustain ecosystem services.
2. Biodiversity and Landscape.
3. Rational use of soil resources.

***Climate related - 8%***

1. Improvement of Resilience to Climate Change:

- **Extent the technology will contribute to reduce vulnerability to climate change impacts.**
- **Ability to adapt to the effects of climate change.**
- **The potential of the technology to demonstrate tangible and concrete results of protection of water bodies in a short space of time.**

***Other - 6%***

1. Alignment to national policies.
2. Available resources in the country.
3. Institutional capacities.

| *Major Criteria* | *Criteria Description* | *Sub-criteria (Weight Factor)* | *Criterion weight, %* |
|---|---|---|---|
| **Costs, 21 %** | | Set up costs (CAPEX) | **8** |
| | | Annual Operational Costs | **7** |
| | | Maintenance Costs | **6** |
| | | | **21** |
| **Co-Benefits** | **Economic 21%** | Maintaining the sector as economic activity | **8** |
| | | Productivity | **10** |
| | | Trigger private investments | **3** |
| | | | **21** |
| | **Social 24%** | Employment (Jobs creation) | **8** |
| | | Increased wages | **8** |
| | | Recreational Value | **8** |
| | | | **24** |
| | **Environmental 27%** | Contribution of the technology to protect and sustain ecosystem services | **9** |
| | | Biodiversity and Landscape | **9** |
| | | Rational use of soil resources | **9** |
| | | | **27** |
| | **Climate related 9%** | Resilience to Climate Change | **9** |
| | | | **9** |
| | | | **81** |
| **Other** | **Institutional/ Implementation** | Alignment to National Policies | **1** |
| | | Available resources in the country | **3** |
| | | Institutional capacities | **2** |
| | | | **6** |
| | | | **100** |

*Table 6.0.2 List of criteria and criteria weighting used for the prioritization exercise.*

## 6.3 Results of technology prioritization

The results of technology prioritisation are presented here, with a brief description of the selected technologies, and their benefits. Technology fact sheets (contents indicated in Annex III) for the technologies that are selected through technology prioritisation should be put in Annex I of the report.

Out of the total of 13 technologies from the LLT, the 3 scoring the highest weighted value have been prioritized. These are:

**1. Conservation Agriculture System (crop rotations, No-till, cover crops, soil mulching).**

**2. Climate-smart rotations and using of predecessors capable to prevent problems.**

**3. Climate-smart rotation in the frame of a network of shelter belts and ponds for increasing the humidity of the air.**

**CEREALS**

**Scoring matrix (for each criterion score should be from 0 to 100)**

| | Costs | | | Economic | | | Social | | | Environmental | | | Climate related | Other | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Technologies** | **Cost to set up** | **Annual operational cost** | **Mentenance expences** | **Maintenaning the sector as economic activity** | **Productivity** | **Trigger private investment** | **New jobs** | **Increasing wages** | **Recreational areas value** | **Contribution of the technology to protect and sustainable** | **Biodiversity and landscape** | **Rational use of soil resources** | **Improvement of resilience to climate change** | **Public policy documents** | **Available resources** | **Institutional capacities** |
| 1. Climate-smart rotations and using of predecessors capable to prevent problems | 90 | 90 | 90 | 20 | 20 | 10 | 10 | 80 | 80 | 90 | 90 | 90 | 90 | 20 | 90 | 30 |
| 2. Conservation Agriculture System (crop rotation, No-till, cover crops, soil mulch) | 15 | 20 | 20 | 80 | 80 | 60 | 70 | 90 | 85 | 90 | 90 | 90 | 90 | 15 | 10 | 20 |
| 3. Soil organic matter management and monitoring at farm and landscape levels | 20 | 20 | 20 | 80 | 85 | 70 | 75 | 85 | 85 | 90 | 90 | 95 | 90 | 15 | 20 | 20 |
| 4. Climate-smart rotation in the frame of a network of shelter belts and ponds for increasing the humidity of the air | 10 | 15 | 10 | 90 | 90 | 90 | 90 | 90 | 90 | 95 | 95 | 95 | 95 | 10 | 10 | 15 |
| 5. Including perennial legumes and grasses in crop rotations and for farm mosaics | 90 | 90 | 80 | 20 | 25 | 30 | 20 | 80 | 90 | 85 | 90 | 90 | 85 | 15 | 80 | 25 |
| 6. Integration of crops and animals for recycling of nutrients in each crop rotation | 10 | 10 | 15 | 90 | 90 | 90 | 80 | 90 | 90 | 90 | 95 | 85 | 95 | 10 | 10 | 10 |
| 7. Increased production and use of organic fertilizers and amendments (e.g. composts, biochar, green manure) | 15 | 20 | 20 | 80 | 85 | 85 | 80 | 85 | 80 | 85 | 85 | 90 | 85 | 15 | 20 | 15 |
| 8. Improve soil structure by increasing the input of carbon in soil and reduced rates of mineralization | 20 | 15 | 20 | 80 | 50 | 70 | 75 | 80 | 80 | 85 | 90 | 90 | 85 | 15 | 15 | 20 |
| 9. Real time wireless soil moisture monitoring system | 50 | 60 | 70 | 20 | 20 | 20 | 20 | 10 | 20 | 15 | 20 | 25 | 30 | 80 | 80 | 80 |
| 10. Irrigation by using the most efficient system | 25 | 20 | 20 | 80 | 80 | 80 | 80 | 30 | 20 | 20 | 15 | 20 | 40 | 40 | 60 | 60 |
| 11. Integrated Pest, Disease and Weed Management | 20 | 25 | 20 | 70 | 70 | 70 | 70 | 40 | 30 | 30 | 20 | 30 | 30 | 30 | 50 | 50 |
| 12. Integrated Nutrient Management | 20 | 25 | 20 | 70 | 70 | 70 | 70 | 40 | 30 | 30 | 20 | 30 | 30 | 30 | 50 | 50 |
| 13. Application of anters culture and „in vitro" isolated pollen methods to obtain and use double haploid lines in plant breeding | 10 | 20 | 10 | 90 | 90 | 80 | 90 | 30 | 20 | 20 | 10 | 15 | 20 | 10 | 15 | 10 |
| Criterion weight | 8 | 7 | 6 | 8 | 10 | 3 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 1 | 3 | 2 |
| | | | **21** | | | **21** | | | **24** | | | **27** | **9** | | | **6** |

*Table 6.3. Screenshot of the scoring matrix for the technological options selected for horticulture.*

| | Costs | | | Economic | | | Social | | | Environmental | | | Climate related | Other | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Technologies** | **Cost to set up** | **Annual operational cost** | **Mentenance expences** | **Maintenaning the sector as economic activity** | **Productivity** | **Trigger private investment** | **New jobs** | **Increasing wages** | **Recreational areas value** | **Contribution of the technology to protect and sustainable** | **Biodiversity and landscape** | **Rational use of soil resources** | **Improvement of resilience to climate change** | **Public policy documents** | **Available resources** | **Institutional capacities** | | |
| **Technologies** | **Decision matrix: Weighted scores** | | | | | | | | | | | | | | | | **Total score** | **Priority rank** |
| 1. Climate-smart rotations and using of predecessors capable to prevent problems | 720 | 630 | 540 | 160 | 200 | 30 | 80 | 640 | 640 | 810 | 810 | 810 | 810 | 20 | 270 | 60 | 8040 | 2 |
| 2. Conservation Agriculture System (crop rotation, No-till, cover crops, soil mulch) | 120 | 140 | 120 | 640 | 800 | 180 | 560 | 720 | 680 | 810 | 810 | 810 | 810 | 15 | 30 | 40 | 8095 | 1 |
| 3. Soil organic matter management and monitoring at farm and landscape levels | 160 | 140 | 120 | 640 | 850 | 210 | 600 | 680 | 680 | 810 | 810 | 855 | 810 | 15 | 60 | 40 | 7495 | 4 |
| 4. Climate-smart rotation in the frame of a network of shelter belts and ponds for increasing the humidity of the air | 80 | 105 | 60 | 720 | 900 | 270 | 720 | 720 | 720 | 855 | 855 | 855 | 855 | 10 | 30 | 30 | 7785 | 3 |
| 5. Including perennial legumes and grasses in drop rotations and for farm mosaics | 720 | 630 | 480 | 160 | 250 | 90 | 160 | 640 | 720 | 765 | 810 | 810 | 765 | 15 | 240 | 50 | 7305 | 6 |
| 6. Integration of crops and animals for recycling of nutrients in each crop rotation | 80 | 70 | 90 | 720 | 900 | 270 | 640 | 720 | 720 | 810 | 855 | 765 | 855 | 10 | 30 | 20 | 7555 | 5 |
| 7. Increased production and use of organic fertilizers and amendments (e.g. composts, biochar, green manure) | 120 | 140 | 120 | 640 | 850 | 255 | 640 | 680 | 640 | 765 | 765 | 810 | 765 | 15 | 60 | 30 | 7295 | 7 |
| 8. Improve soil structure by increasing the input of carbon in soil and reduced rates of mineralization | 160 | 105 | 120 | 640 | 500 | 210 | 600 | 640 | 640 | 765 | 810 | 810 | 765 | 15 | 45 | 40 | 6865 | 8 |
| 9. Real time wireless soil moisture monitoring system | 400 | 630 | 420 | 160 | 200 | 60 | 160 | 80 | 160 | 135 | 180 | 225 | 270 | 80 | 240 | 160 | 3560 | 13 |
| 10. Irrigation by using the most efficient system | 200 | 140 | 120 | 640 | 800 | 240 | 640 | 240 | 160 | 180 | 135 | 180 | 360 | 40 | 180 | 120 | 4375 | 11 |
| 11. Integrated Pest, Disease and Weed Management | 160 | 175 | 120 | 630 | 700 | 210 | 560 | 320 | 240 | 270 | 180 | 270 | 270 | 30 | 150 | 100 | 4385 | 10 |
| 12. Integrated Nutrient Management | 160 | 175 | 120 | 630 | 700 | 210 | 560 | 320 | 240 | 270 | 180 | 270 | 270 | 30 | 150 | 100 | 4535 | 9 |
| 13. Application of anters culture and „in vitro" isolated pollen methods to obtain and use double haploid lines in plant breeding | 80 | 140 | 60 | 720 | 900 | 240 | 720 | 240 | 160 | 180 | 90 | 135 | 180 | 10 | 45 | 20 | 3920 | 12 |

*Table 6.4. Screenshot of the scoring matrix for the technological options selected for horticulture.*

The results of the prioritization exercise are summarized in the table below.

| ***Name of the Technology*** | ***MCA Score*** | ***Priority ranking*** |
|---|---|---|
| **1. Climate-smart rotations and wheat predecessor programmes** | **8040** | **2** |
| **2. Conservation agriculture (including no- and minimum tillage, continuous soil cover, etc)** | **8095** | **1** |
| 3. Soil C monitoring at farm and landscape level | 7495 | 4 |
| **4. Network of shelter belts, agroforestry, and ponds for increasing the humidity of the air** | **7785** | **3** |
| 5. Including perennial legumes and grasses in farm mosaics | 7305 | 6 |
| 6. Integration of crops and animals for recycling of nutrients in each crop rotation | 7555 | 5 |
| 7. Increased production and use of organic fertilizers and amendants (e.g. compost, biochar, green manure) | 7295 | 7 |
| 8. Improve soil structure by increasing the input of carbon in soil and reduced rates of mineralization | 6865 | 8 |
| 9. Real-time wireless soil moisture monitoring system | 3560 | 13 |
| 10. In-vitro isolated pollen methods to obtain and use double haploid lines in plant breeding | 4375 | 11 |
| 11. Integrated Pest Management | 4385 | 10 |
| 12. Integrated Nutrient Management | 4535 | 9 |
| 13. Application of anters culture and „in vitro" isolated pollen methods to obtain and use double haploid lines in plant breeding | 3920 | 12 |

*Table 6.5 Results of the MCA exercise for prioritizing adaptation technologies.*

| ***No.*** | ***Name of the Technology*** | ***Scale of Application (Small, Medium or Large Scale)*** | ***Time Scale (Approx. number of years)*** | ***Potential for adaptation in the Time Scale*** |
|---|---|---|---|---|
| 1 | **Conservation agriculture (including no- and minimum tillage, continuous soil cover, etc)** | Large Scale | 5 years | Large |
| 2 | **Climate-smart rotations and wheat predecessor programmes** | Large Scale | 3 years | Large |
| 3 | **Network of shelter belts, agroforestry, and ponds for** | Large Scale | 5 years | Large |

| No. | Name of the Technology | Scale of Application (Small, Medium or Large Scale) | Time Scale (Approx. number of years) | Potential for adaptation in the Time Scale |
|---|---|---|---|---|
| | increasing the humidity of the air | | | |

Table 6.6. Summary Table for Prioritized Technologies.

The proposed adaptation technologies are not currently applied to a significant extent in Moldova, and stakeholders have stressed the need to expand the uptake of these technologies in order to develop a climate-resilient cereals sector in the country. A barrier analysis will be carried out and technological action plans developed for these priority technologies will be developed to reflect the need for such technological actions in the sector.

| Name of the Technology | Current degree of application | | | |
|---|---|---|---|---|
| | Unapplied | Weak | Medium | High |
| Climate-smart rotations and wheat predecessor programmes | | X | | |
| Conservation agriculture (including no- and minimum tillage, continuous soil cover, etc) | | X | | |
| Soil C monitoring at farm and landscape level | X | | | |
| Network of shelter belts, agroforestry, and ponds for increasing the humidity of the air | X | | | |
| Including perennial legumes and grasses in farm mosaics | | X | | |
| Integration of crops and animals for recycling of nutrients in each crop rotation | X | | | |
| Increased production and use of organic fertilizers and amendants (e.g. compost, biochar, green manure) | X | | | |
| Improve soil structure by increasing the input of carbon in soil and reduced rates of mineralization | X | | | |
| Real-time wireless soil moisture monitoring system | X | | | |
| In-vitro isolated pollen methods to obtain and use double haploid lines in plant breeding | X | | | |
| Integrated Pest Management | | X | | |
| Integrated Nutrient Management | | X | | |
| Application of anters culture and „in vitro” isolated pollen methods to obtain and use double haploid lines in plant breeding | X | | | |

Table 6.7 Current degree of application of selected adaptation technologies.

Only 5 technology options out of 13 proposed have resulted to be somewhat present in Moldova, although their presence is considered weak.

Below is a brief description of the top three technologies prioritized for the horticulture sub-sector in Moldova:

1. **Conservation agriculture (including no- and minimum tillage, continuous soil cover, etc).**
2. **Climate-smart rotations and wheat predecessor programmes.**
3. **Network of shelter belts, agroforestry, and ponds for increasing the humidity of the air.**

The proposed technologies of growing winter cereal crops, as well as conservative agricultural system, have the main objectives: to prevent and to reduce the negative impact of soil erosion and droughts; to reduce the production expenditures related to the utilization of non-renewable sources of energy and their derivatives (mineral fertilizers, pesticides, etc.); to reduce global warming, etc.

Conservation agriculture system is based on the following principles:

- minimum mechanical disturbance of the soil;
- application of crop residues and cover crops;
- respecting crop rotation with a higher diversity of crops.

By including a mixture of perennial legumes and grasses in crop rotation it becomes possible to reduce and even to avoid application of mineral fertilizers, especially of nitrogen, by using biological nitrogen. At the same time, the root system is enriching soil in soil organic matter and is improving soil structure. As a result, the vulnerability of crops to droughts and to water soil erosion is reduced.
Cover crops together with crop mulch are increasing water use efficiency by reducing water evaporation from the soil surface .

By respecting crop rotations, including good predecessors for winter cereal crops, it is possible to receive a good germination and tillering of cereal crops from the autumn, which serves as a guarantee for high level of yields and good quality of grains.

Crop rotation is allowing reducing production expenses through the utilization of chemicals for weed, pests and disease control, as well as for the reduction of moldboard plow.

The other technology is supposing respecting crop rotation in the frame of a network of shelter belts and ponds at the bottom parts of the relief for increasing the humidity of the air, which is crucial in drought conditions. Shelter belts are beneficial in reducing the speed of the wind and consequently in increasing the relative humidity of the air. The beneficial entomofauna is favourable for the biological control of" pests*".*
Through the implementation of the proposed technologies, it would be possible to reduce production expenditures for the application of:

- mineral fertilizers on 40-50 %;
- fuel, especially for moldboard plowing - on 50-60 %;
- chemicals for" pests*, disease and weed control"* - on 60-70 %;
- irrigation on 100 %.

The most important is that the ecological situation will be improved together with the health of people and animals.

# Chapter 7. Summary and Conclusions

There are salient points coming from the results of the technologies prioritization exercise on the four key sub-sectors of agriculture in Moldova. Firstly, Climate Change is impacting all subsectors, and severely so. Climate change, though, is mainly exacerbating a pre-existing situation of stress on agriculture assets caused by several factors, including societal and managerial changes occurred in recent decades. Both chronic, systemic long-term climatic changes such as increased mean temperatures and precipitation patterns, and short-term, erratic, and unpredictable extreme events such as droughts are building up on a weak and poorly resilient agricultural sector multiplying the damages on natural resources and human livelihoods. Gender considerations accompanied the process and helped identify horticulture and to a lesser extent livestock sector as the two areas where women are currently engaged directly, although much less than men, and where key technologies and practices that foster presence and recognition of their role are more necessary.

The TNA process followed the UNEP-DTU methodology for prioritization of the technologies, which is largely reliant on national ownership of the process itself and through it, of its results. A Sectoral Working Group was formed following each sub-sector, discussions have been led by the Sectoral Experts (national consultants) and moderated by the TNA team.

In general, the prioritization of technologies was driven towards very concrete and low-cost options, rather than highly ambitious cutting-edge technologies at lower levels of development. Best practices and management options dominated the prioritization exercise in aquaculture, livestock, and cereals sub-sector, although not completely, with horticulture being the only sub-sector incorporating purely technological solutions among those prioritized at the end of the process. The reasons for this situation shall be further researched. In all prioritization exercises, technology capital costs have been a predominant factor for evaluation and scoring, although quantitative information have been difficult to find and supported by existing literature and proven sources, these received relevant attention by the National Consultants as well as by the SWG members. Similarly, among Co-benefits, economic indicators have had a determining contribution to the final prioritization and ranking of all technologies with high weights across the four sub-sectors. Economic impacts on agriculture are still the predominant concern for sectoral experts and this reflected into the prioritization exercise. Financial exposure for a low-gain economic activity is clearly perceived as a barrier that influenced the prioritization, even before a proper barrier analysis – which has taken place separately as per TNA methodology – was carried out. Solutions therefore seem to be recognized as limited by financial feasibility rather than by lack of technological adequateness and performance, and structural deficiencies are the main cause of limitations on sub-sectors' performances.

Aquaculture, although not a major component of the agricultural GDP in the country, plays an important role with respect to food security and ecosystem services, and technologies that capitalize on such potential have been prioritised. The animal husbandry sector counts only a handful of commercial large scale farms, whereas most livestock is found on household-led settings, and therefore small-scale technologies – in addition to a large scale intervention on providing irrigation for feed and forage production – have been prioritised to support the resilience of smallholders against the threats of climate change. The cereals sector, as in many former Soviet countries, has gone through a rollercoaster of development fuelled by increasing use of chemical inputs and maximisation of monocultures that is now increasingly recognized as unsustainable. The technologies prioritised are in this case very much contributing at changing major management habits at landscape level, with particular emphasis on soil quality maintenance mechanisms. Horticulture is the most cash-intensive sub-sector analysed. Purely technological options have been prioritized for their potential to elevate the conditions of the country to produce horticultural crops despite the limitations posed by the changing climate, and by doing so, also foster the key role of women in this sector towards higher skills and better paid contributions.

All sectors, although from different ends, share common concerns and problems as a consequence of climate change. A more rational and planned management of water resources is felt as a key determinant of development for the aquaculture sector, but at the same time, such smart management is going to benefit the production of open field crops, such as cereals thus having a direct impact on this sub-sector. In turn, the same technologies and practices that can benefit the cereals sector are going to provide better resilience for the forage sector, thus also contributing to enhancing National resilience of the livestock sector. The Prioritization Exercise selected several technologies to compose the four Long Lists of Technologies (LLTs), with a total of about 60 TFS produced. The prioritization exercise showed in the case of aquaculture, livestock, and horticulture a close final scoring and tight ranking of the options. These interconnections call for a holistic approach to the definition of the Technology Action Plan for the adaptation of the agriculture sector of Moldova to the impacts of Climate Change. An approach that, as emerged from this document, must encompass the prioritized technologies that have most redundancy and added value across the sub-sectors and that exploits key linkages among sub-sectors by tapping into the pools of technologies that can scale up the efficacy of the actions proposed by building up on one another.

**Annex I: List of Agriculture sectors stakeholders involved and their contacts.**

## Members of the Sectoral Working Group

| # | *Name* | *Organisation* | *Position* | *Email* |
|---|---|---|---|---|
| 1. | Mr. Viaceslav Grigorita | Ministry of Agriculture and Food Industry | Head of Department Policy for Vegetal Production | viaceslav.grigorita@maia.gov.md |
| 2. | Ms. Stela Drucioc | Ministry of Environment | Head of Department Air Policy and Climate Change | |
| 3. | Ms. Nicoleta Golovaci | Ministry of Agriculture and Food Industry | Senior Consultant, Policy Department | nicoleta.golovaci@maia.gov.md |
| 4. | Mr. Oleg Masner | Scientific Practical Institute of Biotechnology in Animal Husbandry and Veterinary Medicine | Acting Director | izmv56@mail.ru |
| 5. | Mr. Ion Maxim | National Association of Public Association of Beekeepers | President | info@anarm.md |
| 6. | Mr. Gheorghe Plosnita | State Commission on Plant Varieties Testing | Deputy Director | info@cstsp.md |
| 7. | Mr. Petru Timbur, | Agency for Intervention and Payment in Agriculture | Deputy Director | petru.timbur@aipa.gov.md |
| 8. | Mr. Gheorghe Jigau | National Agency for Rural Development (ACSA) | Consultant, Key expert in Pedology | gheorghe.jigau@gmail.com |
| 9. | Mr. Viorel Furdui | Congress of Local Authorities from Moldova | Executive Director | info@calm.md |
| 10. | Mr. Octavii Ivanov | Congress of Local Authorities from Moldova | Consultant | info@calm.md |

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| 11. | Mr. Leonid Popov | Institute of Pedology, Agrochemistry and Soil Protection “Nicolae Dimo” | Director | ipaps_dimo@mtc.md |
| 12. | Mr. Boris Boincean | Research Institute of Field Crops “SELECTIA” | Director | bboincean@gmail.com |
| 13. | Mr. Iurie Hurmuzachi | Federation of Farmers “FARM” NGO | Deputy Director | ihurmuzachi@agrofarm.md |
| 14. | Ms. Valentina Bodrug Lungu | Gender-Centru Public Association | President | valbodrug@mail.ru |
| 15. | Ion Bacean | State Agrarian University | Dean of Agronomy Faculty | i.bacean@uasm.md |
| 16. | Vadim Codreanu | Agency for Modernization and Development of Agriculture | Technical Director | vadim.codreanu@adma.gov.md |
| 17. | Larisa Andronic | Institute of Physiology and Plant Protection | Deputy Director of the Institute | smerea_svetlana@yahoo.com (oleaginous plants) |
| 18. | Ms. Tatiana Maximov | OTP Bank | Head of Department AGRO Business | tatiana.maximov@otpbank.md |
| 19. | Ms. Svetlana Armasu | OTP Bank | Head of Unit Relations with IFI, GTB | svetlana.armasu@otpbank.md |
| 20. | Mr. Lupu Mihail | Institute of Power Engineering | Researcher, Head of Lab | mihu.lupu@gmail.com |
| 21. | Ms. Elena Bicova | Institute of Power Engineering | Researcher | elena1038@ukr.net |
| 22. | Mr. Anatolie Meleca | Institute of Crop Science “Porumbeni” | Researcher coordinator | anatolmeleca@gmail.com (cereals) |
| 23. | Mr. Mosu Alexandru | Research Center for Genetic Aquatic Resources "AQUAGENRESURS" | Researcher | scsp59@mail.ru (aquaculture) |
| 24. | Mr. Vasilii Domanciuc | Research Center for Genetic Aquatic Resources "AQUAGENRESURS" | Researcher | scsp59@mail.ru (aquaculture) |

# Annex II: Terms of Reference for Sectoral Working Groups.

The **Technology Need Assessment** (TNA) process requires ample representation from different stakeholders to adapt the approach to the specific context of the country and its economic sectors. The "*Mainstreaming adaptation into planning processes to reduce vulnerability to climate change at local and central levels in Moldova's Agriculture Sector*"(Ag.SAP) Project creates an inclusive space for stakeholders with local capacity and knowledge that can provide useful insight to the TNA process of Agriculture sector of Moldova.

The sectoral Working Group (SWG) represents the core sectoral stakeholders as part of the development and implementation of the sectoral TNA process and generates a sense of ownership at sector level. The SWG stakeholders are expected to actively engage in the consultation process throughout the TNA phases. Through a highly consultative and participatory process, the SWG members will link elements of the TNA process with local projects, relevant processes and sustainable development programmes and plans. In this sense, it will be possible to generate synergies and avoid duplication of efforts and resources at national levels.

The stakeholders' participation in the TNA process is crucial, therefore:

- Sectoral WG members are encouraged to contribute towards development of strong partnerships and form the basis for future collaboration in the implementation of adaptation technologies in prioritised sub-sector: *cereal production, horticulture, animal husbandry and aquaculture.*
- It is expected that Sectoral WG members, through their technical expertise, their scientific rigor and through the utilisation of the best data available, will provide legitimacy to the TNA process.
- Sectoral WG members are given the opportunity to engage in the process by raising concerns and asking questions, giving them the breadth to help shape the results of TNA process.
- Since data availability is sometimes an issue, some of the TNA steps will require expert judgement and opinion, therefore, the opinion of sectoral and institutional specialists in the process is highly beneficial for this purpose.

The TNA process aims to identify technology options to support pathways of climate-resilient, low emission development. In order to achieve this, three steps have been identified for the process: 1) Technology Identification and Prioritisation; 2) Barrier Analysis and Enabling Frameworks; and 3) Technologies Action Plan (TAP). Each step of TNA process requires active and valuable contribution of sectoral WG members.

# Annex III: Technology Factsheets for selected technologies.

All technology factsheets have been developed by the National Consultants in national language and presented with the SWG members. English translations have been annexed.

**Aquaculture:**

**Technology #1**

| General information | |
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| Sector | Aquaculture |
| Technology Name | **The use of lakes with a complex destination for growing fish for consumption in polyculture.** |
| Short description of the technology option | Use the trophic natural resources of complex lakes that are not used in aquaculture to increase a sustainable volume of fish production and generate additional revenues, protect and restore aquatic biodiversity and improve aquaculture-related ecosystems. The loss of areas and the lower availability of water for aquaculture bring to the modification of the accounts and levels of ponds and lakes and their total drying up due to the frequent increase in temperature, amid the lack of precipitation and the acceleration of evaporation and drought. Lakes with a complex destination are available for use in aquaculture activities, but due to the lack of financial support, they cannot be introduced into production at the moment. Compared to the area set up for aquaculture, the recorded production shows a yield that needs to be improved, with the adoption of modern and innovative management practices in the conditions of climate change and extreme phenomena (drought). The farming technology will allow us to capitalize on the food potential of these water crops and improve the diversification of species that will increase the added value of production and promote resource-efficient aquaculture.<br>The technology provides for the growth of fish for consumption in the polyculture in the 15 lakes with a complex destination with a total area of 3700 ha by capitalizing on all the trophic levels. The technology will capitalize more complexly on the trophic potential through polyculture and foresees the increase in polyculture of the species of: carp - consumer of zooplankton; Silver carp - consumer of excess phytoplankton, Bighead carp - consumer of zooplankton; Grass carp - in the situation where there are aquatic macrophytes; pikeperch - consumer of fish species of low economic value; European wels used as a sanitary and meliorative species that consume over small sizes, celery, amphibian embryos; bream - consumer of zooplankton, untapped by other species.<br>Therefore, as a criterion for determining the formula for populating the basins is the natural trophic regime of the fish species used in polyculture. The number of specimens populated, per unit area, of each additional species depends directly and compulsorily on the potential of the fish basin in the specific trophic link of each species. Currently, in the 3 lakes where the technology is practiced, the following scheme and formula of folk zander use - 120 pcs / ha, European catfish - 100 pcs / ha, bream - 170 pcs / ha.<br>Tenology also provides for the increase of fish production with a diversification of the assortment of consumption fish, using the same human and financial effort. The increase of the fish production at the 2nd year of growth for |

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| | additional species constitutes about 100 -160 kg / ha, perch 40 - 60 kg / ha, European wels 50 - 60 kg / ha, bream 10 - 30 kg / ha. The calculations prove that the growth of additional species increases the gross income per 1 ha is 4000-6000 lei or 200 -300 euros. |
| Country social development priorities | Technology can be within competitive and resilient deployment through:<br>● Ensures the supply of nutritious and healthy products;<br>● It creates economic opportunities and jobs;<br>● Ensuring social acceptance and consumer information;<br>● Improving knowledge and innovation. |
| Country economic development priorities | ● Development of new infrastructures, restoration, modernization and arrangement of ponds and lakes of complex use to ensure reserves in periods of flow deficit;<br>● Increase the fish productivity of the basin by applying polyculture and using all trophic levels.<br>● Ensuring the attractiveness of aquaculture activity for investors, for the labour force and for the development of professional and higher specialized education;<br>● Stimulation of public and private financial investments;<br>● Improving the integration of activities. |
| Country environmental development priorities | The contribution of the technology analysed from the point of view of the action on the environment can only be made by distributing mineral fertilizers in large quantities and as a result the pollution of the waters flowing from these lakes. The problem can be analysed from the point of view of the management of the lakes with complex destination in which the technology is implemented and their action has a landmark point with the priorities of developing the environment with reference to the management of the hydrological basin according to the geographical location in the context of promoting the principle of integrated water management, at the hydrographic basin level, for the purpose of conservation, rational use and protection of waters and elaboration of legislative and normative acts of policies in the field of drought management from the perspective of assessing the impact on the water field. |
| Country climate priorities | Technology makes an essential contribution in elucidating applicative aspects aimed at increasing the effectiveness of the use of aquatic resources, dependent on climate change, in fish farming using advanced technologies and rational exploitation of biological resources. The objective pursued by the implementation of aquaculture policy technology is to increase the production of fish for consumption in lakes with complex destination as a food security measure by compensating for the decrease in the production of fish grown in totally dried water bodies |
| Adaptation needs. How the technology contributes to adaptation | The use of lakes with a complex destination for growing fish for consumption by grazing is determined by the need for rational use of lakes with a complex destination by introducing valuable species of fish into the polyculture. The restoration by including in the complex polyculture, of the new species of European wels and pikeperch as species of melioratory fish in order to reduce the numerical number of species with small economic value allows the effective capitalization of the trophic potential of the basin, the rational use of the natural productive potential. |

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| Implementation assumptions and applicability scale | The biological and fishing opportunity of this technology is the application of polyculture being a cost-effective method due to the use of all trophic levels, thus causing the increase of the fish productivity of the basin. That is why the technology will frequently monitor the water level, the hydrochemical and ichthyopathological state of the conditions of fish growth in periods with temperature variations and extreme weather phenomena - drought. |
| Technology characteristics | |
| Capital costs | Fish material for folk - 5 million lei;<br>Development of technologies for growing fish for consumption and monitoring -1 million lei;<br>Organization of fishing in lakes with a complex destination – 5 million lei;<br>Purchase of equipment - 5 million lei |
| O&M costs | Initial, operational and maintenance costs in the project<br>● Fish material for folklore - 5 million lei<br>● Purchase of material for the popular: pikeperch – 120 pcs x 20g x 3700 ha = 11100 kg x 200 lei = 1776000 lei<br>● European wels - 100 pcs x 50 g x 3700 ha = 18500 kg x 120 lei = 2220000 lei<br>● Bream - 168 pcs x 20g x 3700 ha = 12444 kg x 45 lei = 560000 lei. Transporting the sapling – 444000 lei<br>● Development of technologies for growing fish for consumption and monitoring -1 million lei<br>● Elaboration of technologies for growing fish for the consumption of pikeperch, European wels, bream in polyculture in lakes with complex destination – 600000 lei<br>● Monitoring of hydrological, chemical conditions, trophic potential – 400000 lei<br>● Organization of reproduction and fishing in lakes with complex destination – 5 million lei<br>● Reproductive expenses 4 households (electricity, fuels,) – 800000 lei Materials for incubation – 4 enterprises x 100000 lei = 400000 lei<br>● Nests in water, collection and installation in incubation devices - 5000 x 100 lei = 500000 lei<br>● Expenses (work) – 16 people x 2 months x 12000 lei – 384000 lei<br>● Nest transport – 4 x 30000 lei = 120000 lei<br>● Expenses for organization of fishing for fish for consumption in lakes – 15 households x 165 thousand lei = 2475000 lei<br>● Equipment for monitoring water quality – 4 incubators x 25000 lei = 100000 lei<br>● Other expenses - 221000 lei<br>● Purchase of equipment for the reproduction of species and organization of reproduction in households that have breeders of pikeperch, European wels and bream - 5 million lei<br>● Purchase of incubation devices for the pikeperch, bream – 16000 lei x 10 pcs x 4 households = 64000 thousand lei<br>● Purchase of incubation devices for sleep - 27000lei x 10 pcs x 4 households = 1080000 lei<br>● Water heating system in incubators – 4 households x 350000 lei = 1200000 lei |

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| | • Expenses for water supply of incubators – 4 households – 50000 lei = 200000 lei<br>• Purchase of water pumps – 4 pcs x 15000 lei = 60000 lei<br>• Purchase of materials and making nests for breeding pikeperch and bream – 5000 nests x 327 lei = 1635000 lei<br>• Purchase of equipment for monitoring – 15 pcs x 25000 lei – 375 000 lei<br>• Purchase of fishing gears - 246000 lei<br>• Equipment for the transportation of nests 4 x 35000 lei = 140000 lei<br>Total – 16 million lei |
| Safety, Reliability | Based on comparable experiences of repopulation in 3 lakes with pikeperch, European wels and bream, no infections or diseases were detected. |
| Availability and Maturity | The implementation of good practices would be established and disseminated for aquaculture and other activities aimed at balancing the use of lakes with the effective conservation of aquatic biodiversity. In addition, it would support the development, implementation and monitoring of comprehensive aquaculture management plans to ensure drought production, while managing trade-offs between production, nature protection and adaptation to climate change, the relations of all stakeholders. The availability of juveniles for popular Asian carp and cyprinids can be ensured by breeding enterprises and farms.<br>Currently, in the Republic of Moldova there are 4 certified breeding enterprises that deal with the reproduction of cyprinid species. These households are willing to reproduce new species embodied by technology. The "ACVAGENRESURS" Center has the technical documentation and tested and patented technologies for breeding the species of perch and bream. Breeding technologies may be involving the production of incubation apparatus that can be installed in existing incubator spaces. These breeding enterprises solve the complete supply of the necessary larvae, predeveloped larvae and juveniles for populating the water bodies used in aquaculture. |
| Country specific applicability | |
| Institutional Capacity | In the absence of a policy to support aquaculture, in order to implement the technology, the government by developing and implementing a subsidy mechanism (which exists in the livestock sector) must financially support the farmers of the first years in particular, until the individuals of these species, for the partial procurement of the juveniles in particular the precipice, and then to form batches of breeders for their further reproduction. Another way of support may be support by external partners or funds in the form of grants. Fermi within the limits of the available finances can only achezion the brood of cyprinids and some of the brood needed for the folk of the perch, American catfish and hat. The "ACVAGENRESURS" Center has collaborators with experience in breeding these species to provide farmers with training on the technology nominated by organizing seminars. |
| Applicability scale | The technology can be applied in all 15 lakes with complex destination with an area of 3700 ha under the management of the Apele Moldovei Agency and private economic agents through concession or in water bodies with water availability located in the basins of rivers with a surface of over 70 ha. |
| Time horizon- Short /Medium/long term | The project will require an implementation period of 3 years (Medium term) for 15 lakes. |

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| Status of technology in country | The challenge of developing technologies that can respond to the evolutionary nature of adaptation to existing climatic conditions and require continuous research and development. |
| Acceptability to locals | The technology will be attractive to all categories of farms and fisheries, as it creates new opportunities for revenue generation using trophic natural resources and allows for a greater integration of resource use at the production level. Farms using this technology should look for alternative means to cover the shortage of juveniles of pikeperch, European wels and bream to develop a capacity for resilience to climate change. As climate change has a direct influence on the artificial reproduction of fish, alternative techniques and/or the improvement of existing breeding technologies for indoors and pike are needed. The successful breeding of these introduced and local fish species suitable for aquaculture is a major requirement in aquaculture in the climate change scenario. |
| Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact? | Achieving gender equality, the implementation of technologies will contribute by framing women in incubators and scientific interventions. |
| Other country specific characteristics related to the technology (such as market potential) | The changes in the annual rainfall regime in the recent past have a significant impact on the water retention in the lakes and create the uncertainty of maintaining the necessary amount of water for aquaculture and the need for juveniles for the population. The availability of brood for popular Asian carp and cyprinids will be ensured by breeding enterprises and farms. Fish farms using this technology should seek financial means to cover the shortage of brood of perch, European catfish and bream, develop a capacity for resilience to climate change. As climate change has a direct influence on the reproduction of these species, alternative techniques and/or the improvement of existing technologies of artificial and natural reproduction are needed. Successful breeding is a major requirement in the climate change scenario of these fish species for aquaculture. |
| Paradigm Shift Potential | |
| Expandability, replicability, and applicability | The efficient management of the technology will allow you to use the trophic natural resources of lakes with complex destination that are not used in aquaculture to increase a sustainable volume of fish production of about 4-5 thousand tons of fish consumption and generate additional income, protect and restore aquatic biodiversity and improve aquaculture-related ecosystems. In the technology of growing fish by grazing, feed or other factors of production are not used, therefore, the available natural food is used by polyculture fish species. The breeding potential of the species mentioned in the actiualmente is represented by the breeding lots in the 3 enterprises with a numerical herd of about 5000 specimens of different ages and can be completed by fishing in the Dubasari and Costești-Stînca reservoirs. |

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| Potential for knowledge sharing and capacity building | • The need to assess information, skills and technology needs in order to continuously improve farmers' skills and knowledge in climate-friendly technologies;<br>• Increasing the understanding of communities and farmers about political, legal and institutional frameworks and strengthening the capacity of human resources through the training and recruitment of qualified personnel who need to be involved in building farmers' trust and to ensure that their concerns are pursued in the future planning of the challenges of climate change;<br>• Existing and new information on adaptation technologies needs to be made more accessible to farmers through methods such as demonstrations of visits in exchange for farmers, holding field days, etc.;<br>• Documenting, evaluating and integrating indigenous knowledge and management and conservation practices of water bodies. |
| Potential for enabling environment to diffuse technology | Practice of fish farming of this type has a beneficial influence on the environment, both by providing support for biodiversity in ecosystems that integrate such exploitations, but it also decreases the pressure on fishery resources in natural environments. At the same time, aquaculture s carried out in harmony with the cycles of nature and depends on the quality of the environment (water, soil, biotope), and the risk management is provided in the operating regulations of each aquaculture farm, based on the environmental legislation, ecological fish farming and the one that provides environmental services being priorities of traditional fish farming. Improve the technologies for growing fish in polyculture that allow the exploitation of the food potential of lakes with complex destination and the diversification of species in order to increase the added value of aquaculture production. |
| Potential contribution to establishing regulation and policy framework | Technology in the implementation has no potential contribution to establishing the regulatory and policy framework |
| Economic benefits | |
| Employment | The technology will create new job opportunities on fish farms that will be engaged in breeding new species included in polyculture. |
| Investment | Investment opportunities can be mentioned by developing and implementing a subsidy mechanism (which exists in the livestock sector) of farmers and joint financial support with partners through funds in the form of grants for the partial purchase of juveniles in particular the shop and for the purchase of equipment for the organization and carrying out of reproduction, materials for the construction of incubation apparatus or the purchase of appliances and equipment for monitoring the quality of water in incubation devices. |
| Public and private expenditures | Public and private expenditures in the form of funds and grants will support farmers to efficiently manage the lakes and carry out aquaculture activities for the breeding of new species included in the polyculture, by supporting the purchase of juveniles. |
| Social benefits | |
| Income | Additional revenue for fish farms as a result of increased value added. Make fish for consumption of different species available to large communities around fish basins at an affordable price. |

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| Learning | In terms of the breadth of knowledge, the greater the knowledge, the more likely a respondent is to perceive that the impact of climate change is significant on fish production. |
| Health | The technology will ensure the health of fish for consumption in fish basins as the factor that most clearly mirrors the ecological situation, related to the health of the population living near the fish basins. |
| Development impacts, indirect benefits | |
| Environmental benefits | No local pollutants and degradation of ecosystems. |
| Other, if any | Zero impact on aquatic fauna. |

**Technology #2**

| General information | |
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| Sector | Aquaculture |
| Technology Name | **An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology.** |
| Short description of the technology option | The large water deficit recorded in the lakes and ponds used in aquaculture places the Republic of Moldova in the category of countries with insufficient water and an increased risk of the impact of climate change. The negative consequences of climate change, in particular the increased incidence of heat and drought, require the government to implement adaptation practices and supportive policies to help and strengthen fish farms to reduce the threats posed by climate change to aquaculture and to seize the opportunities to invest in coherent and convergent risk reduction and adaptation measures to anticipate and reduce the impact of extreme phenomena. Following the change in climatic conditions, it is expected to change the frequency, duration and location of these phenomena, that is why aquaculture in the Republic of Moldova must move from reactive management after the production of the extreme phenomenon - drought to the proactive reduction of climate risks and dangers.<br>Riverbeds in most of the tributaries of the r. Prut, which feeds water bodies, are bred with aquatic vegetation and innate. Water from the slopes does not flow into the ponds, but spreads over the entire surface of the floodplains, penetrates the soil and evaporates. At the same time, the springs of the water storage channels are obstructed and beaten, and the ponds are intensely subjected to the clogging processes, which contribute to the sharp decrease of their volume. |
| Country social development priorities | This technology ensures a long-term increase in the volume of fish grown, creates economic prerequisites for sustainable aquaculture based primarily on the employment of natural processes, biological and renewable resources, and only secondly - on the resources purchased. Conserved domestic resources, soil with its characteristics, water, biodiversity, etc., are a prominent feature of sustainable agriculture and, subsequently, of combating desertification and land degradation caused by climate change. This technology will ensure the efficient management of ponds in the long term - the main means of production in freshwater aquaculture leading to impoverishment of the population and migration. It will effectively protect against the damage caused by drought, ensure the long-term well-being of the rural population, reduce population migration, make it possible to develop and implement various social projects. |
| Country economic development priorities | Cleaning and deepening of water supply channels, modernization and arrangement of the ponds and lakes of complex use will ensure enough water reserves in the periods of flow deficit. The management and restoration of environmental assets is seen as a way to balance conservation with sustainable use and the promotion of economic development. |
| Country environmental development priorities | This technology can contribute to carrying out quantitative assessments and water demand for all aquaculture utilities, taking into account the expected impact of different climate change scenarios. In addition, another environmental priority of the country is supporting productive activities for aquaculture farms whose activity and level of production contribute to the |

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| | achievement of environmental values, thus activities based on ecological concepts of landscape restoration and resilience. |
| Country climate priorities | ● Developing the planning and management capacity of water body ecosystems (including monitoring);<br>● Conservation, protection and valorisation of water resources for aquaculture and combating/reducing the impact of polluting anthropogenic activities.<br>● Development of research, education and training in the field of protection of water resources.<br>● Supporting environmentally friendly small and medium-sized enterprises. |
| Adaptation needs. How the technology contributes to adaptation | The rehabilitation and restoration of water bodies by carrying out works to increase the water flow, will not only provide protection against potential threats of tying up ponds caused by climate change, but also other socio-economic benefits such as increasing additional income for farms and fisheries enterprises following increased fish productivity and improving water quality, and increased food security for local communities that are provided with fish at affordable prices. |
| Implementation assumptions and applicability scale | The intervention to increase the water flow in the ponds used for growing fish in polyculture is a technology accepted on a small scale and only by farms and fisheries enterprises that have financial sources for carrying out the cleaning of the water supply system of the ponds. |
| **Technology characteristics** | |
| Capital costs | Work on cleaning the canals - 1700 million lei.<br>● Dredging ponds and bringing back into use dried water bodies.<br>● Dredging the water supply channels of the ponds. |
| O&M costs | Maintaining water supply channels free of obstructions after the initial major cleaning and the reforestation of the protection areas of the water bodies will cost about 3- million lei per year. |
| Safety, Reliability | Ensuring safe exploitation in order to improve the condition of the water bodies requires that for each of them an action plan is drawn up, which provides for: the elaboration of the demolition map of the pond basin with the execution of the works of decolmatization of the alluvial deposit basin, the delimitation and registration of the land of the water fund and the marking of the limits of the riparian protection strip, monitoring and liquidation of pollution sources of water bodies. |
| Availability and Maturity | The technology is available for deployment from a technical point of view and less from a financial point of view with a reduced maturity. |
| **Country specific applicability** | |
| Institutional Capacity | The insufficient use of existing production capacities serves as a basis for restructuring and strengthening fish farms the expansion, restoration, modernisation of existing farms and the establishment of new aquaculture production capacities. Compared to the area set up for aquaculture, the recorded production shows a yield that needs to be improved, with the adoption of modern and innovative management practices in the conditions of climate change and extreme phenomena (drought). Local authorities are not fully recognizing the importance and role played by aquaculture and require substantive capacity development, in terms of staffing as well as training, to be able to deliver instruments that can support the sector long term. |
| Applicability scale | Long-term |

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| Time horizon- Short /Medium/long term | Long-term |
| Status of technology in country | Such interventions have not been implemented in the last 30 years, it cannot be said that the technology is new. That is why some studies need to be carried out to determine the water bodies in which these works will be carried out. |
| Acceptability to locals | Due to its low cost, this technology will be acceptable to stakeholders |
| Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact? | This technology has little direct impact on gender, as most aquaculture farms are led by men and the activities of restoration of water flows would also be likely carried out by male personnel. |
| Other country specific characteristics related to the technology (such as market potential) | The total growth of fish for consumption during the entire period of action of the technology, on the rehabilitated areas will be about 3 thousand tons of fish for consumption per year. If applied regularly, this technology contributes to a yield increase of 1.0 -1.2 tons per ha, or about 2000 € / ha / year. |
| **Paradigm Shift Potential** | |
| Expandability, replicability, and applicability | Data on replicability potential of this technology is not available, but expert opinion suggests there are several hundred ponds in the country at risk of disappearance due to increased clogging and reduced water flow. |
| Potential for knowledge sharing and capacity building | The implementation of this technology has little knowledge sharing potential though it will inform and develop the capacity of farmers and institutions on the importance of ecosystem approaches in the management of water flow regimes in aquaculture. |
| Potential for enabling environment to diffuse technology | As of now, the diffusion of this technology is hindered by several barriers including the lack of an appropriate enabling environment. Pilots and demonstrated success stories will enhance the interest of stakeholders towards this technology and in turn will procure the means for the enabling environment to diffuse the technology. |
| Potential contribution to establishing regulation and policy framework | The technology has the potential to contribute to establishing a policy framework on the management of water basins and natural water flow. |
| **Economic benefits** | |
| Employment | The bulk of the employment generation opportunities will be temporary jobs for excavation and dredging works. However, a small number of jobs for the monitoring and maintenance of the water flow might also be procured by the implementation of this technology. |
| Investment | The realization of technology requires support through investments in systems and solutions that reduce water losses, in works to reduce the risk of water deficit, in river basin infrastructure and support for actions to increase water efficiency. |

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| Public and private expenditures | The revenues generated by most aquaculture actors do not allow to support the costs of dredging water channels. Public forms of financial support in the form of public expenditures are likely to be necessary. |
| **Social benefits** | |
| Income | This technology will sustain aquaculture farmer's income by providing a mean to respond to decreased productivity of aquaculture ponds due to lower water flow. |
| Learning | No major impacts on learning is expected from this technology. |
| Health | No major impacts on human health is expected from the implementation of this technology. |
| **Development impacts, indirect benefits** | |
| Environmental benefits | • Possible favourable impact on ponds biodiversity as a consequence of increased water flow.<br>• Limited long-term degradation of pond ecosystems. |
| Other, if any | Risk: depending on how the cleaning operations are carried out biodiversity and the natural environment might be impacted negatively by the dredging works. |

**Technology #3**

| General information | |
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| Sector | Aquaculture |
| Technology Name | **Fish protection system and ensuring food security in conditions of climate change.** |
| Short description of the technology option | The fish protection system presents a complex of measures to improve the conditions for the growth and wintering of fish, prophylaxis and use of populations with genetic resistance. Changes in the conditions of increased temperatures above the optimal tolerance range, changes in precipitation regime and extreme phenomena like drought, have a significant impact on water retention, changes in the precipitation model create uncertainty about maintaining the necessary amount of water for aquaculture.<br>It is therefore necessary to elaborate *fisheries and biological justifications* (FPB) for the water bodies, using as a database on the inventory, mapping, evaluation of hydrological, hydrochemical indices, trophic potential, and the classification according to the existing climatic conditions of the water bodies in the fisheries areas of Moldova, in order to predict the availability of water in the ponds, enabling farmers to adapt to existing climate change. |
| Country social development priorities | Ensuring the health of fish for consumption in fish basins as the factor that most clearly mirrors the ecological situation, related to the health of the population living near the fish basins. Morbidity and mortality in fish, caused by anthropogenic eutrophication of the basin, statistically truthfully reflects the state of health of the population, the intensity and quality of aquaculture activity in the basin region. This technology will create a direct link between the monitoring of fish population's health and the quality of the product, with sanitary implications for consumption, which is a social development priority in Moldova. |
| Country economic development priorities | Developing and implementing a Fish Protection System will allow to increase fish productivity and efficiency, thus economic margins by improving aquatic conditions for fish breeding, increasing the yield of cultivated objects, and feed savings by 25-30%. |
| Country environmental development priorities | A monitoring system for aquaculture would indirectly touch upon environmental development priorities such as biodiversity conservation, water quality and availability, and emission reduction. |
| Country climate priorities | In the medium and long term, climate change may lead to changes in the hydrological regime of the sources of water supply to aquaculture farms. As a result of the decrease in the volumes of water available in certain aquaculture farms, it will be necessary to change the structure of species, to change technological processes, etc. Monitoring the impacts of certain policy and technological interventions is key to evaluate the direction towards which the sector is moving also in terms of country climate priorities. In fact, adaptation is a key option for the climate policy of Moldova and this technology contributes to meeting such goal. |
| Adaptation needs. How the technology contributes to adaptation | Understanding the impacts of climate hazards on aquaculture performances is key to a resilient sector. Coherent countermeasures can only be developed based on monitoring of impacts of climate change on fish growth and production, and through this technology Moldova can meet its adaptation |

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| | needs by building a solid, science-based, dataset to be used for early warning and quick response to the impacts of climate change on fish production. |
| Implementation assumptions and applicability scale | ● The technology for implementing the fish protection system and ensuring food security in the conditions of climate change can be used by all farms and fisheries enterprises, promoted in particular by the scientific institution Acvagenresurs Research Center and the National Association of Fish Farmers. The final products of this technology:<br>● Fisheries-biological justifications (FPB) for water bodies in fisheries areas of Moldova to predict the availability of water in water bodies, allowing farmers to adapt to climate change;<br>● Development of a legal framework for regulating the aquaculture activity;<br>● Determination of the natural fish productivity of water bodies and the volume of fish that can be produced in existing basins under conditions of water scarcity and drought;<br>● Determination of the number of water bodies whose sources and channels of water supply are to be cleaned (improved);<br>● Ensuring the health of fish for consumption in fish basins. Reconstruction of breeding incubators;<br>● Carrying out the inventory, mapping and bonitation (evaluation of hydrological, hydrochemical indices, trophic potential) and classification according to the existing climatic conditions of the water bodies (aclimatic rayoning).<br>● The scale of application of this technology is national. |
| **Technology characteristics** | |
| Capital costs | ● The development of breeding techniques for climate change also influences the reconstruction of breeding incubators 10.8 million lei. The cost of capital may vary depending on the number of reconstructed incubators and the material used. Technical studies that may vary in cost will also be required. |
| O&M costs | ● Elaboration of fisheries-biological justifications (FPB) for water bodies in the fisheries areas of Moldova and elaboration of a legal framework for regulating the aquaculture activity 12.3 million. lei Inventory, mapping – 4 million lei.<br>● Disseminating knowledge and strengthening the capacities of governmental institutions, research and aquaculture producers.1.5 million lei. Total – 13,86 min.lei per year. |
| Safety, Reliability | As a monitoring and knowledge building technology, this has no safety issues. Reliability has also been demonstrated in few other countries, but the technology is still in the demonstration stage. |
| Availability and Maturity | The maturity status of the technology at national level is on a low scale in general, but some applications of the protection system are implemented in households (medium potential). The technology is available for implementation as a result of the development of a methodology for the implementation of the system by the „ACVAGEBRESURS" Research Center related to current practices. |
| **Country specific applicability** | |
| Institutional Capacity | The technology will allow to strengthen the administrative capacity at national, regional level to carry out actions aimed at adapting the sector to climate change, improving the compatibility between production systems and the characteristics of fisheries areas. It will increase farmers' capacity to respond to the effects of climate change by identifying, mapping and maximising fisheries at national level by aquaculture productivity classes, will contribute to |

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| | increasing aquaculture production and increasing environmental benefits and services, by:<br>● Determining the level of the natural fodder base and forecasting and planning the volume of fish for each body of water;<br>● Determination of the real, factual and legal situation of all the land areas on which the fish facilities are located - water bodies (ponds and lakes) used for the production of fish production;<br>● Identification of farms and fisheries that have suffered as a result of climate change.<br>● Drawing up the register of the units that activate and the users of water in aquaculture;<br>● Determination of the required volume of water to supply these bodies in drought conditions;<br>● Disseminating knowledge and capacity building of government institutions, research and aquaculture producers. |
| Applicability scale | National scale. |
| Time horizon- Short /Medium/long term | Long term. |
| Status of technology in country | Basic know-how about technology is available in Moldova. However, the challenge of developing the protection system that will be able to respond to climate change variability would require continuous research and development. |
| Acceptability to locals | This technology should be acceptable to all local stakeholders, as it is a strategy already accepted by research institutions and the Association of Producers as an important monitoring issue and is specifically mentioned in the Climate Change Adaptation Framework. It will be favourable as it will prevent the degradation of lake and pond ecosystems and the associated loss of services, and may also affect aquaculture, which can have serious economic implications. |
| Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact? | Addressing gender gaps and contributing to gender equality, in particular gender opportunities such as income generation, capacity building and employment. |
| Other country specific characteristics related to the technology (such as market potential) | Technology will allow to: - determine the real situation of the aquaculture sector in the conditions of climate change; - identify the production units operating and the number of users of water for aquaculture; - determine the volumes of the meliorative works of cleaning the water supply channels of the ponds. For this reason, data on the dynamics of epizootological control and water quality in fish farms in the Republic of Moldova in the current climatic conditions are capable of being of interest to many other fields of activity. |
| **Paradigm Shift Potential** | |
| Expandability, replicability, and applicability | The realisation of the technology will essentially make it possible to improve the ecological situation in water basins and to make sustainable use of aquaculture in all fisheries. In connection with the aggravation of the |

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| | epizootiological situation in the fish basins in the conditions of the water deficit, there was a need to restore the protection and control system in all fish farms, permanent sanitary-veterinary supervision, carrying out in them the measures of prophylaxis and control of diseases in fish and ensuring food security. |
| Potential for knowledge sharing and capacity building | ● Strengthen the capacities of relevant institutions to forecast the future incidence of climate change and identify action plans and improve resilience capacities in rural communities.<br>● Raising stakeholders' awareness of fish producers' competence on the potential benefits of innovative technologies to adapt to climate change.<br>● Conducting seminars, awareness-raising workshops in communities adjacent to fish farms, about the links with local livelihoods and the potential consequences of pond loss, on the well-being of the population, as a relevant measure for raising the awareness of farmers, decision-makers and practitioners about the sustainable management of aquaculture.<br>● The availability of fish farmers of knowledge and skills to support each other, with their inclusion in the development of training manuals and materials for data communication, consolidation and analysis.<br>● Dissemination of knowledge through an effective knowledge transfer programme. |
| Potential for enabling environment to diffuse technology | This technology will promote aquaculture with a high level of environmental protection and improve infrastructure for the modernisation of domestic aquaculture production. |
| Potential contribution to establishing regulation and policy framework | Based on the lack of clarity of regulatory policy in aquaculture, stakeholders interested in the implementation of the technology will propose that policies for the adoption of the sector in climate change be reviewed. Increase the understanding of communities and farmers about political, legal and institutional frameworks and strengthen the capacity of human resources through the training and recruitment of qualified personnel who need to be involved in building farmers' trust and to ensure that their concerns are pursued in the future planning of climate change challenges. |
| **Economic benefits** | |
| Employment | The technology will create new job opportunities on fish farms that will be engaged in breeding new species included in polyculture. |
| Investment | Financial resources are one of the key factors in determining adaptability, as most of the planned adaptation actions that are subject to technology deployment require investments that producers and other stakeholders currently lack. The financial resources of existing aquaculture producers but also of those who want to develop a business in this field are, in most cases, deficient in ensuring the co-financing of investments in the field of aquaculture. |
| Public and private expenditures | In the absence of subsidisation of aquaculture activities, expenditure can only be private. |
| **Social benefits** | |
| Income | Additional income for fish farms. Making available fish for consumption of different species at an affordable price. |
| Learning | For a more coherent and easier approach to the design, implementation and monitoring of actions under technology, they will be structured according to criteria on economic, environmental and social aspects. In the implementation |

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| | all stakeholders require to commit to common objectives and share risks, but the main basic element is mutual trust. With commitment and responsibility from all sides, difficulties can be overcome, success can be achieved, and development can be achieved. |
| Health | The technology will ensure the health of fish for consumption in fish basins as the factor that most clearly mirrors the ecological situation, related to the health of the population living near the fish basins. |
| **Development impacts, indirect benefits** | |
| Environmental benefits | ●No GHG emission in CBF.<br>·No local pollutants and ecosystem degradation.<br>·Minimum use of power.<br>·Zero impacts on indigenous/endemic aquatic fauna. |
| Other, if any | |

**Horticulture:**

**Technology #1**

| General information | |
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| Sector | Horticulture |
| Category | Agriculture |
| Technology Name | **Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.).** |
| Short description of the technology option | Reliable, efficient, and environmentally friendly irrigation systems are needed to support sustainable intensification of agriculture in the context of adaptation to climate impacts in Moldova. Water and energy are important resources for economic and social development as well as for environmental integrity, while both are essential to irrigation. One approach for improving water use efficiency is to replace surface irrigation systems with more efficient pressurised (sprinkler and drip) systems to significantly reduce water application on the farm scale, thereby increasing water and land productivity, but also increasing energy and investment requirements. The energy used by pumping stations generates significant greenhouse gas (GHG) emissions, which then contribute to accelerating climate change, therefore modern irrigation systems necessarily need to rely on technologies that maximise both water use efficiency (e.g. drip irrigation) as well as energy efficiency. |
| Country social development priorities | Supporting young people, especially those from rural areas, in their professional affirmation, by stimulating their employment, professional counselling and encouraging career growth, especially young people who are not in the labour market, in the educational system and do not benefit from training for the development of the sector agriculture by increasing the competitiveness, sustainability, productivity and quality of horticultural production. |
| Country economic development priorities | Thanks to the provision of jobs to the population, it is possible to provide the workers with a salary and from it taxes that will lead to the economic growth of the country. At the same time, a good part of the population that receives social aid will be employed, thus the unemployment rate is reduced, and the state will reduce its own allowances for the maintenance of the population. |
| Country environmental development priorities | Irrigation of cultivated areas is becoming increasingly necessary in light of climate change's drastic impact on agriculture. In addition to the fact that it is possible to increase the productivity of agricultural crops per surface unit, it creates a favourable environment for the occurrence of solidification processes and the diversification of flora and fauna, with a beneficial outcome on the balance in nature. |

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| Country climate priorities | Currently, because of climate change, not only the average annual, monthly and daily temperature is increasing, but also the number of days with actual temperatures. Thus, in combination with irrigation and fencing, it will allow farmers to cultivate the land with crops that have a longer vegetation period. Precipitation is decreasing, but the problem of water insufficiency can be solved by accumulating it in reservoirs from regular or torrential rains, which are becoming frequent in the Republic of Moldova. |
| Adaptation needs. How the technology contributes to adaptation | In the Republic of Moldova, the lack of humidity is considered the biggest limiting factor in crop production. All measures taken to maintain soil moisture are welcome, but the high impact effect remains from the irrigation of agricultural land. The irrigation technology must respond to the specific needs of horticultural crops, especially in the phenophases of maximum consumption if the soil moisture is insufficient due to precipitation. Application of this technology in combination with RES will allow farmers to have an affordable and sustainable production of crops for a longer period and tailor the production to the market requirements. |
| Implementation assumptions and applicability scale | Irrigation systems are a necessity for our country in providing the population with fresh food products now and the importance will grow with advances of climate impacts, particularly under pessimistic climate scenarios. The need to use irrigation is major, but it is applied in a restricted manner due to a number of limiting factors among which the high upfront capital costs, water availability, limited knowledge and skills in combining RES with irrigation system. Specific skills are needed to apply efficient irrigation methods such as underground, and drip irrigation.<br><br>Depending on the type of technology used to irrigate plants, it can be applied at small scale up to 10 ha and large scale – thousands of ha. In the last case, if the irrigation system is sustained using RES, a large surface of PV (mono- or polycrystalline) is required to be in place. |
| **Technology characteristics** | |
| Capital costs | The costs for a drip irrigation system reach values of 48 thousand MDL/ha for drip irrigation, 40 thousand MDL/ha for sprinkler irrigation, MDL thousand lei/ha for underground irrigation. |
| O&M costs | Operation and maintenance of an irrigation system would consist 5-10% annually of the total value of hard components of technology. Additional costs will require the maintenance of the PV system. |
| Safety,<br><br>Reliability | Agricultural producers who have knowledge and skills in the field can accept and successfully use irrigation systems in horticultural production. But, at the same time, the acquired skills require constant updating and improvement to ensure the sustainability of production in a rapidly changing environment under climate change. The hard component of this technology is not difficult to use but requires good maintenance and availability of spare parts. |

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| Availability and Maturity | Various types of irrigation systems are currently available on the market. However, the combination of modern irrigation systems operationalized by RES is a novelty and currently has limited application. At the same time, considering the advantages of this approach the interest is a growing one and is expected to have a large application at farm level, particularly for small scale production. |
| Country specific applicability | |
| Institutional Capacity | Irrigation systems, like other technologies, are supported by the policies of the state and the Ministry of Agriculture and Food Industry, through the development of strategies and subsidies to cover the partial expenses borne by agricultural producers. The Banks' policy also provides lines of credit to agricultural producers, although the rates are high. There are other national/international funding bodies – IFAD, LED, ODA, USAD, etc. |
| Applicability scale | Irrigation systems can be used for all horticultural crops from annual to perennial crops, in which one or more crops can be obtained per year. The applicability is high because water scarcity is becoming more acute. Due to the flexibility of the technology, it can be applied by small farmers and also in industrial production. It is assumed that the potential for this technology is on 300 thousand ha area. |
| Time horizon- Short /Medium/long term | The operating period of the irrigation system is 12-17 years, depending on how it is maintained. |
| Status of technology in country | The estimates show that irrigated agricultural land cultivated with horticultural crops is over 8 thousand ha, of which over 4700 ha are drip-fed, approximately 3300 ha are sprinkled, and up to 200 ha are underground. |
| Acceptability to locals | The technology is not absolutely new, it is known by the locals, so it is accepted, regardless of complexity and endowment, as it responds to the producers needs and also to the local market with high potential for export. |
| Impact on gender.<br><br>Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact? | Depending on the complexity of the technology, both women and men can be involved in the work process. If men are mostly involved in the actual setting up of the system, then women can successfully monitor and direct the process as operators. |
| Other country specific characteristics related to the technology (such as market potential) | Fruits, vegetables and grapes grown through the use of irrigation and RES systems can compensate for their insufficiency or obtain horticulture products earlier when they are in demand on the market and have a higher selling price. They would substitute imported products which do not always have the appropriate quality and price. |
| **Paradigm Shift Potential** | |

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| Expandability, replicability, and applicability | Considering current climatic variability and expected climate changes that come with high water shortage, it is necessary to expand the area of irrigated lands in horticulture production to ensure its sustainability, country's food security and healthy diet of population. |
| Potential for knowledge sharing and capacity building | There are companies in the country that offer consultations and services regarding the construction and operation of irrigation systems by different methods for different groups of crops and with different ways of energy used, mostly conventional and less RES. At the same time, producers are open to sharing their experiences and results obtained in the cultivation process. Horticulture producer associations play an important role in this regard. |
| Potential for enabling environment to diffuse technology | There is a big potential for defusing this technology, if the equipment would be produced locally, with less imported parts, particularly for PV, which would reduce the up front and O&M costs. The policy and regulatory framework is to be more supportive in the use of this technology , with more fiscal facilities. Irrigation systems will allow cooperation between agricultural producers and scientific researchers in order to establish the optimal parameters for one or another method (drip, underground, micro-sprinkling, aspersion) and disseminate the results to the entire production sector with a possible implementation of the results in practice. |
| Potential contribution to establishing regulation and policy framework | Agricultural producers, by joining various producer associations, can have the opportunity to submit to the Ministry, government, parliament, various Draft Amendments, Laws, Decisions to contribute to a more friendly enabling environment for use of the technology. As mentioned, more tax facilities would benefit a quicker deployment of this technology |
| Economic benefits | |
| Employment | Application of the proposed irrigation and RES technologies will generate the opportunity to have new jobs for both skilled and professionally trained personnel , but also for unskilled people. |
| Investment | Costs for purchasing and installing irrigation systems: drip irrigation on the surface: 2000 - 5000 euros/ha, depending on the chosen options and equipment; underground drip irrigation: 2100 – 5500 euros/ha. They depend on the materials, machines, devices, technologies used. Valoric, these being reflected above |
| Public and private expenditures | The size of the state subsidy is granted to agricultural producers, including through water user associations, for the partial compensation of expenses incurred when using energy resources to pump water for irrigation (electricity, diesel and gasoline), as follows:<br><br>1) 50% – of the cost of expenses incurred when using electricity to pump water from centralized irrigation systems;<br><br>2) 80% – of the cost of expenses incurred when using electricity to repump water two or more times from the centralized irrigation system; |

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| | 3) 0.5 lei for each 1m3 of water actually used for irrigation through the irrigation systems, other than those mentioned in sub-points 1) and 2) of this point, according to the reports on water use, approved in the manner established by the "Moldova Waters" Agency ".<br><br>The expenses of agricultural producers are summed up in the use of inputs and outputs, namely: maintenance of irrigation systems, machinery, apparatus; the cost of water used for irrigation; the cost of fuel and lubricants; salaries, all categories of taxes and fees, costs of transport, marketing, logistics, etc. |
| Social benefits | |
| Income | Extended period of horticulture production based on an autonomy source of energy will become a reliable income source. |
| Learning | Both specialists and workers will have expertise in horticulture sustainable production and build up a climate resilient production in a risky area . |
| **Health** | Horticultural production will contribute to the healthy diet of the population. |
| **Development impacts, indirect benefits** | |
| **Environmental benefits** | The systems facilitate the cultivation of various varieties and species of plants for greater diversification of agricultural crops. |
| **Other, if any** | |

**Technology #2**

| General information | |
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| Sector | Horticulture |
| Category | Agriculture |
| Technology Name | High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency. |

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| Short description of the technology option | Low-tech greenhouses are single-span pad and fan-cooled high tunnels. The medium-<br><br>Tech greenhouses are tall, multi-span, glass-covered greenhouses with a soilless growing system, a heating system usually diesel or natural gas-fired, and a controllable shade screen. The Medium-tech greenhouses are also pad and fan-cooled. Modern High-Tech greenhouses are made of advanced thermal efficiency materials, including a plethora of different double or triple-glazed glass panels, or even cutting-edge phase-change materials (PCM). These greenhouses use renewable energy systems to provide heat and cooling. Making best use of available agricultural residues (such as pruning waste, post-harvest waste biomass etc.) these greenhouses are equipped with biomass burners that can dry and filter the exhaust gases to deliver only $CO_2$ to growing vegetables. Hi-Tech greenhouses are also equipped with heat-pump air conditioning systems, and the structure can be completely sealed from the outside air. Because of this sealed environment, biogenic $CO_2$ injection can be used to promote production and displace fossil fuels. |
| Country social development priorities | Increasing the level of employment by increasing the number of jobs, raising the employment rate, and attracting the inactive population, especially from rural areas, temporary migrants, young people, etc. in the labour market. Improving the quality of the labour force and increasing labour productivity by correlating the requirements of the educational system with the needs of the labour market, considering the changes due to the digitization and robotization of jobs and promoting lifelong learning. Facilitating the integration of vulnerable groups in the labour market by reducing and eliminating barriers that limit their entry or return to the labour market, as well as improving their employability through programs adapted to their needs. |
| Country economic development priorities | Thanks to the provision of jobs to the population, it is possible to provide the workers with a salary and from it taxes that will lead to the economic growth of the country. At the same time, a good part of the population receiving social assistance will be employed, thus the unemployment rate will be reduced, and the state will reduce its own allowances for the maintenance of the population. |
| Country environmental development priorities | Considering that the greenhouses are closed spaces, they prevent the entry of pests and birds inside, thus reducing the need to apply methods to combat them, especially chemical methods. At the same time, thanks to the monitoring of the growing conditions, the risk of disease of cultivated plants or the treatment of outbreaks of sick plants is reduced. The aforementioned will lead you to reduce environmental pollution and maintain the diversity of natural flora and fauna. Greenhouses allow the mass use of biological methods of protection, namely – the use of biopreparations, entomophages, etc. |

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| Country climate priorities | The Republic of Moldova, having a temperate continental climate, has a series of diverse climatic conditions, both negative and positive.<br><br>The duration of the effective sunshine during the year oscillates on the territory of the country from 1940 to 2180 hours, summer is 60 - 70%, and winter 20 - 30%. Solar energy reserves, expressed by the size of the radiation balance, constitute about 2100 MJ/m2 per year, which is the basic energy source, which ensures soil heating, evaporation and the average air temperature level.<br><br>Thanks to the climate changes of recent years and considering the difficult possibility of monitoring climatic factors, greenhouses allow non-stop monitoring and regulation of ecological factors (temperature, air and soil humidity, gas regime, etc.).<br>Winters in the Republic of Moldova are cold, with average temperatures of -4°C and -6°C. Summer in the Republic of Moldova is warm, with average temperatures of 25-27°C in June and 29-32°C in July and August. In summer, the rains are heavy and often cause damage. The months of May and September are similar in average temperature, which is, in both months, 18°C during the day and 10°C at night. |
| Adaptation needs. How the technology contributes to adaptation | Considering that greenhouses present temporary or capital constructions where ecological factors are more or less controlled. Depending on the technical equipment they have, it makes this technology not dependent on climate change, or the greenhouses must be equipped with irrigation systems to compensate for the lack of water, heating systems during the cold period of the year and ventilation systems during the warm period of the year, shading systems, etc. adapted to the needs of agricultural crops. |
| Implementation assumptions and applicability scale | Modern and efficient greenhouses are an opportunity for our country to provide the population with fresh and safe food products. Part of the population in rural areas has simple greenhouses on very small areas to ensure their own consumption of vegetables. Thus, modern and efficient greenhouses that use renewable energy can be used for the production of annual crops (vegetables) as well as perennial crops (fruits, apple trees and grapes, etc.). |
| Technology characteristics | |
| Capital costs | The costs for the construction of the tunnels vary between 5000-10000 lei, for permanent greenhouses 2000000-4500000 lei or about 100000 – 2000000 €. |
| O&M costs | Maintenance would constitute 5-10% annually of the value of goods and machinery. |
| Safety,<br><br>Reliability | The greenhouses present modern, efficient, and safe technology both in the production of horticultural crops and provide safety in the work process of the employees. Greenhouses can also achieve ecological and/or biologically safe production. |

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| Availability and Maturity | Agricultural producers who have knowledge and skills in the field can accept and successfully use greenhouses in agricultural production. But, at the same time, it also requires some improvement of skills and knowledge that can be ensured by involvement in providing consultations and supervising production by national and/or international experts. |
| Country specific applicability | |
| Institutional Capacity | The construction of modern and efficient greenhouses along with other technologies are supported by the policies of the state and the Ministry of Agriculture and Food Industry, through the development of strategies and subsidies to cover the partial expenses borne by agricultural producers. The Banks' policy also provides lines of credit to agricultural producers, although the rates are high. There are other national/international funding bodies – IFAD, LED, ODA, USAD, etc. |
| Applicability scale | Greenhouses are those temporary or capital constructions that can be used for a wide spectrum of agricultural crops from annual to perennial ones, in which one or more harvests per year can be obtained. |
| Time horizon- Short /Medium/long term | The average life of a polycarbonate greenhouse is about 7–10 years. However, much depends on the quality of the material and the assembly of the structure itself: in some cases, the greenhouse becomes unusable after 3–4 years of operation, and sometimes it lasts up to 15 years. |
| Status of technology in country | Based on our studies, at the present time the area of greenhouses on the territory of the Republic of Moldova is approximately 332 ha, of which vegetables 84 ha, vines - 44 ha, fruit crops and fruit bushes 145 ha and flowers - 59 ha. |
| Acceptability to locals | The technology is not absolutely new, it is known by the locals, so it is accepted, regardless of complexity and endowment. |
| Impact on gender.<br><br>Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact? | Every technology has an impact on gender. The necessary work to be done on the agricultural crops in the greenhouses is mostly done by women or in some works people with disabilities may be involved. Men are usually involved in construction work and maintenance of buildings and equipment. |
| Other country specific characteristics related to the technology (such as market potential) | Fruits and vegetables obtained from greenhouses can compensate for their insufficiency in the off-season or obtain them earlier when they are in demand and have a higher selling price. They would substitute imported products which do not always have the appropriate quality. |

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| | Taking into account that all factors are under control, it provides stability in obtaining harvests and respectively ensuring consumers with always fresh products. |
| Paradigm Shift Potential | |
| Expandability, replicability, and applicability | It is real to expand the surface of the greenhouses during their development and depending on the level of their development in terms of labour force and financial resources. |
| Potential for knowledge sharing and capacity building | There are companies in the country that offer consultations and services regarding the construction and operation of greenhouses with different degrees of equipment for different groups of crops and with different ways of using energy (traditional or renewable). At the same time, producers are open to sharing their experiences and results obtained in the cultivation process. Producer associations play an important role in this regard. |
| Potential for enabling environment to diffuse technology | The greenhouses will allow you to collaborate between agricultural producers and scientific researchers in order to establish the optimal parameters for one or another technology and disseminate the results to the entire production sector with a possible implementation of the results in practice. |
| Potential contribution to establishing regulation and policy framework | Agricultural producers, by joining various producer associations, can have the opportunity to submit to the Ministry, government, parliament, various Draft Amendments, Laws, Decisions, etc. to come to the aid of producers and owners of greenhouses. |
| Economic benefits | |
| Employment | It allows the employment of unskilled, skilled and professionally trained personnel. |
| Investment | Investments in the greenhouse complex are different. They depend on the materials, machines, devices, technologies used. Valoric, these being reflected above. |

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| Public and private expenditures | In 2019, the amount (lei) authorized to stimulate investments to produce vegetables and fruits for protected land (winter greenhouses, solariums, tunnels) – 2249891 lei for an area of 152.37 ha. Or for agricultural producers the subsidy will be in the amount of 40% and for groups of producers 50% as support granted by the state.<br><br>The maximum value of the subsidies can be 150,000 lei or the amount of the support granted is calculated in the form of compensation in percentage instalments in proportion to 30% of the cost of the greenhouse modules, equipment and machinery purchased, necessary for the production of vegetables on protected land.<br><br>The expenses of agricultural producers are summed up in the use of inputs and outputs, namely: maintenance of greenhouses, machinery, apparatus; the cost of seeds and planting material; the cost of PUF and fertilisers; the cost of water used for irrigation; the cost of fuel and lubricants; salaries, all categories of taxes and fees, costs of transport, marketing, logistics, etc. |
| Social benefits | |
| Income | Source of income for employees and development of the entity. |
| Learning | Both specialists and workers require the improvement of the level of knowledge and personal skills. This is achievable by working with academia. |
| Health | Horticultural production in protected land allows the population to be provided by covering their needs with some products of plant origin in some periods of the year. |
| Development impacts, indirect benefits | |
| Environmental benefits | The protected land limits the access of harmful environmental factors (diseases, pests, etc.) that require the reduced use of phytosanitary products, as a result it does not increase the toxicity of the environment. |
| Other, if any | |

**Technology #3**

| **General information** | |
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| **Sector** | Horticulture |
| **Category** | Agriculture |
| **Technology Name** | Hydroponics with recyclable solutions |

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| **Short description of the technology option** | Hydroponics is a type of hydroculture that consists of growing plants without soil. This implies that the roots of the plants are either immersed in a nutrient solution or planted in an inert and porous medium, such as mineral wool, clay balls or coconut fibres, which retain some of the nutrient solution and help to oxygenate the plant properly. The nutrient solution is calculated to perfection, and its pH and temperature must be constantly checked with measuring instruments.<br><br>The main objective of hydroponics is to stimulate plant growth by controlling the amounts of water, mineral salts, and dissolved oxygen they receive. Oxygenation of the root zone is essential because it lack leads to the inhibition of root formation and growth (their mass and length are much smaller) and the reduction of rooting percentage. Oxygen is also what ensures the transport of nutrients in the plant, in the form of molecules. |
| **Country social development priorities** | The biggest challenge of the rural population of Moldova is the lack of stable jobs, especially during the cold period of the year. Thus, it leads to the migration of the population from rural to urban areas or they leave the country to find a job abroad, where these opportunities exist. The construction of hydroponic systems in rural localities will lead to the maintenance of the population in the communities, thanks to the favourable working conditions and the assurance of a stable income. The latter will lead to the increase of the population trained in agriculture and respectively, to provide the population with fresh domestic food products. |
| **Country economic development priorities** | The hydroponic system is a system that requires investment, but the spaces that you had another destination can be used, then a vertical hydroponic system with the surface of 60 m2 can be managed by a single worker. In this way, taxes can be collected for the rent of premises, including in cities, and it solves the problem of insufficient labour force.<br><br>A perspective estimate of the level of productivity of horticultural crops for the next 10 years suggests an increase in the level of productivity of orchards, nut trees and fruit bushes towards the horizon of 2030 of about 8.3 t/ha (+45% compared to 2020). Thus, the pessimistic version indicates an increase of about 5.1%, while the optimistic forecast assumes an increase of about 86%. In fact, the optimistic version approaches the maximum level of productivity (9.9 t/ha), recorded in the Republic of Moldova in 1983. |
| **Country environmental development priorities** | Hydroponics have recently evolved with ways to reduce the environmental impact they cause. They are those closed systems that reuse the nutrient solution as a result of environmental protection and greater economy in its use. Plants tend to be less prone to disease. To combat harmful factors, advanced methods of combating insects and diseases affecting plants can be introduced. Thus, the risk of environmental pollution with residues of fertilizers and phytosanitary products is minimized |

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| **Country climate priorities** | Hydroponic greenhouses have minimal dependence on external factors - the production process is fully automated with control of temperature, humidity, light, pH and nutrients. Virtual monitoring of all production processes crops are not influenced by weather conditions and can be cultivated in several cycles all year round. Crops are not influenced by the season, they can be productive 12 months a year. Crops can be grown all year round, you no longer have to worry about low or high temperature outside. At the same time, being a closed-cycle technology, it does not emit greenhouse gases and is a technology with good adaptation to climate change. |
| **Adaptation needs. How the technology contributes to adaptation** | Depending on the technical endowments they have, it makes this technology not dependent on climate changes, or hydroponic systems must be equipped with water supply systems for the formation of the plant growth environment, heating systems during the cold period of of the year and ventilation systems in the warm period of the year, shading and lighting systems, etc. adapted to the needs of agricultural crops. |
| **Implementation assumptions and applicability scale** | Modern hydroponic systems are a necessity for our country to provide the population with fresh and safe food products. Some of the population in rural areas have simple hydroponic systems on very small surfaces to ensure their own consumption and the local market. Thus, modern and efficient hydroponic systems that use renewable energy can be used to produce vegetables and greens. |
| **Technology characteristics** | |
| **Capital costs** | The necessary costs for 1 ha of hydroponic systems are between 2000000-5250000000 thousand lei or approximately €300-600 for each m$^2$. |
| **O&M costs** | Maintenance would fall within 5-10% annually of the value of goods and equipment. |
| **Safety,**<br><br>**Reliability** | The technology is safe in the process of producing vegetables and greens and provides safety in the work process of employees. Also, by means of hydroponic systems, ecological and/or biological safe production can be obtained up to 8-10 harvests per year. |
| **Availability and Maturity** | Hydroponic systems are accepted by growers to a lesser extent. This is due to the more limited level of knowledge and skills. |
| Country specific applicability | |
| **Institutional Capacity** | The construction of ordinary hydroponic systems with other technologies are supported by the policies of the state and the Ministry of Agriculture and Food Industry, through the development of strategies and subsidies to cover the partial expenses borne by agricultural producers. The Banks' policy also provides lines of credit to agricultural producers, although the rates are high. There are other national/international funding bodies – IFAD, LED, ODA, USAD, etc. |

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| **Applicability scale** | Hydroponic systems are those technologies that can be used for a wide spectrum of horticultural crops, in which one or more crops can be obtained per year. Currently, the area of hydroponic greenhouses exceeds the area of 200 ha. |
| **Time horizon- Short /Medium/long term** | Depending on the structure and quality of the materials and goods used, it can be from 10-15 years and more. |
| **Status of technology in country** | Currently there are few agricultural producers who implement hydroponic systems in obtaining horticultural production. |
| **Acceptability to locals** | The technology is relatively new, less known by the population, so it is interesting and can be accepted, regardless of complexity and endowment. |
| **Impact on gender.**<br><br>**Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact?** | Every technology has an impact on gender. The necessary work to be done on the agricultural crops in the greenhouses is mostly done by women or in some works people with disabilities may be involved. Men are usually involved in construction work and maintenance of buildings and equipment. |
| **Other country specific characteristics related to the technology (such as market potential)** | Vegetables obtained from hydroponic systems can compensate for their insufficiency in the off-season or obtain them earlier when they are in demand and have a higher selling price. They would substitute imported products which do not always have the appropriate quality.<br><br>Considering that all factors are under control, it provides stability in obtaining harvests and respectively ensuring consumers with always fresh products. |
| **Paradigm Shift Potential** | |
| **Expandability, replicability, and applicability** | It is necessary to expand the surface of hydroponic systems during their development, but it depends on the level of their development in terms of labour force and financial resources. |
| **Potential for knowledge sharing and capacity building** | There are companies in the country that offer consultations and services regarding the construction and operation of hydroponic systems with different degrees of endowment for different groups of crops and with different ways of energy used (traditional or renewable). At the same time, producers are open to sharing their experiences and results obtained in the cultivation process. |
| **Potential for enabling environment to diffuse technology** | Hydroponic systems will stimulate the collaboration between agricultural producers and scientific researchers to determine the optimal parameters for one or another technology and the dissemination of the results to the entire production sector with a possible implementation of the results in practice. |

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| **Potential contribution to establishing regulation and policy framework** | Agricultural producers, by joining various producer associations, can have the opportunity to submit to the Ministry, government, parliament, various Draft Amendments, Laws, Decisions, etc. to help producers and owners of hydroponic systems. |
| **Economic benefits** | |
| **Employment** | It allows the employment of unskilled, skilled and professionally trained personnel. |
| **Investment** | The necessary costs for 1 ha of hydroponic systems are between 2000000-5250000000 thousand lei or approximately €300-600 for each $m^2$. |
| **Public and private expenditures** | The expenses of agricultural producers are summed up in the use of inputs and outputs, namely: maintenance of greenhouses, tilings, apparatus; the cost of seeds and planting material; the cost of phytosanitary products and fertilizing agents; the cost of water used; the cost of fuel and lubricants; salaries, all categories of taxes and fees, costs of transport, marketing, logistics, etc. |
| **Social benefits** | |
| **Income** | Additional income for agricultural producers owning a hydroponic system because of increased added value. Make vegetables and greens for consumption available to large communities around the place of production at an affordable price. |
| **Learning** | Both specialists and workers require the improvement of the level of knowledge and personal skills. This is achievable by working with academia. |
| **Health** | The horticultural production obtained in hydroponic systems allows the provision of the population by covering their needs with some products of vegetable origin in some periods of the year and the provision of diverse, fresh, and healthy products. |
| **Development impacts, indirect benefits** | |
| **Environmental benefits** | Hydroponic systems limit the access of harmful environmental factors (diseases, pests, etc.) that require the reduced use of PUF, as a result it does not increase the toxicity of the environment. At the same time, the technology provides for the use of recyclable solutions, which will only benefit the environment. |
| **Other, if any** | |

**Livestock:**
**Technology #1**

| General information | |
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| Sector | Livestock |
| Technology Name | **Increase of areas under irrigation to produce feed** |
| Short description of the technology option | Food security is regularly affected by weather conditions. Drought, floods, and other extreme natural phenomena (torrential rains, hail, storms and frosts) occur regularly and have a significant impact on living standards and the rural economy as a whole. This has been felt acutely over the past 5-10 years, so the number of cattle has drastically decreased in both the commercial farms as well as household farms. If in the case of poultry and pigs it is possible to import feed (maize and wheat), for cattle the import of silage is not feasible due to complicated logistics. To provide a dairy-producing cow, about 1 Ha of arable land is needed (for growing maize for silage, hay and cereals). As of 2023, in the Republic of Moldova, the population of milking cows in commercial farms reached some 5 thousand heads. Of the daily quantity of feed, the largest share is held by maize silage, about 25-30 kg / day per animal. According to field data, the annual harvest of maize silage is about 30-40 tons / Ha, during drought years it yield is reduced by up to 50%, or 15-20 t/ha. However, the use of proper irrigation systems on maize can sustain yields of 25-35 tons / Ha. Along these lines, high input management (irrigation, fertilizers application, crop rotations, etc.) would increase productivity to about 50 t / ha in non-dry years.<br><br>In the Republic of Moldova, the irrigation system is practiced for food crops and to a lesser extent for feed production.<br>In order to fill the yield gap due to recurrent droughts and provide enough feed to the national heard, it is proposed to increase the irrigation area of forage crops (especially maize for silage) by about 5 -15 thousand hectares in the northern and south-eastern areas of the country respectively, where cattle farms are concentrated and have been historically more affected by silage shortage.<br>Deploying efficient irrigation systems for feed production in Moldova will require a two-stage approach. Firstly, attentive planning and feasibility studies will be carried out to define the impacts of the system on the national renewable water resources and estimate farm costs and benefits, select farming areas and consortia of farmers to be enrolled. The second stage is the deployment of the planned irrigation system using most efficient technologies as per the recommendations of the feasibility study. Sprinklers are being phased-out as an irrigation technology due to their vast losses and lack of efficiency in delivering water to the plant when and where needed. Drip irrigation systems, especially sub-surface ones, are replacing sprinklers even for silage maize production and coupled with GPS guided tractors can operate at high efficiency in maize fields. Monitoring system for irrigation efficiency will be a relevant component in this technology to ensure that gains are maximized through the use of advanced technologies such as the Internet of Things and App-based control interfaces., Concerning the irrigation technology, the LPS system, which stands for Low Pressure System, is a solution that uses a principle similar to that of conventional drip irrigation except that it has been designed to irrigate large surface areas without any part of the system being pressurized. With only 1 or 2 bar of |

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| | pressure permitted by the setting up of a relatively high head and large diameter primary pipes with very low head losses conveying large volumes of flow, the LPS system allows for more than 30 ha to be irrigated in one irrigation, even more if the land is flat. The drippers used for this solution have a very low flow rate of 0.6 l/h. The quality of the filtration upstream is, therefore, essential for a sustainable system. |
| Country social development priorities | The development of the livestock sector is a major priority, including the development of small and micro farms. Provided that development grants from international projects (World Bank), the EU-funded IPARD program, will be available for the livestock sector, these could represent a useful resource for increasing the resilience of livestock farms in Moldova to the impacts of climate change in the context of feed production. |
| Country economic development priorities | The national development strategy "Moldova 2030" foresees a 5% to 7% growth rate in GDP towards 2030. In addition, specific livestock sector policies such as the "National Program for the Development of the Milk Sector in the Republic of Moldova 2020-2026" indicate that the development and efficiency of the livestock sector in general and, the milk in particular refers to the improvement of the production performance of all animal species, as well as of their growing and exploitation conditions, which will lead to an increase in the relative share of livestock production in the economic and social value of agricultural production. |
| Country environmental development priorities | The National Development Strategy "Moldova 2030" indicates: Environment.<br>Healthy: ensuring the fundamental right to a healthy and safe environment.<br>Ensuring flood and drought risk management (Environmental strategy)<br>for the years 2014-2023 and the Action Plan for its implementation). |
| Country climate priorities | The national strategy for the development of the irrigation sector 2030 emphasizes the need to reset and rehabilitate the irrigation sector, and the goal of increasing for the total irrigated surface by 250 thousand ha by 2030.<br>At the same time, the “National Strategy for Agricultural And Rural Development 2022 – 2027”, Which will also include the National Program for the development of the milk production sector – which will have the target of setting up 100 new dairy farms, with a herd of 100 heads of milking cows per holding (total herd 10 thousand heads), the average productivity being 8 thousand kg / head / lactation. At the same time, emphasis will also be placed on the modernization of the over 200 already existing livestock farms, as well as their completion with highly productive animals. Thus, the number of animals on dairy farms is expected to increase in the coming years from 5 thousand heads to 15 thousand heads. To provide these animals with fodder (especially maize silage) it is necessary to equip with irrigation systems about 15 thousand ha of land to produce fodder. |
| Adaptation needs. How the technology contributes to adaptation | Drought, because of climate change, has a major impact on the provision of animal feed, subsequently the provision of food for the population. Drought, which in Moldova has been observed to recur every 2-3 years over the last two decades, animal husbandry suffers from lack of feed, especially cattle breeders. Thus, when due to drought there is a shortage of feed, especially silage, farmers are forced to slaughter their animals to get rid of liability. The intensity of the drought in recent years requires the implementation of this technology for the survival of the livestock sector. |

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| Implementation assumptions and applicability scale | It is proposed that initially the irrigation systems for forage crops will be implemented for farmers in the north of the country where the milk sector is more developed. Also, a priority will be those farmers who have access to water from rivers. Local irrigation systems of farmers are planned to be connected to centralized ones that are in turn feeding from surface water sources such as rivers. According to MAFI data in the northern area of the country, about 50 cattle farms are located, part of which could implement this technology.<br>According to the strategy: Annually until 2030, about 11 thousand ha of land suitable for irrigation will be built / arranged for irrigation connected to sustainable sources of quality water for irrigation. This would allow by 2030 to be additionally arranged for irrigation at least 108 thousand ha in the service area of 77 central irrigation system rehabilitation.<br>To provide the milk sector with fodder, it is proposed as a technology to increase the irrigation area of fodder crops by 15 thousand Ha. |
| **Technology characteristics** | |
| Capital costs | The cost of technology at the given stage is complicated to estimate. A feasibility study is necessary to establish the areas that have access to water.<br>The arrangement for irrigation of 15 thousand ha during 2021-2030 are necessary investments in the amount of about 115 million Euro (design works, workmanship, equipment, machinery, pipes, etc.).<br>If the irrigation areas will have access to the water from a centralized system, then only the cost for the irrigation equipment (pumps, Hose Reel Irrigation Machine and drip irrigation systems) for this area will be about 50 million Euro. |
| O&M costs | Operating and maintenance costs are difficult to calculate, but will be significant. Especially since they need to be maintained, repaired, carry out prophylaxis work and in years when they will not be used (rainy years). |
| Safety, Reliability | The technical design will be developed according to all EU rules and requirements, thus ensuring their full safety. |
| Availability and Maturity | Irrigation technology implementation procedures, as well as the experience gained in the irrigation sector are sufficient for the application of the technology in the Republic of Moldova. |
| **Country specific applicability** | |
| Institutional Capacity | MAFI together with Agency of "Waters of Moldova" has enough experience in implementation of hydro-improvement and management policies water resources. |
| Applicability scale | The national strategy for the development of the irrigation sector 2030 explicitly indicates: "To ensure the achievement of the objectives of this Strategy and to obtain harvests stable and high agricultural crops, irrigation sector will be modernized, ensuring the necessary quality and quantity of water (about 700 million m3 of water qualitative for irrigation of about 300 thousand ha, of which in the implementation this strategy - 250 thousand Ha arranged and equipped with high-performance equipment for irrigation until 2030)".<br>From this area it is proposed that up to 15 thousand Ha should have newly irrigated land devoted to forage crops. |
| Time horizon- Short /Medium/long term | Short term – towards 2030.<br>This technology will be used both in the short time (the next 5-7 years), but also in a much longer perspective, based on the fact of the evolution in the next period of climate change and the development of the livestock sector. |

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| Status of technology in country | To date, very few livestock farms use irrigation systems for growing forage crops. |
| Acceptability to locals | 100% acceptability. |
| Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact? | Technology will not have a negative impact on gender equality.<br>The final beneficiaries will be both men and women in the livestock sector. Moreover, in recent years, the involvement of women in animal husbandry is much more active, so it is assumed that women will benefit to an equal or greater extent from the benefits of the project and the given technology. |
| Other country specific characteristics related to the technology (such as market potential) | In coming years, the growth and modernization of the livestock sector in Moldova is forecasted as a result of several factors such as the acceptance of the import of poultry production to the EU, and effects on agricultural products markets of the war in Ukraine.<br>At the same time, given that Moldova is an EU candidate country, the considerable increase of funds for the development of agriculture will follow soon, respectively the market will need this technology.<br>The project from the World Bank – AGGRI, which provides for financial sources worth 55 million lei for the modernization of the irrigation systems and of the livestock sector, especially the milk sector, is in the process of negotiations. |
| **Paradigm Shift Potential** | |
| Expandability, replicability, and applicability | The technology will be quickly used and developed easily.<br>The experience gained and the application of new technologies in irrigation could broaden the area of application of the technology throughout the country. |
| Potential for knowledge sharing and capacity building | The technology aims to strengthen farmers' capacities in the field of animal husbandry to adapt to hydrological risk phenomena (droughts) in the conditions of climate change. |
| Potential for enabling environment to diffuse technology | High. In the conditions of climate iridization – irrigation is one of the most efficient adaptation technology. Dissemination and expansion of technology, in particular use of irrigation systems – can be carried out throughout the country. |
| Potential contribution to establishing regulation and policy framework | Facilitating access to water for irrigation by improving/amending normative framework. Improvement of the subsidy system to encouraging water users (especially in the livestock sector) to develop the internal infrastructure for water accumulation and use. Analysis of irrigation water taxes and evaluation of post-modernization costs. Stimulating the association of users of water for irrigation. |
| **Economic benefits** | |
| Employment | Modernizing and creating new irrigation systems will contribute to the creation of<br>new jobs. The implementation of irrigation systems for fodder crops will increase the supply of feed, as a result will stimulate the creation of new cattle farms according to the plan of the NATIONAL STRATEGY FOR AGRICULTURAL AND RURAL DEVELOPMENT 2022 - 2027, which foresees the creation of 200 new farms, and there exists the potential for the technology to contribute to creating about 2000 jobs. |

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| Investment | The investment for irrigation equipment ((pumps, mobile irrigation machines with drum (coil) at 100 ha is estimated 100 000 Euro. |
| Public and private expenditures | Mostly, private investments will be made in the creation of new farms (about 200 farms), the cost of which may exceed 100 million euros, which will be partially subsidized later by the state from the subsidy fund for the development of the livestock sector.<br>Surely the expenses will be high and especially from external sources, from different donors. |
| **Social benefits** | |
| Income | Farmers will earn higher incomes by lowering production costs and achieving higher productivity. Due to the use of silage in animal feed, it will be possible to sway the feed ration, thus increasing the productivity of animals by 20-30%. Thanks to these technologies it would be possible to obtain a 10 liters production increase per dairy animal.<br>At the same time, the cattle breeding sector will be always provided with fodder, including in dry years, when the price of feed is higher, as does the cost of livestock production.<br>Likewise, these technologists will have an effect in maintaining the livestock and increasing it. At the same time, the safety of the business environment will also increase the safety of the business environment to invest in the given sector, minimizing the risk of lack of fodder. |
| Learning | Farmers will improve knowledge in the field of growing forage crops by using irrigation.<br>Understanding and awareness by the population of the process of adaptation to climate change manifested by the rational use of water resources. |
| Health | Only indirectly. |
| **Development impacts, indirect benefits** | |
| Environmental benefits | All projects will comply with environmental requirements, having in the structure of the general project and the environmental protection compartment (the condition required under the national legislation in the elaboration of projects). |
| Other, if any | |

**Technology #2:**

| **General information** | |
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| Sector | Livestock |
| Technology Name | **Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and the observance of the populated areas of the animals.** |
| Short description of the technology option | In the Republic of Moldova, most of the existing farms are rebuilt starting from existing farms, which were built before 1990. There are very few farms built from scratch in the last 10 years in the country. Due to the high cost of design work, bureaucratic barriers to their approval and the lack of specialists in the field, most of the farms were rebuilt, rehabilitated, transformed from one type of farm to another (for example, from cattle farm to poultry farm or vice versa). In most cases retrofitting was done without taking into account animal welfare, thermal insulation (energy efficiency) and biosecurity of the farm.<br>Also, in most cases, not all the EU normative acts on animal welfare that have been or are to be harmonized in the Republic of Moldova have been considered.<br>Within the framework of the technology, it is proposed to equip the existing halls with cooling systems to ensure the necessary microclimate conditions for animals (according to welfare requirements) and to develop standard design plans (technological design) for livestock farms (depending on the species).<br>For each species of animals, a different design plan will be drawn up:<br>For dairy cattle - 20, 40, 60, 80 and 100 animals.<br>For fattening pigs – 100, 300, 500, 700 and 1000 animals.<br>For laying birds – 20 000 and 50 000 heads.<br>For broiler chickens – 25 000, 50 000, 75 000 and 100 000 heads.<br>The design plan should contain the animal-specific technology plan ensuring biosecurity conditions and animal welfare in line with EU requirements. The project must also be developed according to the latest requirements on energy efficiency (thermal insulation) and maximum automation. Climate control and monitoring of all climate parameters inside the production halls (air circulation, $CO_2$ and $NH_3$ level, temperature, humidity) is ensure by dedicated monitoring equipment and technological solutions such as forced air circulation and exchange, etc.<br>The design plan will be built using CAD software and offered to farmers who will adapt them to the conditions of location of the farm or land (it will be framed in the conditions of the farmer's land and its necessity). This technological plan will be used as the basis for design on livestock farms, and the design companies will integrate it into the farm project by its specialists in resistance, communications, architecture, etc.<br>These types of projects will primarily benefit small farmers, who have limited possibilities both financially and organizationally (specialized personnel). |
| Country social development priorities | The development of the livestock sector is a major priority, including the development of small and micro farms. Provided that development grants from international projects (World Bank), the EU-funded IPARD program, will be available for the livestock sector, these could represent a useful resource for increasing the resilience of livestock farms in Moldova to the impacts of climate change. |
| Country economic development priorities | The national development strategy "Moldova 2030" foresees a 5% to 7% growth rate in GDP towards 2030. In addition, specific livestock sector policies |

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| | such as the "National Program for the Development of the Milk Sector in the Republic of Moldova 2020-2026" indicate that the development and efficiency of the livestock sector in general and, the milk in particular refers to the improvement of the production performance of all animal species, as well as of their growing and exploitation conditions, which will lead to an increase in the relative share of livestock production in the economic and social value of agricultural production. Likewise, several normative acts regulate the welfare conditions of animals such as:<br>LAW No. 50 of 28.03.2013 on official controls to verify compliance with feed and food law and animal health and welfare rules.<br>DECISION No. 793 of 22.10.2012 approving the Sanitary and Veterinary Rules on the protection and welfare of animals during transport. (Council Regulation (EC) 1/2005 of 22 December 2004)<br>DECISION No. 859 of 14.07.2008 approving the Sanitary and Veterinary Rules on minimum criteria for the protection of pigs for rearing and fattening.<br>DECISION No. 677 of 06.06.2008 approving the Sanitary Veterinary Rules on the protection of laying hens. (Council of Europe Directive No 1999/74 of 19 July 1999).<br>DECISION No. 1275 of 17.11.2008 approving the Sanitary and Veterinary Rules for the protection of farm animals.<br>DECISION No. 1325 of 27.11.2008 approving the Sanitary and Veterinary Rules aying down minimum requirements for the protection of calves for rearing and fattening.<br>DECISION No. 415 of 08.07.2009 approving the Sanitary and Veterinary Rules on the protection of chickens kept for meat production.<br>Normative in construction - NCM E.04.01- 2006 Thermal protection of buildings. |
| Country environmental development priorities | The technology is aligned with Country's environmental priorities, including lowering greenhouse gas emissions and protecting the environment from pollution. |
| Country climate priorities | As a national priority is established the reduction of emissions of gases with the effect of greenhouse and implementation of measures to adapt to climate change. |
| Adaptation needs. How the technology contributes to adaptation | Equipping existing farms with cooling systems will help to improve animal welfare conditions for their adaptation to climate change.<br>In parallel with this, the technological plans will stimulate the correct construction of farms, which will include all the requirements regarding animal welfare, biosecurity, energy efficiency (thermal insulation) and maximum automation. The use of standard projects will allow farmers in the livestock sector to save time (usually design work can take up to 6 months), money (costs for technological projects can also reach 10-20 thousand Euros). |
| Implementation assumptions and applicability scale | The technology can be applied to practically all small and medium-sized farms, where at the given time they are missing. It can be applied to all species of animals. |
| **Technology characteristics** | |
| Capital costs | The cost of a cooling system, depending on the species, varies from 10 – 40 thousand euros. To this amount costs for installation (including construction works) for about 20 thousand euros per project should be added. In Moldova, |

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| | as of 2023 it is necessary to install these systems to about 100 existing farms. The maximum cost of the investment will be 6 million Euros.<br>For technical projects (for new farms) - the cost of a project will not exceed 20 thousand euros. The total cost of engineering drawings is expected to be around 300 thousand euros. |
| O&M costs | The operating cost for cooling systems (repair, maintenance) will not exceed 2 thousand euros annually for each system. |
| Safety, Reliability | The technical design will be developed according to all EU rules and requirements, thus ensuring their full safety. |
| Availability and Maturity | The technology is very mature and widely available in several countries in the EU and elsewhere. |
| **Country specific applicability** | |
| Institutional Capacity | The technology is welcomed by both the private sector and state institutions (MAIA, ANSA). |
| Applicability scale | The technology can be applied to practically all small, medium and large scale farms and can be applied to all species of animals.<br>The installation of cooling systems can be at 100 existing farms, and the engineering drawings for thermally efficient new stables can expand by additional 100 new farms. |
| Time horizon- Short /Medium/long term | The technology is a long-term solution that can be deployed right away. |
| Status of technology in country | At the moment, very few farms are rebuilt/built according to projects that comply with all the norms and needs of the animals. Most of them do not fully comply with all the requirements of national and EU legislation |
| Acceptability to locals | The livestock sector supports the urgent need for this technology to be implemented. |
| Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact? | Technology will not have a negative impact on gender equality.<br>The final beneficiaries will be both men and women in the livestock sector. Moreover, in recent years, the involvement of women in animal husbandry is much more active, so it is assumed that women will benefit to an equal or greater extent from the benefits of the project and the given technology. |
| Other country specific characteristics related to the technology (such as market potential) | In coming years, the growth and modernization of the livestock sector in Moldova is forecasted because of several factors such as the acceptance of the import of poultry production to the EU, and effects on agricultural products markets of the war in Ukraine.<br>At the same time, given that Moldova is an EU candidate country, the considerable increase of funds for the development of agriculture will follow soon, respectively the market will need this technology. |
| **Paradigm Shift Potential** | |

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| Expandability, replicability, and applicability | The technology will be quickly used and developed easily. |
| Potential for knowledge sharing and capacity building | The technology will improve farmers' knowledge of breeding and livestock need. |
| Potential for enabling environment to diffuse technology | The light technology will be disseminated to farmers. |
| Potential contribution to establishing regulation and policy framework | The use of technological projects will facilitate compliance with animal welfare legislation. |
| **Economic benefits** | |
| Employment | For starters, the technology will provide jobs for specialists involved in design services, later to those involved in construction. And in the end, farmers will benefit from jobs. |
| Investment | About 6 million euros are needed for cooling systems and about 300 thousand euros for the technical project. |
| Public and private expenditures | Mostly, private investments will be made, which will be partially subsidized by the state from the subsidy fund for the development of the livestock sector. The private sector will make investments based on a technological project depending on the size and type of farm of about 1-3 million Euro / farm. 50% of the investments will be covered from the subsidy fund (but no more than the ceiling stipulated in the regulation). |
| **Social benefits** | |
| Income | Farmers can increase income by lowering production costs (energy efficiency), and by achieving higher productivity (respect for well-being and biosecurity). They will also be able to obtain direct subsidies from European funds for animal welfare afterwards. |
| Learning | Farmers will improve their knowledge in the field of animal welfare and compliance with biosecurity conditions on farms. |
| Health | The improved conditions in the halls will ensure both the welfare of the animals and will also ensure a beneficial effect on the people who care for these animals (decrease in the concentration of harmful gases, high temperatures, air currents). |
| **Development impacts, indirect benefits** | |
| Environmental benefits | All projects will comply with environmental requirements, having in the structure of the general project and the environmental protection compartment (the condition required under the national legislation in the elaboration of projects). |
| Other, if any | |

**Technology #3:**

| **General information** | |
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| Sector | Livestock |
| Technology Name | **Construction of platforms for the accumulation and storage of manure.** |
| Short description of the technology option | It is proposed to build special places platforms for storing manure on small and medium-sized farms in the country. In total, about 100 special platforms will be created (these will include special ones for cow, poultry and pig farms). It is proposed to be done in 2 stages, the first - the design phase and the second - the construction. The design and construction of the platforms will be carried out according to special technologies depending on the species of animal and its physical consistency (liquid or solid). The same will be considered for the volume depending on the production capacity of the farm, the possibility of expansion and the storage period.<br>These special platforms will be possible to collect and keep manure separated from wide debris (plastic, glass, etc.). As a result, it will be possible to use it later as an organic fertilizer for agricultural trains.<br>It is proposed that the platforms are compact, to take up little space. At the same time, they must be designed to ensure the prevention of groundwater pollution. The storage of manure will take time and they will be able to be used as organic fertilizers for the agricultural sector. |
| Country social development priorities | The development of the livestock sector is a major social priority for creating and securing jobs in the rural sector. Including the country's policy is for the development of small and micro farms. |
| Country economic development priorities | Increasing agricultural productivity and lowering the cost of production including those in the livestock sector and organic farming. |
| Country environmental development priorities | Aligning the Republic of Moldova with EU requirements also implies harmonization of legislation in line with EU directives, including environmental directives. |
| Country climate priorities | Aligning environmental priorities is insightful, including lowering greenhouse gas emissions and protecting the environment from pollution. |
| Adaptation needs. How the technology contributes to adaptation | The technology will impact greenhouse gas emissions. |
| Implementation assumptions and applicability scale | The technology can be applied to practically all small and medium-sized farms, where at the given time they are missing. It can be applied to all species of animals. |
| **Technology characteristics** | |
| Capital costs | The design cost is about $ 5000.<br>The cost of construction of the concrete platform with the observance of technology depending on the capacity varies between $ 50-100 000. |
| O&M costs | Annual maintenance costs will not exceed $1000 for repair work in the first 10 years. After this period the cost will be double. |
| Safety, Reliability | It is safe and reliable. |

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| Availability and Maturity | It is currently available at a limited number of livestock farms, mostly large. It practically sticks to micro and small farms. |
| **Country specific applicability** | |
| Institutional Capacity | Animal husbandry law (nr. 213 of 21. 07. 2022)<br>Law on environmental protection (no. 1515-XII from 16.06.1993).<br>Law on drinking water (no. 272-XIV from 10.02.1999).<br>Law on payment for environmental pollution (no. 1540-XIII from 25.02.1998).<br>Law on air protection (no. 1422-XIII from 17.12.1997).<br>Law on ecological expertise (no. 851-XIII from 29.05.1996).<br>Law on areas and strips for the protection of waters, rivers, and water basins (nr.<br>440-XIII/ 27.04.1995).<br>Law on Waste (no. 209 of 29.07.2016).<br>Law nr. 129 of 19.09.2019 on animal by-products and derived products not intended for human consumption.<br>Law on ecological network (no. 94 from 05.04.2007).<br>Government Decision nr. Order of the Minister of Public Health no. 606 of 28.06.2000 on the approval of the National Program for recovery of production and household waste.<br>Government Decision nr. Order of the Minister of Public Health no. 248 of 10.04.2013 on the approval of the Waste Management Strategy in the Republic of Moldova for 2013-2027.<br>Order of the Ministry of Agriculture, Rural Development and Environment no. 1 of 04.01.2019 on the approval of the Guide on the execution of environmental impact assessment procedures.<br>Order of the Ministry of Agriculture, Rural Development and Environment nr. 160 of 27.07.2020 on the approval and implementation of the Code of Good Agricultural Practice on the Protection of Waters against Nitrate Pollution from Agricultural Sources. |
| Applicability scale | The technology can be applied to practically all small and medium-sized farms, where at the given time they are missing. It can be applied to all species of animals.<br>The same can be applied to larger farms. |
| Time horizon- Short /Medium/long term | The design works and approval can take up to 6 months.<br>The platform can be built for 120 days and operated in 20 years. |
| Status of technology in country | At the moment at a small part of the farms there are special platforms, left over from the time of old farms. At the same time, in the early 2000s, there was a World Bank project that financed such a type of activity, but it was for the town halls in rural areas. |
| Acceptability to locals | Local farmers will have access to store the manure separately from other scraps, and later it could be used as an organic fertilizer for the local lands, especially for ecological and conservative agriculture. |
| Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender | Technology will not have a negative impact on gender equality.<br>The final beneficiaries will be both men and women from rural areas working in the agricultural field. Moreover, it is assumed that the beneficiaries of fertilizers that can be used in organic farming will be mainly women, who largely practice this type of business. |

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| equality? What is the expected magnitude of the impact? | |
| Other country specific characteristics related to the technology (such as market potential) | At the moment because the price of chemical fertilizers has increased considerably, the demand for organic fertilizers is increasing.<br>At the same time because of the small number of animals, the fertilizers obtained from them are sought after on the market in the country. |
| **Paradigm Shift Potential** | |
| Expandability, replicability, and applicability | Proper manure storage will be a good example for farms that will be built from scratch, will be replicated by existing farms under pressure from environmental organs, full of their exemplification.<br>The use of organic fertilizers will stimulate the growth of cultivated agricultural areas. Organic and conservative agriculture will be stimulated. |
| Potential for knowledge sharing and capacity building | It will increase the capacity and exchange of knowledge in the correct preservation of manure, reducing its impact on the environment. At the same time, stimulation of organic agriculture. |
| Potential for enabling environment to diffuse technology | There are many, predominantly small farms that do not store the manure correctly. The exemplification of the technology will allow them to be widely distributed in the country. |
| Potential contribution to establishing regulation and policy framework | The existence of farms that correctly use and store manure will ensure the implementation of European legislation. |
| **Economic benefits** | |
| Employment | The workforce will be occupied both during the construction of the platforms, but also later in the management of the platform. Also, labour will be required in the use of the finished product – organic fertilizers. |
| Investment | Most of the investment will be in the construction of the platform. |
| Public and private expenditures | Initial funding is required through grants and subsidies, and maintenance through private investments. |
| **Social benefits** | |
| Income | The income of platform owners will be provided by marketing organic fertilizers to farmers.<br>And farmers' incomes will be provided from the marketing of the agricultural production that will be higher due to the use of fertilizers. Also, an additional income will be obtained by marketing organic production that is more expensive. |
| Learning | Proper disposal of farmyard manure will encourage household livestock owners to follow suit. |
| Health | The decrease in groundwater pollution by manure will have a direct impact on the health of the rural population. |
| **Development impacts, indirect benefits** | |
| Environmental benefits | Storage of manure in specially designated places will prevent air, soil, and water pollution (having a direct impact on the accumulation of greenhouse gases). |

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| | It will also have an impact by reducing nitrate pollution from agricultural sources by properly storing manure and reducing the use of chemical fertilizers. |
| Other, if any | Storage of manure on special platforms will allow them to be subjected to the fermentation process, respectively, the destruction of pathogenic flora from manure, thereby minimizing the risk of the spread of infectious diseases in animals. |

**Cereals**

**Technology #1:**

| General information | |
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| **Sector** | Agriculture |
| **Technology Name** | **Conservation Agriculture System (crop rotation, No-till, cover crops, soil mulch)** |
| **Short description of the technology option** | The conservation agriculture system is allowing: to prevent erosion and simultaneously to reduce the drought; to increase the competitiveness of farmers due to less production expenses.<br>Conservation Agriculture System (CAS) is an alternative to conventional agriculture allowing to reduce production expenses and to reduce the negative impact of both soil erosion and droughts.<br>CAS is based on the following principles:<br>• a higher diversity of crops, including mixture of perennial legumes and grasses<br>• keeping crop residues on soil surface and/or using of cover crops as long as possible during the vegetation period<br>• minimum soil disturbance by practicing No-till farming.<br>CAS makes farmers more competitive in the conditions of increased prices for industrial inputs and their derivates as well as reduces the negative impact of agriculture on the environment, including the reduction of green gases emissions.<br>For a more efficient restoration of soil fertility (soil organic matter is the integral index of soil fertility). It is desirable to integrate animals in crop rotation. Farmyard manure and composts will allow to better recycle nutrients and water in each farm and consequently to reduce application of mineral fertilizers, pesticides, moldboard and irrigation. By respecting the whole farming system, it becomes possible to improve soil health and to provide better ecosystem and social services. |
| **Country social development priorities** | To reduce poverty and to reduce the vulnerability of people with lower income |
| **Country economic development priorities** | To increase the wellbeing of all people by providing employment and good living conditions for all people |
| **Country environmental development priorities** | To use more effective and to protect natural resources |
| **Country climate priorities** | To mitigate and to adapt to climate change.<br>The adaptation to climate change is possible from the following reasons:<br>• mixture of legumes and grasses improves soil structure and consequently the infiltration capacity of the soil;<br>• the mulch from crop residues on soil surface is reducing the evaporation of soil moisture;<br>• minimum soil disturbance is reducing the decomposition of soil organic matter, thus contributing to a higher carbon sequestration and better adaptation to droughts;<br>• using of cover crops is enriching soil in soil organic matter or is increasing the infiltration capacity of the soil. |
| **Adaptation needs. How the technology** | The technology (farming system) provides a higher level of carbon sequestration and is reducing GHG emission. |

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| **contributes to adaptation** | |
| **Implementation assumptions and applicability scale** | Implementation requires a system approach to agriculture intensification and a long-term vision not only on crop production but also on the restoration of soil fertility. It can be used for the whole territory of Moldova. |
| **Technology characteristics** | |
| **Capital cost** | The intention is to extend the area under Conservation Agriculture System in Moldova on half of the arable area, which consists 850 thousands hectares of land.<br>One No-till planter for compact drilled crops costs 40 000 Euro and one for row crops costs 35 000 Euro.<br>One drill can saw 4 ha per hour by a speed of 8 km/h. During 8 hours it is possible to drill 32 ha, but during 12 hours - 48 ha. The crops should be sown during 4-5 days in order to achieve good and uniform germination of crops. It means that one drill can saw 240 ha. Half of the intended sowing area will be sown with row crops and the other half with compact drilled crops.<br>The total requirement in compact sown crops consists 1770 drills and the same amount for row crops.<br>The total cost for the procurement of drills will consists (1770x40.000 Euro + 1770x35.000 Euro) €132,8 million.<br>We need also sprayers for pesticides. The price for one sprayer is 25 000 Euro. Each sprayer can cover 200 ha of land per day. If to do the work during 5 working days it would be necessary to have 850 sprayers. The total costs for sprayers consists €21,2 million.<br>The total cost of the equipment for the implementation of Conservative Agriculture System on half of the arable land in the Republic of Moldova consists €164,0 million.<br>The CAS will be implemented in different regions of the Republic of Moldova. |
| ***O* and *M* costs** | One thousand Euro per ha. |
| **Safety, Reliability** | The system of agriculture is safe and reliable for agricultural production |
| **Availability and Maturity** | Knowledge is available, but more research are required regarding the efficiency of CA for different crops in the crop rotation.<br>Our researchers at Selectia Research Institute of Field Crops for cereal crops in Conservation Agricultural System have proved the possibility to maintain the level of yields similar to conventional agriculture by respecting the transition period of time, which suppose using of perennial legumes (in mixture with grasses) for the improvement of soil fertility.<br>The most important is that by using CAS farmers become more competitive from an economic point of view through reduction of the production expenses. In the same time farmers are becoming less vulnerable to the climatic extremes (torrential rains or droughts). |
| **Country specific applicability** | |
| **Institutional capacity** | There are state organizations capable of working out Conservation Agricultural Systems (CAS).<br>Two state organizations in the Republic of Moldova have initiated research in the domain of CAS - State Technical University (former Agricultural State University) and Selectia Research Institute of Field Crops (Bălți).<br>Fortunately, there are some farms which are practicing CAS and they can be used as the experimental base for training and extending the area under CAS. |

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| **Applicability scale** | The application of CA is limited by different factors-the domination of economic, interest under environmental and social interests; the domination of short-term leasing of land; low prices for agricultural products and lack of cooperation, including for processing of raw materials; lack of financial means for the procurement of special equipment for CA, etc.<br>Taking in consideration that the lack of financial means for the procurement of the equipment for CAS is one of the main obstacles in promoting this new innovative system of agriculture we can suppose that it can help in overcoming this difficulty by increasing the areas under CAS up to at least half of the sowing area in Moldova. It will require active involvement of the research institutions and the state service for technological transfer. Besides equipment research institutions can assist in the training programs for farmers (crop rotations; cover crops; IPM; etc.)<br>At the moment the area under CAS in Moldova is very low, because farmers are using this system only under separate crops, like cereal crops, but no areas under all crops in the crop rotations. |
| **Time horizon-short/medium/long term** | Long term. |
| **Status of technology in country** | Known, but neglected, untrusted. |
| **Acceptability to locals** | Poor accepted because of domination of the concept of *”green revolution”*. |
| **Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact?** | The technology (farming system) doesn`t impact the gender inequality. |
| **Other country specific characteristics related to the technology (such as market potential)** | The Conservation Agriculture System will stabilize market potential of the country by reducing the vulnerability to extreme natural calamities and by increasing economic competitively of farmers. |
| **Paradigm Shift Potential** | |
| **Expandability, replicability and applicability** | The farming system can be extended, replicated and applicated only in the conditions of changing the orientation of farmers not only on profit, but also towards environment protection and providing ecosystem and social services |
| **Potential for knowledge sharing and capacity building** | There is high potential for knowledge sharing and for capacity building |
| **Potential for enabling environment to diffuse technology** | By organizing living Laboratories and light houses real possibilities exist for enabling environment to diffuse technologies. |

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| **Potential contribution to establishing regulation and policy framework** | A new law regarding soil health should be approved together with a better communication between researchers-producers and policy makers. |
| **Economic benefits** | |
| **Employment** | More working places will be created. |
| **Investment** | More investors can be attracted. |
| **Public and private expenditures** | Public and private expenditures will be reduced due to a higher biodiversity above and under soil surface- |
| **Social benefits** | |
| **Income** | Incomes will increase and become more stable over time.<br>The efficiency of CAS will be determined by many factors such as:<br>the level of the weed infestation of fields, especially with perennial weeds; soil compaction; application of organic fertilizers, especially composts etc. |
| **Learning** | Changes need more learning from others and from the own experience. |
| **Health** | The health of people and the environment will be improved due to a better soil health. |
| **Development impacts, indirect benefits** | |
| **Environmental benefits** | The farming system is oriented towards preventing but not towards controlling the consequences on the environment, health of people and animals. |
| **Other, if any** | By respecting the system approach to farm management, it would be possible to achieve a more sustainable and resilient development of agriculture. |

Technology #2:

| General information | |
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| **Sector** | Agriculture |
| **Technology Name** | **Climate-smart rotation and using of predecessors capable to prevent problems.**<br>One of the following crop rotations should be used:<br>1. Mixture of alfalfa and grasses for green mass<br>2. Mixture of alfalfa and grasses for green mass<br>3. Mixture of alfalfa and grasses for green mass (harvested in June in order to keep soil moisture for the optimal terms of sowing winter cereal crops in October);<br>4. Winter wheat (or winter barley);<br>5. Sugar beet;<br>6. Corn for grain;<br>7. Peas for grain;<br>8. Winter wheat;<br>9. Corn for grain;<br>10. Winter barley or spring barley. |
| **Short description of the technology option** | By respecting crop rotations with a higher diversity of main and cover crops, including optimal alternation of annual and perennial crops, it would be possible to prevent but not to control such problems as: nutrients and water deficiency, pest, disease and weed, and soil compaction, etc.<br>CAS with a good crop rotation which includes mixture of perennial legumes and grasses together with cover crops in crop rotation without mechanical disturbance of the soil doesn't provide o positive balance of soil organic matter. Supplementary application of farmyard manure is required. Unfortunately crop and animal husbandries have been disintegrated during the land reform.<br>Returning of alfalfa in crop rotation will allow to use nitrogen from the biological fixation, but at the same time the above ground biomass of alfalfa for fermentation and biogas production.<br>One installation for biogas production can produce 500 KW of electricity. The cost for one biogas installation consists of $2 million. The requirements for the electricity in Moldova consist 1,6 billion KW annually. In order to cover the total requirements in electricity for Moldova we need 3200 units of biogas generators.<br>The total cost for these units will consists of $6,4 billion. Such calculations are very important because they can provide energetical security of the country together with food security. The investments are very high, but they can reduce the energetical vulnerability of the country.<br>We propose at the initial stage to have three installations for biogas production - one of them in the North part of Moldova, the other one in the central part and the other one in the South part of Moldova.<br>These farms will serve as model farms where farmers can learn how to integrate crops and animals and how to reduce the dependence from industrial inputs. In the same time they can prove how realistic is the possibility to achieve food and energy security in Moldova.<br>The total investment for 3 installations for the methanization of the green mass of alfalfa and other crop and animal residues will consist of $6 million. |

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| **Country social development priorities** | To reduce poverty and to reduce the vulnerability of people with lower income. |
| **Country economic development priorities** | To increase the wellbeing of all people by providing employment and good living conditions for all people. |
| **Country environmental development priorities** | To use more effective and to protect natural resources. |
| **Country climate priorities** | To mitigate and to adapt to climate change. |
| **Adaptation needs. How the technology contributes to adaptation** | The technology (farming system) provides a higher level of carbon sequestration and is reducing GHG emission. |
| **Implementation assumptions and applicability scale** | Implementation requires a system approach to agriculture intensification and a long-term vision not only on crop production but also on the restoration of soil fertility. It can be used for the whole territory of Moldova. |
| **Technology characteristics** | |
| **Capital cost** | |
| ***O* and *M* costs** | One thousand Euro per ha. |
| **Safety, Reliability** | The system of agriculture is safe and reliable for agricultural production. |
| **Availability and Maturity** | The knowledge about crop rotation and the compatibility of crops are available. |
| **Country specific applicability** | |
| **Institutional capacity** | There are state organizations capable to work out Climate-Smart rotations and using of predecessors capable to prevent problems in agriculture. |
| **Applicability scale** | The applicability scale exists for the whole territory of Moldova, but many obstacles exists for extending of optimal crop rotations (lack of a monitoring system regarding the state of soil fertility in Moldova). |
| **Time horizon-short/medium/long term** | Long term. |
| **Status of technology in country** | Known, but neglected. |
| **Acceptability to locals** | Poor accepted because of the domination of the concept of *”green revolution”.* |
| **Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact?** | The technology doesn`t influence the gender inequality. |
| **Other country specific characteristics related to** | The farming system proposed will increase stability of fields in time due to a better adaptation to climate change and due to the improvement of soil health. |

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| **the technology (such as market potential)** | |
| **Paradigm Shift Potential** | |
| **Expandability, replicability and applicability** | The farming system can be extended, replicated and applicated only in the conditions of changing the orientation of farmers not only on profit, but also towards environment protection and providing social services. |
| **Potential for knowledge sharing and capacity building** | There are high potential for knowledge sharing and for capacity building. |
| **Potential for enabling environment to diffuse technology** | By organizing living Laboratories and light houses real possibilities exist for enabling environment to diffuse technologies; more cooperation is needed between farmers as well as between farmers and researchers. |
| **Potential contribution to establishing regulation and policy framework** | A new law regarding soil health should be approved together with a better communication between researchers-producers and policy makers. |
| **Economic benefits** | |
| **Employment** | More working places will be created. |
| **Investment** | More investors can be attracted. |
| **Public and private expenditures** | Public and private expenditures will be reduced due to a higher biodiversity above and under soil surface. |
| **Social benefits** | |
| **Income** | Incomes will increase and become more stabile. |
| **Learning** | Changes need more learning from others and from the own experience. |
| **Health** | The health of people and the environment will be improved due to a better soil health. |
| **Development impacts, indirect benefits** | |
| **Environmental benefits** | The farming system is oriented towards preventing but not towards controlling the consequences on the environment, health of people and animals. |
| **Other, if any** | By respecting the systems approach to farm management, it would be possible to achieve a more sustainable and resilient development of agriculture. |

**Technology #3:**

| General information | |
|---|---|
| **Sector** | Agriculture |
| **Technology Name** | **Climate-smart rotation in the frame of a network of shelter belts and ponds for increasing the humidity of air.**<br>According the scientific recommendations the optimal share of shelter belts on arable land should be 4-6%. In average 5%. From the total area of arable land in the Republic of Moldova - 1,7 million ha, the area under shelter belts should be 85 000 ha. For half of the territory of arable land it would be necessary to plant 40 000-42 000 ha of shelter belts. Shelter belts should be 20 meters wide.<br>The design of planting trees in shelter belts should be 2,5x0,7 (1m). The main species of trees and bushes should be: Quercus; Fraxinus; Tilia; Sofora; Acer; Alnus; Seringa etc.<br>The expenses for the plantation of one hectare of shelter belts consists of €1300 Euro up to €2400.<br>For the area of 42500 ha the total expenses will consist €55,2-102,0 million.<br>The main obstacle in promoting this idea is the lack of legislative regulations regarding using of arable land for plantation of shelter belts. In order to implement this program for the creation of a whole network of shelter belts the educational program at the state level should be promoted. |
| **Short description of the technology option** | Crop rotation with the mixture of perennial cereal and legumes should be located in the frame of a network of shelter belts and ponds for increasing the humidity of the air and consequently for the reduction of the negative impacts of droughts and soil erosion, infestation by pests and diseases, etc. |
| **Country social development priorities** | To reduce poverty and to reduce the vulnerability of people with lower income. |
| **Country economic development priorities** | To increase the wellbeing of all people by providing employment and good living conditions for all people. |
| **Country environmental development priorities** | To use more effective and to protect natural resources. |
| **Country climate priorities** | To mitigate and to adapt to climate change. |
| **Adaptation needs. How the technology contributes to adaptation** | The technology (farming system) provides a higher level of carbon sequestration and is reducing GHG emissions. |
| **Implementation assumptions and applicability scale** | Implementation requires a system approach to agriculture intensification and a long-term vision not only on crop production but also on the restoration of soil fertility. It can be used for the whole territory of Moldova. |
| **Technology characteristics** | |
| **Capital cost** | The cost of the planting material (trees) and plantation. |
| ***O* and *M* costs** | One thousand Euro per ha+ planting of shelter beets. |
| **Safety, Reliability** | The system is safe and reliable for agricultural production. |

| | |
|---|---|
| **Availability and Maturity** | The knowledge about soil and shelter belts management are available. |
| **Country specific applicability** | |
| **Institutional capacity** | There are state organizations in the Republic of Moldova capable to work out the necessary documentations for successful implementation of this Faming system |
| **Applicability scale** | As a model for this Farming System can be used the network of shelter belts at Selectia Research Institute of Field Crops. It can be applied for the whole territory of Moldova. |
| **Time horizon-short/medium/long term** | Long term. |
| **Status of technology in country** | Known, but neglected, because of short-term market economy orientation. |
| **Acceptability to locals** | Poor accepted because of longer period for achieving final results. |
| **Impact on gender. Does this technology have the potential to address gender inequalities? How can it contribute to achieving gender equality? What is the expected magnitude of the impact?** | The technology (farming system) doesn`t impact the gender inequality. |
| **Other country specific characteristics related to the technology (such as market potential)** | The farming system proposed will increase stability of yields in time due to a better adaptation to climate change and reduce the production expenditures because of less pesticide use for pests and disease control |
| **Paradigm Shift Potential** | |
| **Expandability, replicability and applicability** | The farming system can be extended, replicated and applicated only in the conditions of changing the orientation of farmers not only on profit, but also towards environment protection and providing social services. |
| **Potential for knowledge sharing and capacity building** | There is high potential for knowledge sharing and for capacity building. |
| **Potential for enabling environment to diffuse technology** | By organizing living Laboratories and light houses real possibilities exist for enabling environment to diffuse technologies. |
| **Potential contribution to establishing regulation and policy framework** | A new law regarding soil health should be approved together with a better communication between researchers-producers and policy makers. |
| **Economic benefits** | |
| **Employment** | More working places will be created. |
| **Investment** | More investors can be attracted. |

| | |
|---|---|
| **Public and private expenditures** | Public and private expenditures will be reduced due to a higher biodiversity above and under soil surface. |
| **Social benefits** | |
| **Income** | Incomes will increase and become more stabile. |
| **Learning** | Changes need more learning from others and from the own experience. |
| **Health** | The health of people and the environment will be improved due to a better soil health. |
| **Development impacts, indirect benefits** | |
| **Environmental benefits** | The farming system is oriented towards preventing but not towards controlling the consequences on the environment, health of people and animals. |
| **Other, if any** | By respecting the systems approach to farm management, it would be possible to achieve a more sustainable and resilient development of agriculture. |

**Annex IV Technology Factsheets used to inform SWG members on the technologies' characteristics during the prioritisation exercise (MCA).**

**Aquaculture sub-sector**

| | |
|---|---|
| TNA technology name | **1. The use of lakes with complex destination for growing fish for consumption in polyculture** |
| National policy framework supporting technology | Law on fisheries, fisheries and fish farming no.149/2006 of 08.06.2006 Law no.272 of 23.12.2011 Water Code Law No.439-XIII of 27.04.95. Annex No. 2. The regulation on the protection of fishery resources and the regulation of fishing in fish basins in the republic (RPRP) // in MO RM no.62-63/688 from 09.11.1995. Decision of the Parliament of the Republic of Moldova nr. Order of the Minister of Public Health no. 325-XV of 18.07.2003 on the approval of the Concept of National Water Resources Policy<br>Strategic Guidelines for a more sustainable and competitive aquaculture in the EU for the period 2021-2030 |
| Brief technological description of the option | The use of lakes with multiple use for raising fish for consumption through grazing is determined by the need for rational use of these lakes through the introduction and subsequent fishing of valuable fish species. The reconstruction of ichthyofauna of lakes by choosing a complex polyculture allows the effective exploitation of the trophic potential of the basin as the main method of intensification and rational use of the natural productive potential. Changes in annual rainfall patterns in the recent past have a significant impact on water retention in lakes and create uncertainty about maintaining the required amount of water for aquaculture. The availability of juveniles for stocking of Asian carp and cyprinids can be ensured by breeding enterprises and farms. Fish farms using this technology should seek alternative means to cover shortages of juvenile perch, pike and bream to develop resilience to climate change. As climate change has direct influences on artificial fish breeding, alternative techniques and/or improvement of existing technologies for breeding perch, pike are needed. The successful reproduction of these fish species for aquaculture is a major requirement in aquaculture under the climate change scenario. |
| Cost and profitability (estimated) | Purchase of stocking material – 5 000000 lei;<br>Development of technologies for growing fish for consumption and monitoring – 1.6 million Lei;<br>Promoting awareness, knowledge and awareness raising activities – 200000 lei;<br>Improving existing technical skills on technology implementation through training, workshops – 150000 lei;<br>Implementing pilot projects - 650000 lei;<br>Organizing the reproduction of additional species - 2525000 lei;<br>Purchasing equipment and equipment for equipping and modernizing incubators 5000000 lei;<br>Planting protection strips on the dams of lakes and vegetation on their slopes – 354000 lei;<br>Organization of fishing in lakes with complex destination – 1221000 lei;<br>Other costs: These would include secondary expenses, etc. - 221000 lei. |
| Market potential (scalalability) | **MAIA,** Asociațiile de producători ferme piscicole. Aria de acoperire – întreprinderi și ferme piscicole din toate 3 zone piscicole |
| Impact and benefits of adaptation | Efficient management of technology will enable the use of trophic natural resources of reservoirs not used in aquaculture to increase sustainable volumes of fish production and generate additional revenues, protect, and restore aquatic biodiversity and improve aquaculture-related ecosystems. The biological and fishing opportunity of this technology is the application of polyculture, being a cost-effective method due to the use of all trophic levels, thus increasing fish productivity. Unexpected changes in rainfall and changes in annual rainfall patterns in the recent past have a significant impact on water retention in lakes and create uncertainty about maintaining the amount of water needed for |

| | |
|---|---|
| | aquaculture. Therefore, technology will frequently monitor the water level in bodies, hydrochemical an etiopathological  fish growing conditions during periods of temperature variations and extreme weather phenomena – drought. |
| Techology innovation | Sustainable development of aquaculture in reservoirs with complex destination in conditions of climate change, represents a medium and long-term socio-economic necessity, involving their integration into the system of grazing fish breeding in polyculture (Asian carp and cyprinids, American catfish, perch, bream), while capitalizing on water areas insufficiently used in aquaculture and trophic potential of viable reservoirs economically and socially and environmentally sustainable. Implementing this innovative technology by creating a model that respects environmental conditions, as well as increasing added value by increasing productivity and diversification of fish production as a modern and innovative management practice in conditions of climate change and extreme phenomena (drought). |

Food and Agriculture Organization of the United Nations

GREEN CLIMATE FUND

# BARRIER ANALYSIS and ENABLING ENVIRONMENT REPORT/BAEF (2)

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# List of Acronyms

| | |
|---|---|
| BAEF | Barrier Analysis and Enabling Environment |
| CA | Conservation Agriculture |
| CAD | Computer Aided Design |
| CEA | Controlled Environment Agriculture |
| DC | Direct Current |
| DFT | Deep Flow Technique |
| DTU | Denmark Technical University |
| EBRD | European Bank for Reconstruction and Development |
| EUR | EURO (currency) |
| FAO | Food and Agriculture Organization of the United Nations |
| GDP | Gross Domestic Product |
| GHG | Greenhouse Gas |
| LED | Light-Emitting Diodes |
| LLT | Long List of Technologies |
| MAFI | Ministry of Agriculture and Food Industry |
| NC | National Consultant |
| NFT | Nutrient Film Technique |
| PCM | Phase-Change Materials |
| PFB | Fishery-Biological Justifications |
| PV | Photovoltaics |
| SOC | Soil Organic Carbon |
| SWG | Sectoral Working Group |
| TAP | Technology Action Plan |
| TNA | Technology Needs Assessment |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USD | United States Dollar (currency) |

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# EXECUTIVE SUMMARY

The analysis of the barriers and the related enabling environment to facilitate the adoption of the prioritized technologies in each of the four key sub-sectors of agriculture has been carried out by the relevant National Consultants in consultation with the TNA Team and the SWGs. The results of these assessments are presented in this report. Key barriers have been identified for all prioritized technologies and trends could be discussed. The process followed the methodological approach proposed by UNEP-DTU in the relevant guidance document[6]. This process requires the application of nine fundamental steps:

1. Organizing the process
2. Screening of the Barriers
3. List of all identified Barriers
4. Select the most important Barriers
5. Decompose the selected Barriers
6. Cost-benefit analysis of market goods
7. Problem Tree Analysis
8. Market Mapping Analysis
9. Identify Measures to overcome Barriers

These nine steps have been followed for all technologies, however Cost-Benefit Analysis has only been initialized due to lack of data for most technologies prioritized and the difficulties in estimating their potential costs and benefits. That being said, the process of assessing the economic costs and potential benefits of addressing all identified barriers is ongoing at the time of writing of this report. The results of such a task indeed will be instrumental in the definition of a sound Technology Action Plan for each prioritized technology.

The main results of the process highlighted the presence of relevant economic barriers blocking the deployment of virtually any of the prioritized technologies. Certainly, for some sub-sectors economic aspects are more relevant than for others, for instance the technologies prioritized for the horticulture sector require a steep capital expenditure for farm owners that are unlikely to be available without external forms of support. Conservation Agriculture practices instead, if on the one had do have an appreciable initial conversion cost for the equipment pool of existing farms, savings in terms of operational costs (maintenance and above all fuel saved) obtained from minimum tillage operations are expected to cover the purchase cost of direct sowing machinery, making economic barriers addressable. The Cereals subsector is mainly limited in its development, and even more so in a sustainable development which encompasses also the prioritized technologies, by non-financial barriers, including human capacity (to which also socio-cultural barriers belong), institutional and organizational and technical barriers. The predominant approach of Moldovan farmers to annual crops production is anchored to outdated concepts that the changing climate is making rapidly evident to all. Yet, farmers' reluctance and inability to understand and conceive agricultural soils as a living organism limits the introduction of sustainable practices. The livestock sector, is predominantly affected by a generalized decline in number and relevance as an economic opportunity, so that most actors

[6] Haselip, J. A., Narkeviciute, R., & Rogat Castillo, J. E. (2015). A step-by-step guide for countries conducting a Technology Needs Assessment. UNEP DTU Partnership.

and at any level, lack a strategic vision and long-term development targets for the sector. Policy-related obstacles are therefore felt as particularly important non-financial barriers for this sector. Several specific barriers have been identified for aquaculture, a sector that covers a marginal share of the GDP portion attributable to agriculture as a whole in Moldova, yet one with strategic value for the sustainable development of the country. Policy barriers are the main hurdle on the path towards a resilient sector capable of coping with the impositions of climate change and many areas have been identified by this report as in need of attention. Institutional and Organizational barriers are also very important in this context.

Dedicated measures to overcome the identified barriers have been proposed for all barriers and all prioritized technologies. The results of this exercise are summarized at the end of every sub-sector specific chapter, as in most cases the measures are shared across the three technologies identified within their sector.

This BAEF report represents the basis for the development of Technology Action Plans of the prioritized technologies and their implementation in the Republic of Moldova.

# CHAPTER – 1. BACKGROUND & INTRODUCTION

## 1.1 BACKGROUND

The Technology Needs Assessment (TNA) is one of the foremost critical steps towards identifying and assessing climate change adaptation challenges within the United Nations Framework Convention on Climate Change's (UNFCCC) technology mechanism on technology development and transfer. For a climate-vulnerable country such as Moldova, the TNA has an added significance for aligning its adaptation needs and opportunities with goals and objectives of its sustainable development programs.

In Moldova, the project on Technology Needs Assessment (TNA) was initiated in 2021 in collaboration with FAO, as a part of the Ag SAP project funded by the Green Climate Fund. This is the second iteration of the Technology Needs Assessment (TNA) for Climate Change Adaptation, building upon the foundations laid during the first TNA, implemented under the UNEP project between 2011 and 2013The purpose of the TNA project is to assist Moldova in the identification of its priority adaptation needs for specific sub-sectors of agriculture, followed by the prioritization of technologies in these sub-sectors. This will form the basis for development of environmentally sound technology projects and programs to facilitate transfer and diffusion of these priority technologies. The main objectives of the project are to:

1. Identify and prioritize, through country driven participatory processes, the technologies that can contribute to adaptation goals of Moldovan's agriculture sector,
2. Identify barriers hindering the acquisition, deployment and diffusion of prioritized technologies; and
3. Develop Technology Action Plans (TAP) specifying activities and enabling framework to overcome the barriers and facilitate the transfer, adoption and diffusion of selected technologies in the priority areas with national relevance.

The TNA process implementation is composed of three stages (see Figure 1 below), as per UNEP-DTU methodology approved by the UNFCCC. In the first stage four agriculture sub-sectors have been identified as most economically important and vulnerable to climate change. Following multi-stakeholder consultations with experts and representatives of local and central government, a technology prioritization exercise highlighted the three most promising technologies for each sub-sector considered. The four sub-sectors considered are:

i. Aquaculture
ii. Livestock
iii. Horticulture
iv. Cereals

The prioritized technologies identified through the TNA process for the **aquaculture** sub-sector of Moldova are:

1) **Technology of complex capitalization of the trophic potential through interspecific polyculture.**
2) **An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology.**
3) **Fish protection system and ensuring food security in the conditions of climate change**

Likewise, priority adaptation technologies identified for the **livestock** sub-sector of Moldova are:

1) **Increase of areas under irrigation for the production of feed**

2) **Construction of platforms for the accumulation and storage of manure**
3) **Ensuring adequate conditions for animal welfare by optimizing the construction requirements of sheds and stables**

The prioritization exercise for the **horticulture** sector ranked the following technologies as the top three for Moldova:

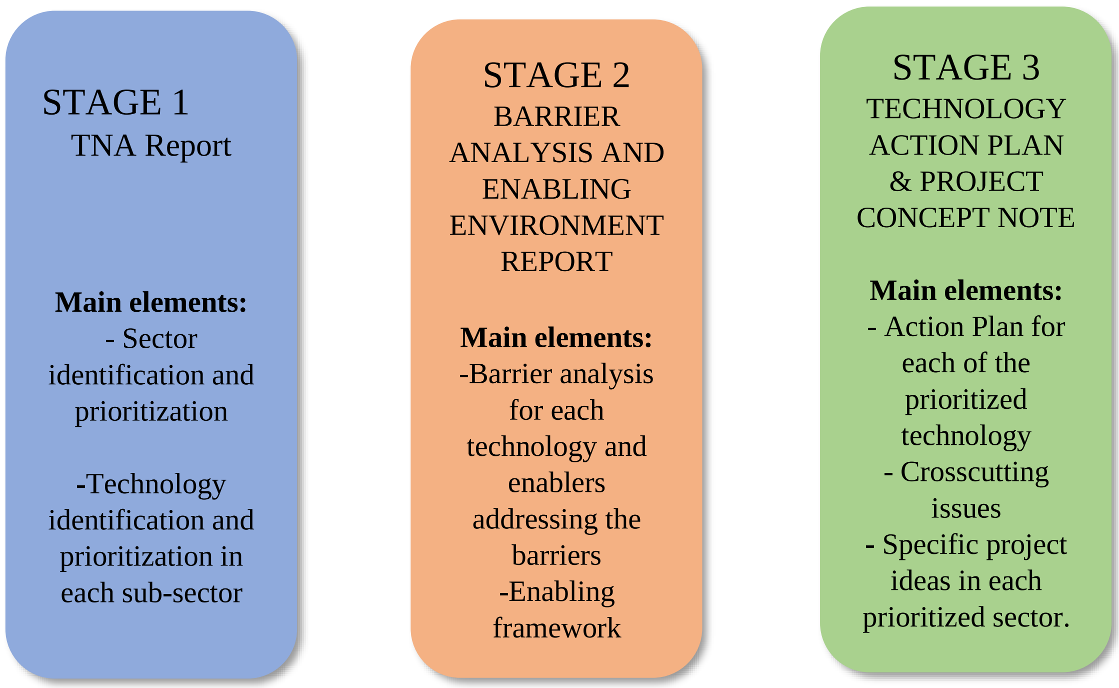
1) **High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency**
2) **Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.)**
3) **Hydroponics with recyclable solutions**

Similarly, concerning the **Cereals** sub-sector, the following technologies and practices have been prioritized:

1) **Conservation Agriculture System (crop rotations, No-till, cover crops, soil mulching)**
2) **Climate-smart rotations and using of predecessors capable to prevent problems**

**Climate-smart rotation in the frame of a network of shelter belts and ponds for increasing the humidity of the air**

*Figure 1: The three stages of the TNA process and how it was implemented in Moldova*




## 1.2. METHODOLOGY

This report is the output of the second phase of the TNA process that covers barrier analysis on transfer, and diffusion of the prioritized adaptation technologies in the selected sectors. In addition, the enabling framework and measures for overcoming barriers is discussed and addressed. For each of the technologies identified a systematic approach of describing and analyzing technology barriers, and identification of measures and enabling framework is provided. The process included:

1. Identify preliminary targets for the technology development and diffusion at sectoral scale.
2. Describe technology properties and its potential adaptation benefits, categorize technology either as a market or a public good and briefly elaborate on its current status in the country. 3.Undertake barrier analysis and identify measures for overcoming the barriers, possible linkage between different technology barriers within a sector and outline a technology enabling framework that would help to overcome barriers and create a supporting environment for the development and successful diffusion of the selected technologies. To carry out these tasks, the TNA Team carried out a literature review of potential economic and financial and non-financial barriers to the diffusion of each prioritized technology in Moldova supported by expert's contributions. These known technology-transfer barriers have been collected as a starting point to guide discussions and selection of the most appropriate or specific barrier to a given value chain or sub-sector. The "non-financial barrier" category was further broken down into sub-categories such as policy, legal and regulatory, institutional and organizational capacity, technical, information and awareness.

Known technology-transfer barriers include:

1. High cost of set up and maintenance and operation process
2. Under-developed, weak supply chain
3. Absence of enacted/approved sectoral policies
4. Weak pricing systems
5. Tenure and property right conflicts
6. High cost of energy to run farming systems
7. Low preference for resource conservation technologies
8. Technical capacity of government institutions and agencies
9. Low technical capacity of consumer groups
10. Low cost effectiveness of technology at field level and in different climate regions
11. Risk of soil degradation due to salinity buildup
12. High maintenance requirement
13. Suitability to the specific country-context
14. Communication gap between technology developers, suppliers and consumer
15. Lack of product certification and quality assurance procedures
16. Poor economic viability of technology for small land holders

As mentioned above, to this first layer of cross-cutting barriers, there is the addition of a technology-specific layer of barriers, particularly non-economic ones. One example of this, for the sub-sector horticulture and for a technology preliminarily targeted in the Long List of Technologies included the following example for technologies for seed quality leading to higher germination rate and increased yield capacity.

The list of non-economic, technology-specific barriers include:

1. Inadequate financial resources for research and development
2. Lack of technical expertise, equipment, physical infrastructure for genetic manipulation of crops.
3. Difficulty in access to good quality seeds domestically to use as benchmark.
4. Poor seed storage facilities.
5. Limited number of seed testing labs for ensuring quality of seeds.
6. Limited number of registered and certified seed supplier in the market
7. Poor credit facilities.
8. Small market size and supplier chain: uncertainty in demand side of the chain, difficult private-sector uptake.
12. Inefficient / poorly equipped seed testing labs to confirm the quality of seed.
13. Inappropriate communication/ extension approaches.
14. Insufficient data sharing and collaboration among research institutions so high chances of project multiplication.

15. Lack of strong legislation and regulatory framework to control seed market.

Screening and short listing of key barriers, particularly where the potential barriers list was long (as in the example above), was performed to select most essential barriers through expanded stakeholders consultations through the use of a *Problem-Solution Tree* and *Market Mapping tools* for relevant technologies.

National Consultants received several trainings on the BAEF methodology from FAO International Consultants. The methodology followed UNEP-DTU guidelines on the subject matter and was applied to the Moldovan case study with pertinent examples and ample discussions mediated by the entire TNA Team. During the training, the nine key steps of the BAEF methodology have been presented, discussed and broken down into individual tasks so that National Consultant could guide the discussions of the SWGs. The key steps discussed include the following:

1. Organizing the process
2. Screening of the Barriers
3. List of all identified Barriers
4. Select the most important Barriers
5. Decompose the selected Barriers
6. Cost-benefit analysis of market goods
7. Problem Tree Analysis
8. Market Mapping Analysis
9. Identify Measures to overcome Barriers

# CHAPTER – 2 THE AQUACULTURE SUB-SECTOR

## 2.1 PRELIMINARY TARGETS FOR TECHNOLOGY TRANSFER AND DIFFUSION IN THE AQUACULTURE SUB-SECTOR

The Republic of Moldova is rich in retained water resources. Comparing the size of the country and the total area of water reservoirs and ponds, it has the largest resources of artificial waterbodies among the countries of Central and Eastern Europe. Water reservoirs, lakes and ponds are owned by public local authorities, irrigation associations, the State and private owners. However, despite the large availability of waterbodies, aquaculture remains below its potential. Large scale farms struggle to succeed due to a mix of policy and organizational barriers. Historically, fish consumption has always been a component of the traditional diet, although the variety of fishery products has always been limited. The established aquaculture farms may face growing challenges to express their potential as expansion and even maintenance of the current levels is being hindered by impacts of climate change. These issues apply also to fishery, both commercial and recreational. The disappearance of sturgeons and other valuable species has been influenced by human factors as the conditions of breeding, feeding and growth of fish have changed considerably. These consist mainly in the use of water resources for irrigation and the pollution of waterbodies with untreated wastewater of agricultural and industrial enterprises discharged pesticides, herbicides and other chemicals into the remaining waterbodies. Increasing temperatures, especially in summer, have changed the composition of the fish fauna of Moldova, due to lower concentrations of dissolved oxygen into the water. Although this sub-sector does not have a monolithic relevance in terms of national GDP, the importance for the diet of local populations and the social relevance for smallholder farmers, coupled with the value of biodiversity conservation of aquatic species in Moldova, makes it a relevant area of work for the TNA process. Technology transfer in this case though requires solving an additional barrier linked to the uptake of the market to increased and diversified aquaculture production.

In the Republic of Moldova, at present, there is a lack of a dedicated framework to regulate the administration of the aquaculture sector. Aquaculture is therefore governed by the Ministry of Agriculture and Food Industry (MAFI) who  is responsible for the administrative supervision of water reservoirs, coordinating activities within the fish production and retail sector. Within the limits of its assigned competences, MAFI monitors the situation of the sub-sector, and it has elaborated an Action Plan on the implementation of the National Program for strengthening and developing the aquaculture sector in the Republic of Moldova for the years 2020-2030. The Action Plan mentions key policy targets for fishery and aquaculture in Moldova, including action to strengthen the capacity of the association of fish farmers, farmers and cooperation in the aquaculture sector. The plan does not emphasize other key needs nor sets any specific additional target for the aquaculture sector, lacking any instrument or even recommendations regarding support for adaptation to climate change and the impact of aquaculture activities on the environment and other economic and social activities. Therefore, the policy landscape surrounding aquaculture requires development and the lack of adequate policies are a first non-economic barrier identified for the sector. The preliminary target for technology transfer in the aquaculture sub-sector therefore include the need to set an overarching structure to govern the sector in the first place, accounting for the impacts of climate change and incentivizing instruments to adapt to such changes.

In this context, this TNA has represented the first technologies proposition to support the adaptation of the aquaculture sector to the impacts of climate change in Moldova. In total, 15 technologies have been preliminarily targeted by the TNA Team. These included the following priority technologies/practices:

| Climate Hazard | Climate Impacts | Priority technologies/practices |
|---|---|---|
| Increased temperatures above the optimal tolerance range | Eutrophication, stress to temperate-climate fish species | 1. Technology of complex capitalization of the trophic potential through interspecific polyculture. |
| | | 2. Restoration and conservation of the genofond populations of native fish of culture |
| | | 3. Fish protection system |
| | | 4. Mapping and crediting of the trophic potential and the climatic rayoning of the water basins |
| | Lower dissolved oxygen content, decreased productivity | 5. Ensuring the food security of fish for consumption in fish basins in the conditions of climate change |
| | | 6. Pond Shading |
| | | 7. Water aerators |
| Change in the precipitation regime | Reduced recharge of ponds and lakes, floods, sedimentation | 8. The use of lakes with complex destination for growing fish for consumption in polyculture |
| | | 9. An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology. |
| Increased frequency of extreme phenomena - drought | Water level reduction in ponds and lakes, stress to fish, low oxygen content | 10. Increasing the production capacity by restoring, modernizing and arranging the ponds for complex use dried up. |
| | | 11. Technology for feeding cyprinids |
| | | 12. Relevant risk management tools to support subsidisation and implementation of the aquaculture credit facility |
| | Complete dry-out of waterbodies | 13. Creation of the climate change information system and knowledge platform in the field of aquaculture. |
| | | 14. Development, implementation and monitoring of comprehensive plans for the management of freshwater aquaculture |
| | | 15. Rainwater Catchment Systems |

*Table 1: Long List of Technologies (LLTs) for the Aquaculture Sector.*

The prioritization exercise carried out under the supervision of the TNA Team Coordinator and National Consultants, led to the selection of the three prioritized technologies below:

1) **Technology of complex capitalization of the trophic potential through interspecific polyculture.**
2) **An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology.**
3) **Fish protection system and ensuring food security in the conditions of climate change**

The evaluation of these technologies and the associated economic and non-economic barriers to their implementation in Moldova are presented in the following chapters.

## 2.2 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR COMPLEX CAPITALIZATION OF THE TROPHIC POTENTIAL THROUGH INTERSPECIFIC POLYCULTURE TECHNOLOGY

### 2.2.1 General description of technology, technology status in Moldova, and market characteristics

The loss of areas and the lower availability of water for aquaculture bring to a change in the number and volume of ponds and lakes, as a consequence of increased evaporation, poor recharge and declining water quality. To maintain the same production levels in absolute tonnage of fish from the national aquaculture sector in this context may benefit from a more efficient and complete exploitation of the available water resources in the country. Manipulating the species pool in aquaculture ponds and lakes by introducing species feeding at different levels and on different substrates without competition within a given system, is technology option that has the potential to increase productivity by unit of pond surface in a context of decreasing availability of suitable water basins as a consequence of climate change. Another activity related to the more efficient exploitation of resources is connected with the insufficient use of existing production capacities as a basis for restructuring and strengthening fish farms the expansion, restoration, and modernisation of existing farms and the establishment of new aquaculture production capacities. Storage lakes are also available for use in aquaculture activities, however in the absence of financial support, these have not been put into production but the incumbent impacts of climate change force aquaculture community to consider also these water bodies. With respect to the area set up for aquaculture, the production levels show relatively low yields if compared to the achievable potential, and these can be enhanced with the adoption of modern and innovative management practices. The decrease in the quantity of fish as a result of the drying up of the ponds and the increase of imports of fish, can be compensated by using storage reservoirs in which commercial fishing is currently prohibited under the legislative conditions, but not the practice of aquaculture.

Polyculture represents an aid to the rational use of the reservoirs Dubasari, Costești Stanca and Ghidighici Lake which are extremely vulnerable to the effects of climate change, by introducing additional native fish species. The reconstruction of the ichthyofauna of the lakes by choosing a complex polyculture system allows for the effective capitalization of the trophic potential of the basin as the main method of intensification and rational use of the natural productive potential. Changes in the annual rainfall regime in the recent past have a significant impact on water retention in lakes and create uncertainty of maintaining the necessary amount of water for aquaculture.

The availability of brood of various cyprinids to be introduced requires the development of local breeding capacity. Fish farms using this technology should seek financial means to cover the shortage of brood of perch, European catfish and bream, thus contributing to developing national resilience to climate change. As climate change has a direct influence on the reproduction of these fish species, alternative techniques and/or the improvement of existing technologies for the artificial and natural reproduction of perch and bream are needed. Successful breeding is a major requirement in the climate change scenario of these fish species for aquaculture. The efficient management of the technology will allow to fully exploit the trophic resources of the reservoirs that are not used in aquaculture to increase a sustainable volume of fish production of about 10 thousand tons of fish per year and to restore the aquaculture's income increasingly lost due to climate change. Increasing native fish biodiversity, without the need for relevant feeding and disease control, will in turn restore aquatic biodiversity and improve aquaculture-related ecosystems. In this technology option, feed or other factors of production are not used, and only the available nutrients are used by polyculture.

Social co-benefits will include employment creation upstream (breeding) as well as downstream in the harvesting/fishing operations. To ensure that high stocking rates do not lead to decay of water conditions and competition among the species however, aquaculture practitioners need adequate capacity to monitor water parameters and intervene in case necessary with actions.

Polyculture has also key environmental co-benefits, by both providing support for biodiversity in ecosystems that integrate such exploitations, as well as by decreasing pressure on catch fishery resources in natural ecosystems. Improve the technologies for growing fish in polyculture that allow the exploitation of all trophic nieces of storage reservoirs in Moldova and the diversification of the species in order to increase the added value of the aquaculture production.

**2.2.2 Identification of barriers for complex capitalization of the trophic potential through interspecific polyculture**

The identification of barriers for the implementation of complex capitalization of the trophic potential of lakes through interspecific polyculture has been carried out by the National Consultant on aquaculture. The barriers have been classified starting from the broadest category as either Economic and financial, Policy, legal and regulatory, Social, cultural and behavioral, Institutional and organisational capacity, Human competencies and capacity, Information and awareness, and technical barriers. In turn, each of these broad barrier categories received a detailed screening to decompose the barrier into sub-barriers within each category. These are summarized in Table 1 below. For instance, under economic and financial barriers, inadequate access to financial resources and lack of subsidies for farmers deploying climate technologies is recognized as one specific obstacle to the diffusion of the technology. The various elements of each decomposed barrier have been considered individually and decomposed barriers were prioritized according to their significance (table 2). As a result of this exercise, the first technology prioritized for the aquaculture sector has 14 barriers , of which 9 were considered "essential" barriers to their implementation. These are:

1) Low awareness among fish producers of the potential benefits.
2) Inadequate funds for the reconstruction of ichthyofauna of lakes with complex destination.
3) Low availability and insufficient support at all levels of society on the technology of using complex lakes.
4) Poor implementation of regulatory policy on the management of natural watersheds and the deployment of climate technologies.
5) Ignoring the protection of water resources by policymakers – the protection of water resources is not taken into account when making decisions about aquaculture, where the main objective is to generate revenue.
6) Lack of an information system on issues related to innovative climate technologies.
7) Lack of support of public authorities in introducing complex lakes into aquaculture activities.
8) Limited knowledge and understanding on adapting the technology of use of complex-purpose varnishes.
9) Use of lakes for other purposes.

| **Wide category of barriers** | **Barriers within a category** | **Elements of barriers** |
|---|---|---|
| Economic and financial | Inadequate access to financial resources and lack of subsidies for farmers deploying climate technologies | No policy to subsidise fish producers including breeding farms |
| | Limited availability of finance for the development of breeding techniques and the reconstruction of gilt hatcheries | Inadequate funds for the reconstruction of ichthyofauna of lakes with complex destination |
| | Low priority for financing environmental protection, R&D activities under existing funding policies. | Limited research and development culture |
| Policy, legal and regulatory | Sufficient in the participation of relevant institutions in the planning of lake management | Lack of coordination between these institutions on the technology of using lakes with complex destination |
| | Ineffective enforcement of regulatory policies on the management of natural watersheds and the deployment of climate technologies | Lack of an appropriate legal framework for the establishment, competence, transfer and dissemination of technology |
| | Inadequate research opportunities and lack of advice on the introduction of technology. | Inadequate research, lack of appreciation of the role of scientific institutions in technological adaptation |
| Social, cultural and behavioral | Lack of support of public authorities in introducing complex lakes into aquaculture activities. | Insufficient willingness to enforce regulations |
| | Low awareness of fish producers about the potential benefits | Limited access to information on technology |
| Institutional and organisational capacity | Ignoring the protection of water resources by policymakers | Protection of the environment and water resources is not taken into account when making decisions on climate change |
| Human competencies and capacity | Inadequately trained staff and experts to provide technology expertise | Inadequate training facilities |
| Information and awareness | Absence of a comprehensive information system for innovative climate technologies. | Lack of mechanisms for generating and disseminating information Knowledge and inadequate access to information and training services |
| | Limited knowledge and understanding on adapting the technology of use of complex-purpose varnishes | Insufficient knowledge of farmers and research institutions to provide information |
| Technical | Low availability and insufficient support at all levels of society on the technology of using complex lakes. | Insufficient capacity to implement technology |
| Other barriers: | The use of lakes for other purposes. | Limited development of recreation services in lakes with complex destination |

*Table 2: Complete list of barriers identified for the technology.*

| Barriers determined | Score | Classification of barriers |
|---|---|---|
| Low awareness among fish producers of the potential benefits | 28 | **Barriers to information and awareness** |
| Inadequate funds for the reconstruction of ichthyofauna of lakes with complex destination | 27 | **Economic and financial barriers** |
| Low availability and insufficient support at all levels of society on the technology of using complex lakes. | 27 | **Technical barriers** |
| Poor implementation of regulatory policy on the management of natural watersheds and the deployment of climate technologies | 26 | **Policy, legal and regulatory barriers** |
| Ignoring the protection of water resources by policymakers – the protection of water resources is not taken into account when making decisions about aquaculture, where the main objective is to generate revenue. | 26 | **Institutional and organizational capacity** |
| Lack of an information system on issues related to innovative climate technologies. | 26 | **Barriers to information and awareness** |
| Lack of support of public authorities in introducing complex lakes into aquaculture activities. | 25 | **Social, cultural and behavioral barriers** |
| Limited knowledge and understanding on adapting the technology of use of complex-purpose varnishes | 24 | **Barriers to information and awareness** |
| Use of varnishes for other purposes | 24 | **Other barriers:** |
| Inadequate access to financial resources and lack of subsidies for farmers deploying climate technologies | 22 | **Economic and financial barriers** |
| Inadequate research opportunities and lack of advice on the introduction of technology. | 22 | **Policy, legal and regulatory barriers** |
| Insufficient in the participation of the relevant institutions in the management planning and the lack of coordination between these institutions on the technology of using the lakes with complex destination; | 21 | **Policy, legal and regulatory barriers** |
| Inadequately trained staff and experts to provide technology expertise | 21 | **Barriers to information and awareness** |
| Low priority granted for financing environmental protection, R&D activities under existing funding policies. | 17 | **Economic and financial barriers** |

*Table 3: Scoring of the barriers assessed in the consultation process*

Table 3

Values of the analytical ecological indexes and the ecological significance index calculated for the samples captured in Stânca-Costeşti Reservoir, 2014

| No. | Species | Index | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Numerical abundance | Dominance | | Constancy | | Ecological significance index | |
| | | | % | Class | % | Class | % | Class |
| 1 | *Alburnus alburnus* | 501 | 29.02 | D5 | 100 | C4 | 29.02 | W5 |
| 2 | *Perca fluviatilis* | 386 | 22.36 | D5 | 100 | C4 | 22.36 | W5 |
| 3 | *Sander lucioperca* | 158 | 9.15 | D4 | 100 | C4 | 9.15 | W4 |
| 4 | *Rutilus rutilus* | 152 | 8.81 | D4 | 100 | C4 | 8.81 | W4 |
| 5 | *Abramis brama* | 98 | 5.67 | D4 | 100 | C4 | 5.67 | W4 |
| 6 | *Carassius gibelio* | 78 | 4.51 | D3 | 100 | C4 | 4.51 | W3 |
| 7 | *Neogobius fluviatilis* | 73 | 4.23 | D3 | 83 | C4 | 3.51 | W3 |
| 8 | *Leuciscus aspius* | 59 | 3.41 | D3 | 100 | C4 | 3.41 | W3 |
| 9 | *Cyprinus carpio* | 54 | 3.12 | D3 | 100 | C4 | 3.12 | W3 |
| 10 | *Gymnocephalus cernua* | 29 | 1.68 | D2 | 100 | C4 | 1.68 | W3 |
| 11 | *Vimba vimba* | 20 | 1.15 | D2 | 83 | C4 | 0.95 | W2 |
| 12 | *Squalius cephalus* | 16 | 0.92 | D1 | 50 | C2 | 0.46 | W2 |
| 13 | *Barbus barbus* | 15 | 0.86 | D1 | 66 | C3 | 0.56 | w2 |
| 14 | *Rhodeus amarus* | 15 | 0.86 | D1 | 33 | C2 | 0.28 | W2 |
| 15 | *Hypophthalmichthys molitrix* | 13 | 0.75 | D1 | 50 | C2 | 0.37 | W2 |
| 16 | *Scardinius erythrophthalmus* | 9 | 0.52 | D1 | 33 | C2 | 0.17 | W2 |
| 17 | *Pseudorasbora parva* | 8 | 0.46 | D1 | 33 | C2 | 0.15 | W2 |
| 18 | *Ballerus sapa* | 6 | 0.34 | D1 | 16 | C1 | 0.05 | W2 |
| 19 | *Chondrostoma nasus* | 6 | 0.34 | D1 | 33 | C2 | 0.11 | W2 |
| 20 | *Cobitis taenia* | 6 | 0.34 | D1 | 33 | C2 | 0.11 | W2 |
| 21 | *Silurus glanis* | 5 | 0.29 | D1 | 33 | C2 | 0.09 | W1 |
| 22 | *Hypophthalmichthys nobilis* | 4 | 0.23 | D1 | 33 | C2 | 0.07 | W1 |
| 23 | *Pungitius platygaster* | 3 | 0.17 | D1 | 16 | C1 | 0.02 | W1 |
| 24 | *Babka gymnotrachelus* | 3 | 0.17 | D1 | 16 | C1 | 0.02 | W1 |
| 25 | *Esox lucius* | 2 | 0.11 | D1 | 33 | C1 | 0.03 | W1 |
| 26 | *Gobio obtusirostris* | 2 | 0.11 | D1 | 16 | C1 | 0.01 | W1 |
| 27 | *Ctenopharyngodon idella* | 2 | 0.11 | D1 | 16 | C1 | 0.01 | W1 |
| 28 | *Perccottus glenii* | 2 | 0.11 | D1 | 16 | C1 | 0.01 | W1 |
| 29 | *Oncorhynchus mykiss* | 1 | 0.05 | D1 | 16 | C1 | 0.01 | W1 |
| | *No. of individuals* | 1726 | | | | | | |

D1-subrecedent species (<1.1%); D2-recedent species (1.2-2%); D3-subdominant species (2.1-5%); D4-dominant species (5.1-10%); D5-eudominant species (>10%); C1-accidental species (1-25%);C2-accessory species (25.1-50%); C3-constant species (50.1-75%); C4-euconstant species (75.1-100%);W1-subrecedent species (accidental) (<0.1%); W2-recedent species (0.1-1%); W3-subdominant species (accessory) (1.1-5%); W4 - dominant species (5.1-10%); W5-eudominant species (characteristic) (>10%).

*Figure 2: Fish community stratification in the Stanca-Costesti reservoir*

The result of a survey in the Stanca-Costesti reservoir shows an example of a well stratified fish community in Moldova. A total of 29 species have been found to inhabit different layers and trophic zones of the lake. Source: Bulat et al., 2018 Romania – Republic of Moldova joint study concerning the fish fauna in Stanca-Costesti reservoir.

### 2.2.3 Economic and financial barriers

Private and public players in Moldovan aquaculture sector lack investment capacity for the reconstruction of ichthyofauna of lakes with complex destination. Limited finance is a common barrier across all prioritized technologies that limits their widespread adoption. Although among the prioritized technologies, reconstruction of a stratified fish community in aquaculture lakes is not particularly financial resource-intensive, the sector has minimal economic margins and therefore private sector entities have limited – if not existent – investment capacity. On the other hand, since fisheries is not a priority sector in national development due to its relatively low impact on the society of Moldova, the government does not allocate financial sources to incentivize the resilience of the sector.

### 2.2.4 Non-financial barriers

The two most important non-financial barriers to the implementation of fish polyculture in Moldova are information and awareness barriers, and policy and institutional capacity-related barriers.

Lack of information and awareness leads to the following three barriers:

1. Low awareness among fish producers of the potential benefits;
2. Lack of an information system on issues related to innovative climate technologies;
3. Limited knowledge and understanding on adapting the technology).

Policy and Institutional capacity barriers include:

4. Poor implementation of regulatory policy on the management of natural watersheds and the deployment of climate technologies

5. Ignoring the protection of water resources by policymakers.
Technical Barriers (i.e. Low availability of fish stocks for repopulation of lakes and insufficient support at all levels of the society on the technology of using complex lakes) is an issue but its magnitude is much lesser than the lack of recognition to the added value that an ecosystem-based approach to adapting aquaculture to climate change can have. National experts that could plan and manage the reintroduction of fish species in lakes with complete trophic stratification exist and, at least initially, the missing fish stocks could be imported by neighboring countries – especially Romania and Ukraine – to adapt native species to Moldovan lakes. Lack of demand for such intervention and lack of response from policymakers in terms of supportive measures are the main non-financial barriers for this technology.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. Through this process then, an initial understanding possible measures to mitigate the existing barriers has been carried out. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization on the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors.
The Problem Tree for the first prioritized technology for the aquaculture sector (fish polyculture) is presented below, whereas the market mapping analysis follows.
The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 2.5).

Food and Agriculture Organization of the United Nations

GREEN CLIMATE FUND

Problem tree for: **Capitalization of the trophic potential through interspecific polyculture**

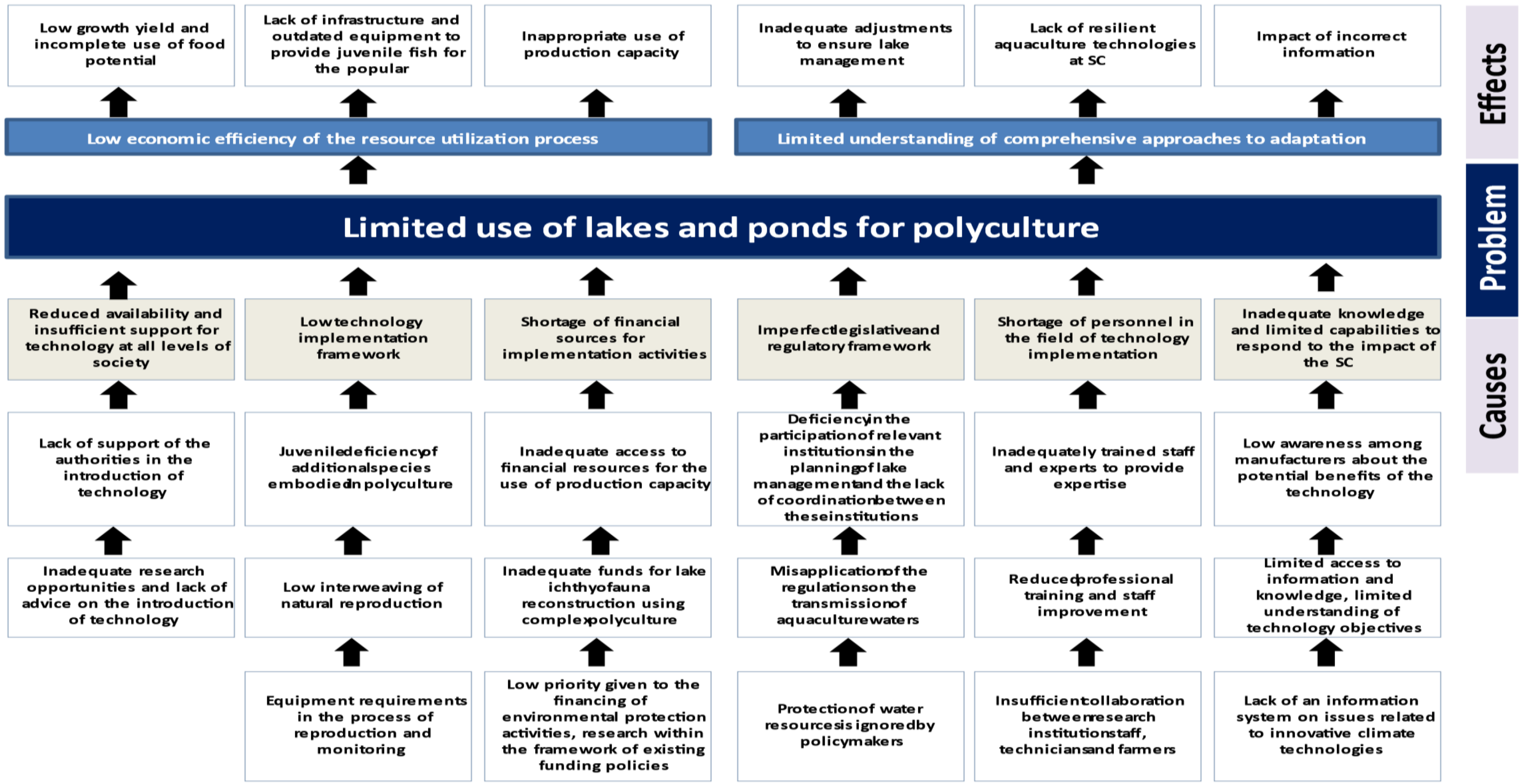



*Figure 3: Problem tree for fish polyculture*

**Market Mapping for: Capitalization of the trophic potential through interspecific polyculture**

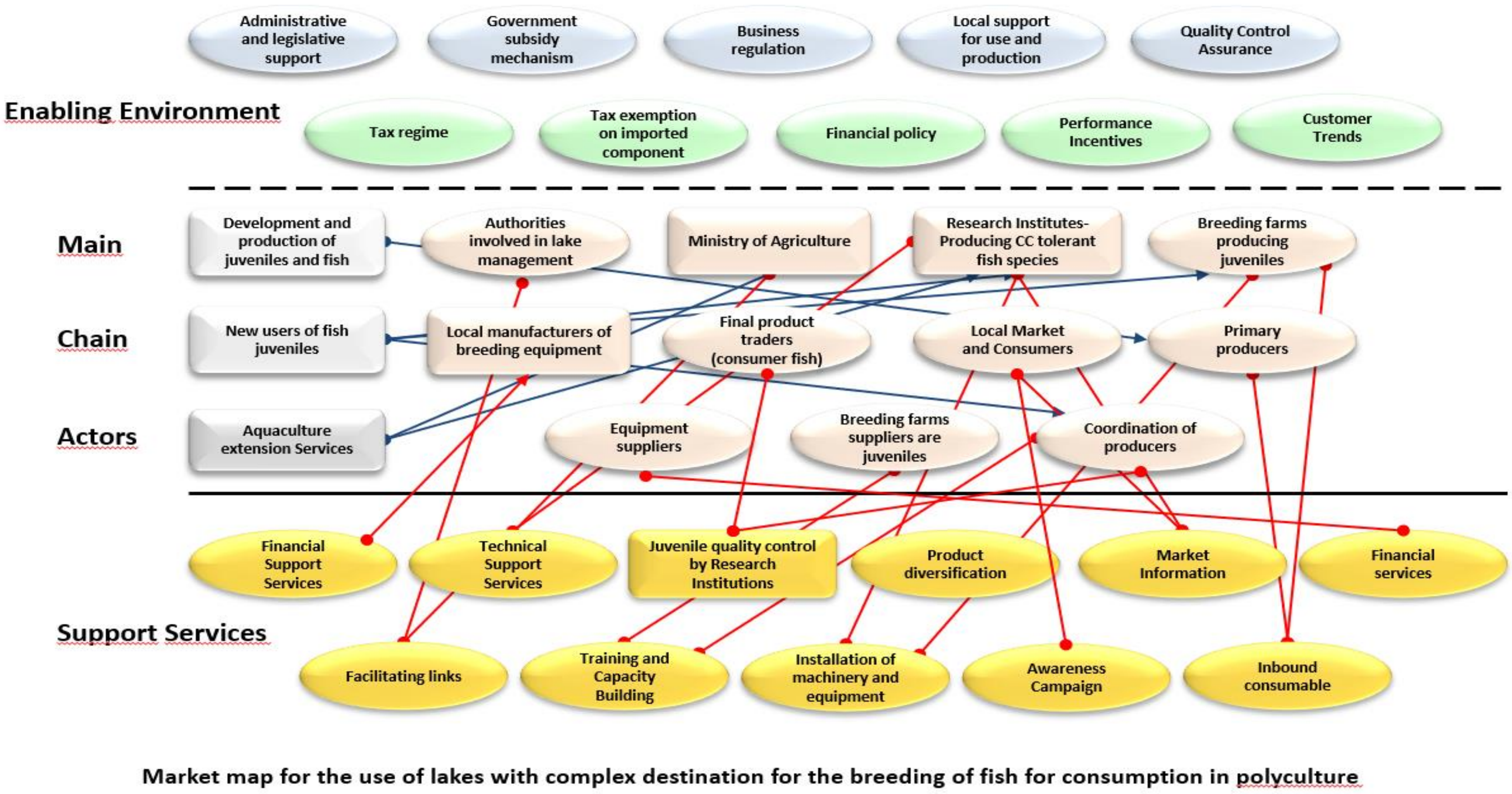



*Figure 4: Market Mapping for fish polyculture*

## 2.3 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR INCREASING THE WATER FLOW IN THE PONDS USED FOR THE BREEDING OF FISH IN POLYCULTURE FOR THE AQUACULTURE SUB-SECTOR

### 2.3.1 General description of technology, technology status in Moldova, and market characteristics

The large water deficit recorded in the lakes and ponds used in aquaculture, places the Republic of Moldova in the category of countries with increasing risk of water stress. The negative consequences of climate change, in particular the increased incidence of heat and drought, call for the implementation of adaptation practices and supportive policies to reduce the threats posed by climate change to aquaculture and to seize the opportunities to invest in coherent and convergent risk reduction and adaptation measures to anticipate and reduce the impacts of extreme phenomena. Riverbeds in most of the tributaries of the Prut river, which feeds water bodies across Moldova, are subject to clogging and water flow reductions due to several concurring factors. The presence of overgrown aquatic vegetation, the presence of wastes and debris and is being recently exacerbated by the reduced amount water flowing through the river and its tributaries as a consequence of increased temperatures and reduced precipitations. Water from the slopes does not flow into the ponds as it used to in previous decades but is distributed over the entire surface of the floodplains, increasing flood risks and spreading over large surfaces instead of flowing through the most direct route into rivers and water basins. In turn, such water is no longer available in lakes and ponds when needed as it evaporates from the floodplains into the atmosphere on a short cycle. At the same time, water channels and rivers are obstructed by vegetation and other debris (including often plastic and other polluting waste) and the ponds are intensely subjected to clogging, which contributes to the sharp decrease of their volume and water quality decays. Avoiding the degradation of fish habitats and maximizing the efficiency of water management is possible by restoring the depth of flowing water bodies (both natural as well as man-made ones). Dredging water supply channels will allow to increase the water flow in fishponds and support the integrated management of water resources within the river basins of small rivers.
Ensuring safe exploitation of the water bodies requires that an action plan is drawn up, which should include specific guidelines and timeline for dredging prioritization and mapping of operations, delimitation and registration of the areas of intervention, the conservation of the riparian vegetation and biodiversity at large, the collection and disposal of the clogging material harvested, particularly pollutants and wastes. Such technology is to an extent already practiced on a small scale and only by farms and fishery enterprises that have financial sources to carry out the cleaning of the artificial ponds, whereas little is done to the river tributaries and water channels.

### 2.3.2 Identification of barriers for increasing the water flow of ponds used in polyculture

As in the case of the first prioritized technology, the identification of barriers for increasing the water flow of ponds used in polyculture has been carried out by the National Consultant on aquaculture. The main broad barrier categories identified for the implementation of this technology belong to the same groups listed for the fish polyculture: 1) Economic and financial, 2) Policy, legal and regulatory, and 3) Social, cultural and behavioral groups. Under the last category of barriers, other sub-categories (i.e. institutional and human capacity, knowledge and awareness) represent relevant obstacles to the uptake of this technology in Moldova. These barriers are summarized in Table 3 below. Very relevant barriers to the implementation of the proposed technology are linked to the policy landscape and are closely coupled to lack of awareness and knowledge on the importance of a healthy waterflow in rivers and their tributaries. The various elements of each decomposed barrier have been considered individually and decomposed barriers were prioritized according to their significance (table 4). As a result of this exercise, the cleaning of water supply channels technology has a total of 20 barriers listed of which 10 were considered “essential” to its implementation. These are:

1) The lack of an adequate legal authority for the protection and management of fish farms and therefore the lack of plans and strategies for the protection and management of resources.
2) Lack of private financial sources for maintenance operations
3) Farmers' resistance to change, perception of complexity and possible negative consequences (risk)
4) Inadequate river basin management of small rivers
5) Inadequate financial assistance for programmes for restructuring and consolidation of fisheries holdings extension, restoration, modernisation of existing farms and establishment of new aquaculture production capacities
6) Lack of recognition of the importance of ecosystem services of lakes and ponds in the country
7) Lack of a knowledge base on successful local case studies to demonstrate the impact of technology on water use efficiency
8) Lack of scientific data or adequate socio-economic analysis of the technology at national level
9) Poor collaboration and communication between extension, research and end-user
10) Limited awareness of adaptation to climate change

| **Wide category of barriers** | **Barriers within a category** | **Elements of barriers** |
|---|---|---|
| Economic and financial | Lack of private financial sources for maintenance operations (soft work to clean up and deepen existing supply channels) | Inadequate financial assistance for programmes for restructuring and consolidation of fisheries holdings extension, restoration, modernisation of existing farms |
| Policy, legal and regulatory | Insufficient support of government institutions. | Inadequate integration of technologies into policy plans; Inconsistency and ambiguity of regulatory policy in the field of transmission of aquaculture waters |
| | The lack of an adequate legal authority for the protection and management of fish farms and therefore the lack of plans and strategies for the protection and management of resources. | The absence of professional associations and effective consumer bodies (problems and opinions on barriers cannot effectively reach policymakers; no lobbying or no lobbying to facilitate technology transfer |
| Social, cultural and behavioral | Unsustainable practices (unplanned developments and projects) in the framework of technology deployment | Farmers' resistance to change, perception of complexity and possible negative consequences (risk) |
| | Limited integration of government institutions into development planning and guidelines and lack of coordination between them | Limited and inadequate coordination between the institutions with stakeholders. This is a serious challenge for the successful transfer and adoption of technology. |
| Institutional and organisational capacity | General lack of public appreciation/awareness of the uses/importance of the technology | Lack of institutions or mechanisms for generating and disseminating information |
| | Limited institutional R&D capacity to undertake practical experiments and pilot projects for demonstrations for farmers. | Legal/regulatory framework that can serve as rules for the necessary standards for the transfer and diffusion of technology. |
| | Lack of recognition of the importance of ecosystem services of lakes and ponds in the country | Protection of water resources is not taken into account when making decisions on climate change |
| | Inadequate river basin management of small rivers | Lack of zonal plans to identify water bodies that need to be rehabilitated by cleaning; |
| Information and awareness | Limited awareness of adaptation to climate change. | Limited knowledge of the benefits of technology - |

| | | |
|---|---|---|
| | Lack of awareness about climate change issues and technological solutions | Poor dissemination of information to users of the technology (on benefits, costs, sources of funding, potential project developers, etc.) |
| | Lack of a knowledge base on successful local case studies to demonstrate the impact of technology on water use efficiency. | Limited knowledge and practical experience for the operationalization of such technologies. |
| | General lack of appreciation/awareness of the public about the uses/importance of the technology | Limited access to information by fish producers on adaptation technologies |
| Human competences | Inadequately trained staff and experts to provide technology expertise | Poor collaboration and communication between extension, research and end-user. |
| Other | Illegal construction practices within the riverbeds | Inadequate management of watersheds of small rivers; |

*Table 4: Complete list of barriers identified for the technology increased water flow of ponds used in polyculture*

| **Barriers determined** | **Score** | **Classification of barriers** |
|---|---|---|
| The lack of an adequate legal authority for the protection and management of fish farms and therefore the lack of plans and strategies for the protection and management of resources. | 31 | **Policy, legal and regulatory barriers** |
| Lack of private financial sources for maintenance operations (soft work to clean up and deepen existing supply channels) | 30 | **Economic and financial barriers** |
| Farmers' resistance to change, perception of complexity and perceived negative consequences (risk) – loss of investment (time, effort, money) | 30 | **Social, cultural and behavioral** |
| Inadequate river basin management of small rivers | 29 | **Institutional and organisational capacity** |
| Inadequate financial assistance for programmes for restructuring and consolidation of fisheries holdings extension, restoration, modernisation of existing farms and establishment of new aquaculture production capacities | 28 | **Economic and financial barriers** |
| Lack of recognition of the importance of ecosystem services of lakes and ponds in the country | 27 | **Institutional and organisational capacity** |
| Lack of a knowledge base on successful local case studies to demonstrate the impact of technology on water use efficiency. | 27 | **Barriers to information and awareness** |
| Lack of scientific data or adequate socio-economic analysis of the technology at national level. | 26 | |
| Poor collaboration and communication between extension, research and end-user. | 25 | |
| Limited awareness of adaptation to climate change. Inadequate awareness about the existence and usefulness of the technology. | 25 | **Barriers to information and awareness** |
| General lack of appreciation/awareness of the public about the uses/importance of the technology | 25 | **Barriers to information and awareness** |
| Illegal practices of construction of dams within riverbeds | 25 | |
| Limited institutional R&D capacity to undertake practical experiments and pilot projects for demonstrations for farmers. | 24 | **Institutional and organisational capacity** |
| Limited integration of government institutions into development planning and guidelines and lack of coordination between them | 24 | **Social, cultural and behavioral** |
| Insufficient support of government institutions. | 24 | **Policy, legal and regulatory barriers** |
| General lack of public appreciation/awareness of the uses/importance of the technology | 23 | |
| Limited access to information by fish producers on adaptation technologies | 22 | **Barriers to information and awareness** |
| Lack of a policy to subsidise fish producers including breeding farms and lack of a lending and subsidy mechanism in aquaculture resulting in fewer economic and financial benefits | 21 | **Economic and financial barriers** |

*Table 5. Scoring of the barriers assessed in the consultation process for the technology of increasing water flow in ponds used for polyculture*

### 2.3.3 Economic and financial barriers

As stated above, aquaculture is marginally lucrative economic activity in Moldova. This results in lack of investment capacity of private and public players. Such general trend applies to any technology for a sector with small economic margins and is a relevant barrier in the country. The operation is not particularly costly per unit of surface, but the economic burden is posed by the extent and scale of the operation which should cover hundreds of kilometers of rivers and water basins of various size. Maintaining the water flow in these rivers and streams, as well as maintaining deep water levels in ponds and lakes has a number of positive environmental and resilience co-benefits in addition to the productivity of these water basins used for aquaculture. However, monetizing such co-benefits has proven challenging, thus the main barrier is the lack of a quantification of potential economic benefits realized through its implementation. Ecosystem services are incredibly relevant from an economic point of view, although these remain difficult to quantify. This is why economic barriers should not be decoupled from awareness barriers (and to an extent, to cultural barriers), which are the most important aspects that limit the diffusion of sustainable technologies and practices for adaptation of the sector to climate change.

### 2.3.4 Non-financial barriers

Non-financial barriers for this technology were found to be particularly relevant. The main barrier for the adoption of this practice is linked to the lack of an adequate planning system and a consequent strategy for the effective maintenance of river and stream flows in the context of climate change and other environmental impacts of anthropological origin, including waste disposal. In Moldova, an authority that oversees the quality of waters used for aquaculture activities does not exist, as a consequence no maintenance activities in rivers and streams are planned, prioritized and executed. This is a major barrier to the uptake of the proposed barrier and especially to its scale-up. If in the context of a pilot project the relevant line ministries (Ministry of Environment and Ministry of Agriculture) could be successfully involved in the demonstration activities, building an inter-ministerial structure that can manage these operations at the national level is a considerable challenge. Some regulations are conflicting, jurisdiction is not well defined and controversies between local and national authorities are likely. Even if such a coordinating structure is put in place and the planning is carried out, specific operations might fall under the responsibility of private farmers and aquaculture entrepreneurs if the maintenance operations interest streams and water bodies on private land (or under concession). Farmers' resistance to changing managing practices is considered another main barrier, this time of socio-cultural and behavioral nature, that is expected to impede the scale-up of the prioritized practice. Small rivers, creeks, and streams (even seasonal ones) are not mapped and difficult to attribute to any entity. By their nature, these flow through different properties and recollecting possible responsible actors, or point sources, is de-facto impossible. In general terms, past Moldovan policies have not posed enough emphasis on water resources protection, and no records of successful examples of benefits directly attributable to cleaning of water bodies exist in the country. In this context then, there is the expectation that poor coordination between extension services and end-users will limit the effectiveness of the planned activities, and the lack of enforcement will require large scale monitoring activities, including remote sensing based (e.g. satellite images, drone inspection) to evaluate areas of intervention.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. Through this process then, an initial understanding possible measures to mitigate the existing barriers has been carried out. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding

of the issue: its localization on the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors.
The Problem Tree for the first prioritized technology for the aquaculture sector (increasing water flow into ponds used for aquaculture) is presented below, whereas the market mapping analysis follows.
The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 2.5).

Problem tree for: **increasing the water flow of ponds used in polyculture**

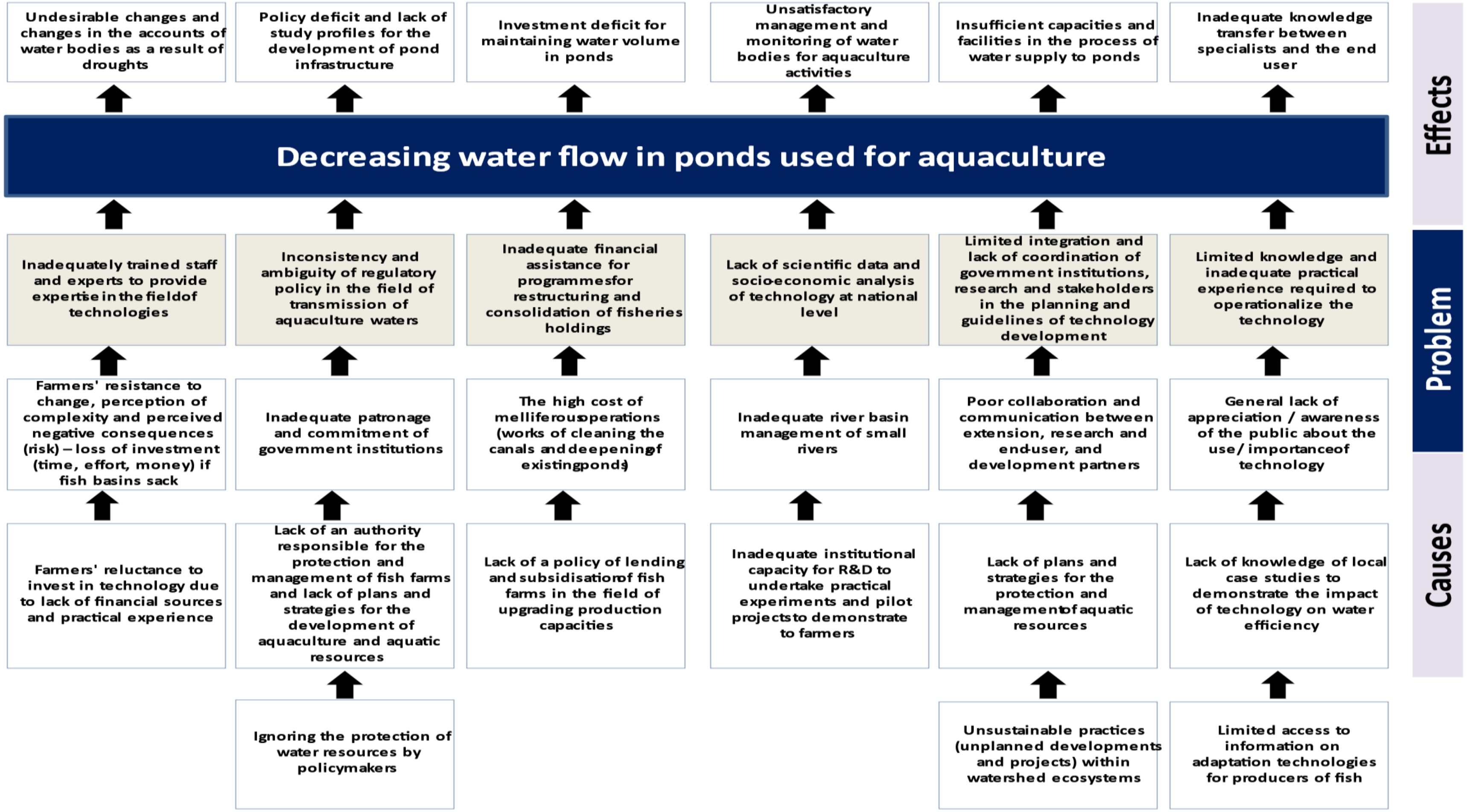
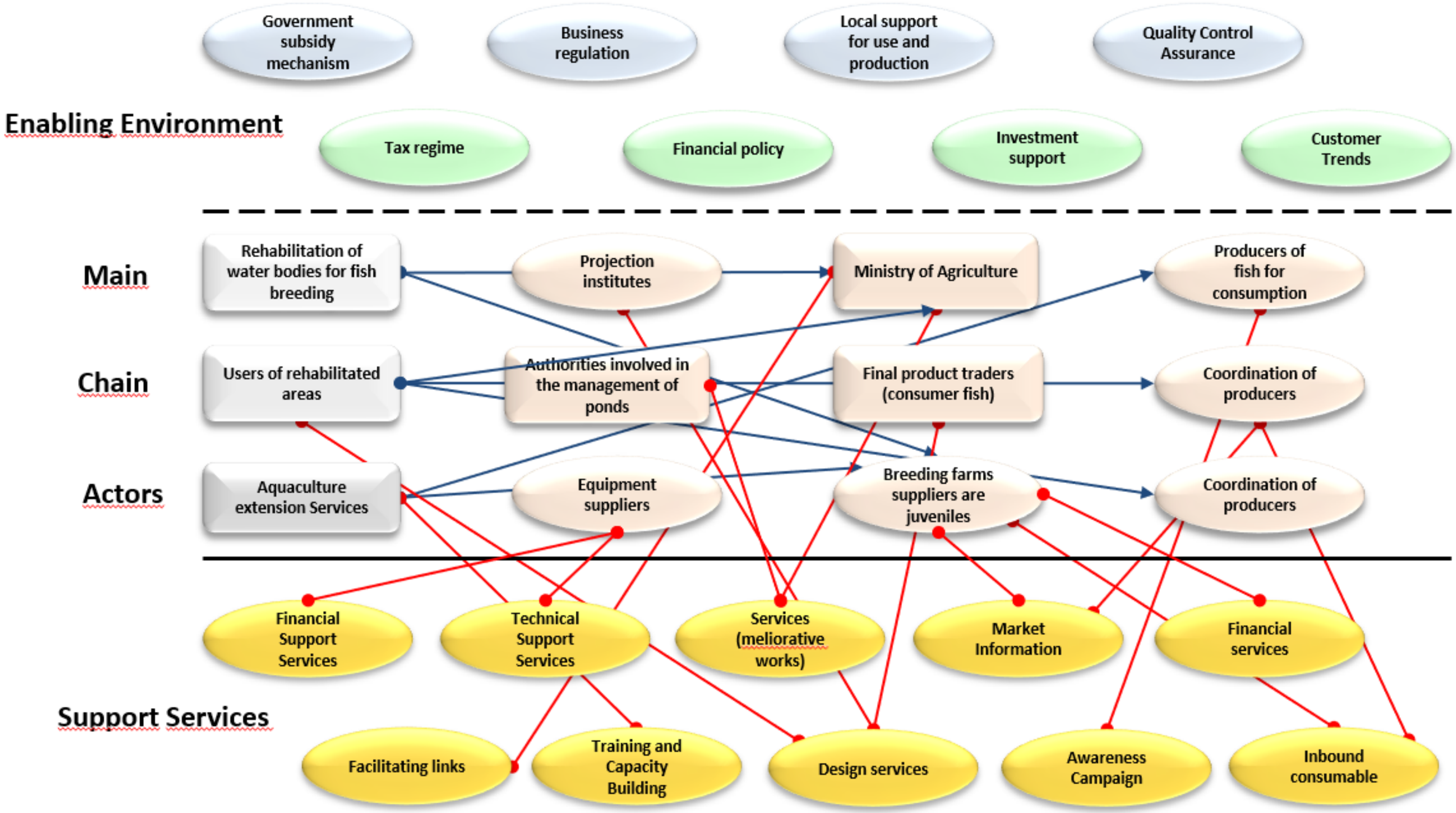



*Figure 5: Problem Tree for increased water flow*

Market Mapping for: increasing the water flow of ponds used in polyculture




**Market map for an intervention to increase the water flow in the ponds used for growing fish in polyculture according to continuous technology**

*Figure 6: Market Mapping for increased water flow*

## 2.4 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR FISH PROTECTION SYSTEM FOR THE AQUACULTURE SUB-SECTOR

### 2.4.1 General description of technology, technology status in Moldova, and market characteristics

The *fish protection system* is a set of measures to aimed at improving the growth and wintering conditions of fish stocks in aquaculture basins through disease prophylaxis and the use of improved genetic material of the populations, while ensuring food security through case-specific actions. Increased high temperatures, changes in precipitation regimes, and extreme drought phenomena are having significant impacts on water quality, retention capacity, and ultimately fish health in aquaculture basins. To counter such trend, it is necessary to elaborate a comprehensive, country-wide inventory of aquaculture activities through a *fishery-biological justifications* (FBJ). This inventory system for aquaculture water bodies has to survey and collect information of existing formally and informally established aquaculture activities, linked to specific cartography and hydrological determinants (e.g. hydrochemical indices, trophic potential, etc.) of aquaculture areas of Moldova. The PFB inventory will be instrumental to forecast and crucially monitor in a spatially impacts on water quality and availability in the water bodies, allowing farmers to adapt to the changes existing climate.

The PFB will allow to:

- determine the actual situation of the aquaculture sector and the impacts of climate change;
- identify the production units operating and the number of users of water for aquaculture;
- determine optimal and actual productivity levels and assess water scarcity and drought impacts on productivity;
- determine the size and coverage of ameliorative actions (e.g. cleaning the water supply channels of the ponds);
- plan and elaborate fish health protocols, including genetic pool needs, nutritional requirements, and disease prophylaxis.

Morbidity and mortality in fish, is often the consequence of eutrophication of the basins, and statistically truthfully reflects the state of health of the population, the intensity and quality of agricultural, industrial, urban, transport and other activity in the basin region [Meyer, Barklay, 1990]. Assessing the baseline status of aquaculture and monitor overtime the determinants that might lead to decay in any of the key parameters of fish health is key to adapt to the impacts of climate change and improve the resilience of the sector.

### 2.4.2 Identification of barriers for fish protection systems

Similarly to the previous technologies prioritized for the aquaculture sub-sector in Moldova, economic barrier are an obstacle, especially because this sector has a small contribution to national GDP and aquaculture is not considered a particularly lucrative activity. The main broad barrier categories identified for the implementation of this technology belong to the same groups listed for the fish polyculture: 1) Economic and financial, 2) Policy, legal and regulatory, and 3) Social, cultural and behavioral groups. Under the last category of barriers, other sub-categories (i.e. institutional and human capacity, knowledge and awareness) represent relevant obstacles to the uptake of this technology in Moldova, as for all three prioritized technologies for the aquaculture sector. All barriers identified are summarized in Table 5 below. Economic barriers are the most important impediment to the development of a nationwide fish protection system, but technical difficulties are numerous and should be regarded with much attention in order to enable the uptake of this technology. Policy and awareness barriers, also present, have a lower impact on the enabling environment for this technology. The various elements of each decomposed barrier have been considered individually and decomposed barriers were prioritized according to their significance (table 4). As a result of this exercise, the fish protection system technology has a total of 18 barriers listed of which 9 were considered "essential" to its implementation. These are:

1) Lack of financial resources dedicated to assessment and monitoring of aquaculture production areas
2) Insufficient research on adapting, improving and evaluating the efficiency of adaptation technologies.
3) Low interest of the relevant institutions in the implementation of technical and sanitary measures that ensure adequate health management on fish farms
4) Lack of support in the development and implementation of biosecurity plans in fish farms
5) Limited access to information by fish producers on climate change adaptation technologies, their capacity and availability;
6) Low interest in promoting climate technologies, with little participation of researchers, consultants and producers and lack of information about the positive influence of climate technologies;
7) Inadequate financial assistance and high initial investment costs for the development, implementation of the effective protection and monitoring, forecasting and early warning systems;
8) Lack of information of specialists and the population on the importance in the current conditions of development of aquaculture and compliance with measures to protect human health and ensure food safety;
9) Inconsistency and lack of clarity about long-term regulations concerning water management for aquaculture purposes.

| **Wide category of barriers** | **Barriers within a category** | **Elements of barriers** |
|---|---|---|
| Economic and financial | Inadequate financial assistance and high initial investment costs for the development, implementation of the protection system. | High resource costs (material, labor, capital) |
| | Lack of subsidies for farmers implementing climate technologies; | High entry requirements |
| | Lack of finance for the development of breeding techniques and reconstruction of breeding incubators | Poor rural infrastructure to provide juveniles for high-quality popular |
| | Lack of financial resources for carrying out complex investigations of production areas, inventory, mapping of water bodies and ensuring the health of fish for consumption. | Inadequate access to investments in the integrated production system Insufficient quantity and quality of control and monitoring equipment |
| Policy, legal and regulatory | Inconsistency and lack of clarity about long-term regulations concerning water management for aquaculture purposes | Conflicting regulations |
| | Lack of fisheries-biological justifications (PFBs) for water bodies in fisheries to predict availability in water bodies, allowing farmers to adapt to existing climate change; | Insufficient availability or capacity to implement fisheries-biological justifications (PFB) |
| | Lack of an adequate legal authority for the protection and management of aquaculture | Lpsa management plans or programmes for the protection and management of resources.; |
| | Lack of coordination between government institutions and fisheries; | Poor collaboration and communication between extension, research and end user |
| | Limited cooperation between relevant government agencies | Lack of close cooperation with relevant institutions for the exchange of knowledge, data – etc.; |
| Social, cultural and behavioral | Lack of information of specialists and population on the importance in the current conditions of development of | Limited knowledge and practical experience necessary for the implementation of the system of |

| | | |
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| | aquaculture and compliance with measures to protect human health and ensure food security; | protection and ensuring the health status of the population |
| | Insufficient demonstration of adaptation technology. | Absence of a knowledge base on case studies to demonstrate the impact of technology |
| Institutional and organisational | Insufficient regulations, by which the relevant institutions cannot fully ensure the monitoring and transparency of the maintenance of the capitalized water basins. | Inadequate links between research, development and enlargement |
| Information and awareness | Limited access to information by fish producers on technologies for adaptation to climate change, their capacity and availability; | Limited understanding of the consequences of climate change and its potential impact on their activities, and the importance of adaptation measures |
| | Low media interest in promoting climate technologies, with little participation of researchers, consultants and producers and lack of information about the positive influence of climate technologies; | Inadequate awareness about the existence and usefulness of technology |
| | Lack of awareness about issues related to climate change and technological solutions; | Inadequate information on the protection system Limited institutional capacity for research and development to undertake practical experiments and pilot projects for farmers' demonstrations. |

*Table 6: Complete list of barriers identified for the technology fish protection systems in aquaculture*

| **Barriers determined** | **Score** | **Classification of barriers** |
|---|---|---|
| Lack of financial sources for carrying out complex investigations of production areas in fish farms | 29 | **Economic and financial barriers** |
| Insufficient research on adapting, improving and evaluating the efficiency of adaptation technologies. | 29 | **Technical barriers** |
| Low interest of the relevant institutions in the implementation of technical and sanitary measures that ensure adequate health management on fish farms | 29 | **Policy, legal and regulatory barriers** |
| Lack of support in the development and implementation of biosecurity plans in fish farms | 28 | **Technical barriers** |
| Limited access to information by fish producers on climate change adaptation technologies, their capacity and availability; | 28 | **Barriers to information and awareness** |
| Low interest in promoting climate technologies, with little participation of researchers, consultants and producers and lack of information about the positive influence of climate technologies; | 28 | **Barriers to information and awareness** |
| Inadequate financial assistance and high initial investment costs for the development, implementation of the effective protection and monitoring, forecasting and early warning system; | 27 | **Economic and financial barriers** |
| Lack of information of specialists and the population on the importance in the current conditions of development of aquaculture and compliance with measures to protect human health and ensure food safety; | 27 | **Social, cultural and behavioral** |
| Inconsistency and lack of clarity about long-term regulations concerning water management for aquaculture purposes | 26 | **Policy, legal and regulatory barriers** |
| Lack of awareness on issues related to climate change and technological solutions; | 26 | **Barriers to information and awareness** |
| Lack of subsidies for farmers implementing climate technologies; | 25 | **Economic and financial barriers** |

| | | |
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| Insufficient regulations, through which the relevant institutions cannot fully ensure the monitoring and transparency of the maintenance of the capitalized water basins. | 25 | **Institutional and organisational capacity** |
| Lack of an information system on issues related to innovative climate technologies; | 25 | **Barriers to information and awareness** |
| High operational and maintenance costs of such a system; | 24 | **Economic and financial barriers** |
| Inadequately trained staff and experts to provide technology expertise. | 24 | **Barriers to information and awareness** |
| Lack of adequate legal authority for the protection and management of aquaculture and therefore lack of management plans or programmes to protect and manage these resources; | 23 | **Policy, legal and regulatory barriers** |
| Lack of coordination between government institutions and fisheries; | 23 | **Policy, legal and regulatory barriers** |

*Table 7: Scoring of the barriers assessed in the consultation process for fish protection systems in aquaculture*

### 2.4.3 Economic and financial barriers

Elaborating a comprehensive, country-wide inventory of aquaculture resources that collects information of existing formally and informally established aquaculture activities, linked to specific cartography and hydrological determinants has high set up costs. The planning and execution of such a plan requires investments that are hardly covered by the potential co-benefits achievable, being the aquaculture sector less lucrative than others and the size of the intervention expectedly rather large. Technologies to survey and collect the necessary information are expensive and the operational costs (especially for personnel) are expected to be particularly high. This coupled with the lack of dedicated public budget for monitoring of natural resources in general, and in particular of aquaculture resources, makes it a rather difficult barrier to overcome. The planning of the system must consider potential co-benefits to include in the cost-benefit analysis (such as multi-sectoral data collection, etc.) to justify the necessary investment, or rely on international climate-related funding opportunities as envisaged in the National Determined Contributions as “conditional” achievements.

### 2.4.4 Non-financial barriers

Technical barriers for monitoring the territory with advanced systems such as satellite data and drone imaging, are another crucial set of barriers for the implementation of a fish protection system. These technologies are not widely available in Moldova and where present have only been applied to other sectors, thus requiring relevant efforts to be adapted to the aquaculture sector. Engineers, technicians, PFB experts are lacking in the country and building the knowledge base necessary to enable the nationwide uptake of this technology is a long-term endeavor. Policy-related barriers, like the lack of supportive mechanisms for the aquaculture sector in general then, also limit the potential for investing in long term strategies for monitoring the territory and the performances of the aquaculture sector. Low interest in promoting climate technologies, with little participation of researchers, consultants and producers and lack of information about the positive influence of climate technologies is another relevant barrier, linked to cultural and awareness aspects.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. Through this process then, an initial understanding possible measures to mitigate the existing barriers has been carried out. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization on the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors.

The Problem Tree for the first prioritized technology for the aquaculture sector (Fish Protection Systems) is presented below, whereas the market mapping analysis follows.

The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 2.5).

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Problem Tree for: Fish Protection Systems

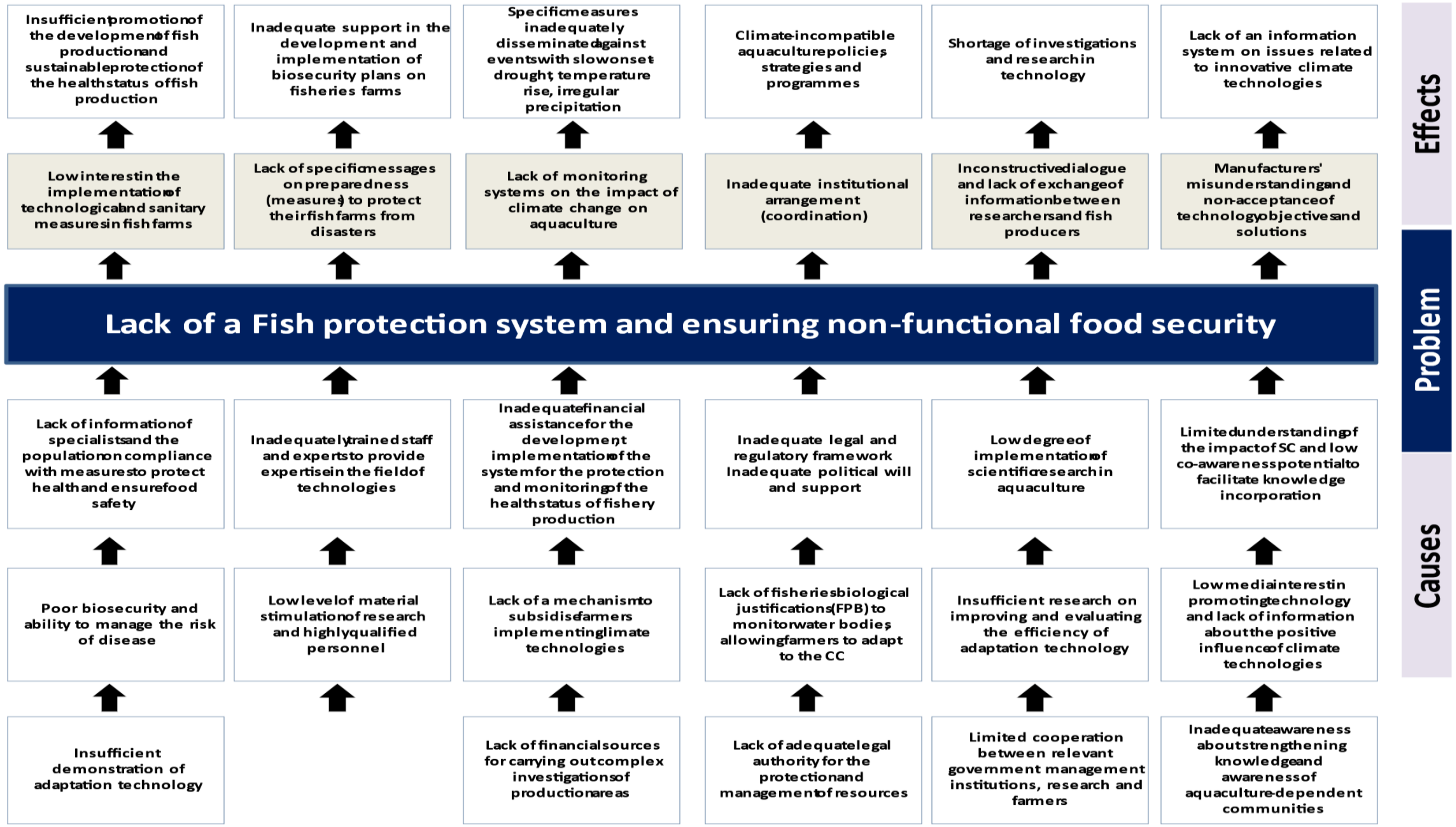


*Figure 7: Problem Tree for Fish Protection Systems*

Market Mapping for: Fish Protection Systems

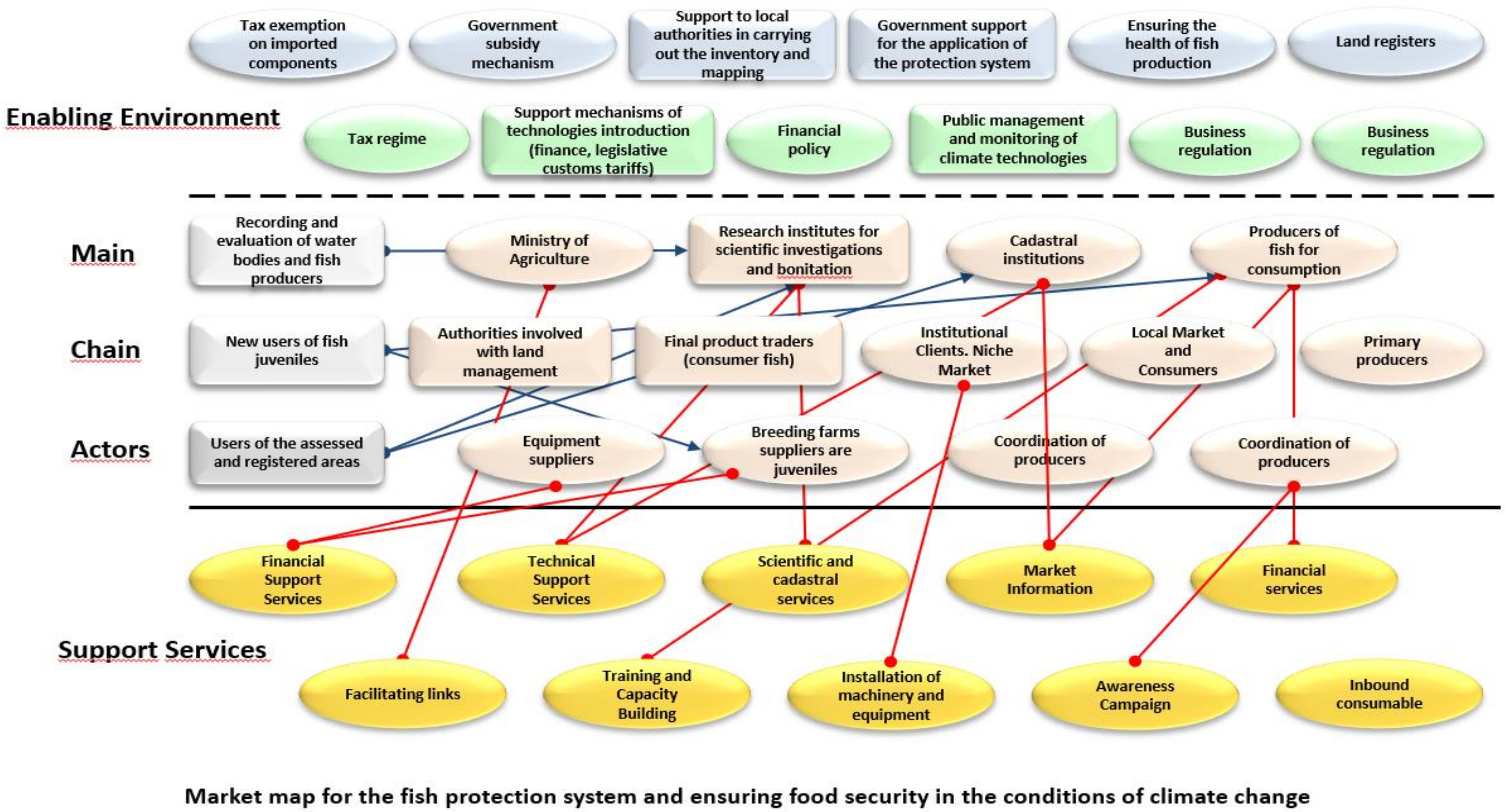


*Figure 8: Market Mapping for Fish Protection Systems*

## 2.5 IDENTIFIED MEASURES

In order to overcome common barriers and effectively tackle climate change in the aquaculture sector, it is essential to create an enabling framework that promotes adaptation action and sustainable development of this subsector of agriculture. A literature review and discussions with stakeholders, researchers and farmers, has shown that creating and strengthening the enabling environment to support technology depends on many key elements that are linked to the policy, regulatory and other institutional and organisational capacity-building arrangements. To understand better the implications of each barrier presented, the National Consultant prepared Problem Trees (Annex 1) and Market Mapping (Annex 2). Based on these two documents, the multistakeholder discussions could target specific and general measures to overcome the barriers, including the roles and the portion of the value chain where these actions should take place. The result of the exercise is a set of targeted and specific measures identified by the relevant members of the TNA team in consultation with the SWG. For ease of reference, the prioritized technologies are recapped and each identified measure is listed next to them.

1) **Identification of measures to remove barriers for complex capitalization of the trophic potential through interspecific polyculture**
2) **Identification of measures to remove barriers for increasing the water flow of ponds used in polyculture**
3) **Identification of measures to remove barriers for the implementation of fish protection systems**

1) **Identification of measures to remove barriers for complex capitalization of the trophic potential through interspecific polyculture**

| ***Categories of barriers*** | ***Barrier*** | ***Measures*** |
|---|---|---|
| ***Economic and financial*** | *Lack of financial sources and High cost of aquaculture operations (construction works to clean up and deepen the water supply channels of existing azuri)* | *Attracting funds through proposals to carry out the construction works of cleaning the channels from the accumulation of water, properly formulated.*<br>*Encouraging investments in river basin infrastructure and supporting actions to increase the efficiency of the use of water bodies used in aquaculture to become more resistant to drought and reduced amounts of water.*<br>*Supporting investments in systems and solutions that maintain water volume or reduce losses, through works to reduce the risk of water supply to fishponds.* |
| | *Lack of a policy to subsidise fish producers including breeding farms and lack of a credit and subsidy mechanism in aquaculture resulting in fewer economic and financial benefits* | *Adequate economic and financial financial incentives to implement the promotion of climate technologies through subsidies for the introduction of good practices.*<br>*Granting financial assistance in the form of special grants to support the initial cost of the construction works and the adequate acceptability of farmers to the special technique for carrying out the cleaning of the water supply channels of the ponds and to promote the use of the technology.* |
| ***Policy, legal and regulatory*** | *Patronage and inadequate commitment of government institutions. Inconsistency and ambiguity of regulatory policy in the field of transmission of aquaculture waters* | *Amendment of the normative acts on the rights and commitments of the users of the water basins, elaboration of the plan of corrective actions within the regulatory framework.*<br>*Creating policies and study profiles for the development of pond infrastructure and raising awareness of the importance of sustainable management of water bodies to facilitate increased funding* |
| | *The lack of an adequate legal authority for the protection and management of fish farms and therefore the lack of plans and strategies for the protection and management of resources.* | *Supporting the integrated management of water resources within the river basins of small rivers on which water bodies are cascaded, so that aquaculture has sufficient water (volume/quality);*<br>*Assisting the institutions responsible for enabling the preparation of programmes and plans for the proper management of fish farms.*<br>*Awareness-raising programs for government institutions to allow the assessment of the need for rehabilitation of ponds for socio-economic benefits.* |

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| | | *Promote competitive aquaculture, support economically viable and socially and environmentally sustainable producer organisations and fish farms.* |
| | | *Strengthen the capacities of R&D institutions to support the introduction of technology and the implementation of activities related to technology and the efficient management of complex lakes; Conducting scientific research on adapting, improving and evaluating the efficiency of innovative technologies in order to disseminate the advantages and disadvantages.* |
| ***Social, cultural and behavioral*** | *Unsustainable practices (unplanned developments and projects) in ecosystems* | *Awareness - raising programmes for those involved in sustainable practices in fisheries to strengthen regulation; Develop new studies needed to substantiate the assessment of water resources at the level of river basins and sub-basins in the conditions of climate change.* |
| | *Limited integration of government institutions into development planning and guidelines and lack of coordination between them* | *Develop the cooperation mechanism, which will allow for the removal of barriers among stakeholders to the use of technology.* |
| ***Institutional and organisational capacity*** | *General lack of public appreciation/awareness of the uses/importance of the technology* | *Encouraging projects that help to rehabilitate fish farms and improve the infrastructure of ponds developed jointly with research institutions.*<br>*Conduct quantitative assessments of the water needs of different users and introduce them in the process of developing river basin management plans taking into account the expected impact of different climate change scenarios.* |
| | *Limited institutional R&D capacity to undertake practical experiments and pilot projects for demonstrations for farmers.* | *Stimulating research and development institutions in carrying out studies and developing projects.*<br>*Increasing water availability in water bodies as a result of ameliorative measures, improving management and monitoring of water bodies through research.* |
| ***Human competences*** | *Inadequately trained staff and experts to provide technology expertise* | *Facilities for the relevant institutions to allow for the regular updating of knowledge through training and research.*<br>*Develop mechanisms for maintaining the current trained staff in research institutions and provide budgetary provisions for the training of staff in research institutions and fish farms.* |
| ***Information and awareness*** | *Limited awareness of adaptation to climate change.* | *Improve the awareness and competence of fish producers about the potential benefits of selection programmes and their implementation.* |
| | *Inadequate awareness about the existence and usefulness of technology.* | *Improving access to technological information and encouraging the transfer of knowledge between specialists and the end user.* |

| | | |
|---|---|---|
| | *The absence of a knowledge base on successful local case studies to demonstrate the impact of technology on water efficiency.* | *Increasing the efficiency of the training process in the field of technologies for adaptation to climate change, expanding trainings for farmers; Stakeholder conduct through media awareness-raising programmes involving industry experts;* |
| | *General lack of appreciation/awareness of the public about the uses/importance of the technology* | *Strengthening information and awareness measures to solve the tasks of saving water resources, implementing projects, publishing recommendations, etc;*<br>*Ensuring technical skills in the maintenance of water supply channels for ponds by organizing/ conducting seminars, workshops and presentations.* |
| ***Technical*** | *Inadequate river basin management of small rivers* | *Establishing regulatory mechanisms for construction programs and developing zonal plans for the identification of water bodies that need to be rehabilitated by cleaning.*<br>*Updating the watershed management schemes of small rivers and implementing measures to rehabilitate the riverbeds that feed the ponds.*<br>*Improving capabilities and equipping with specialized technique in the process of water supply to incubators in the process of reproduction.* |
| | *Ignoring the protection of water resources by policymakers – the protection of water resources is not taken into account when making decisions about aquaculture, where the main objective is to generate revenue.* | *Development of new infrastructures, restoration, modernization and arrangement of ponds and lakes of complex use to ensure reserves in periods of flow deficit.*<br>*Develop new studies needed to substantiate the assessment of water resources at the level of river basins and sub-basins in the conditions of climate change.* |
| | *Lack of scientific data or adequate socio-economic analysis of technology at national level.* | *Assessment of the areas of water bodies that would actually benefit from improved water supply;*<br>*Training of water users and service providers in the design, operation and maintenance of water bodies. Develop practical guidelines for design and management.* |
| ***Other barriers*** | *Illegal practices of construction of dams within riverbeds* | *Removal of illegally built dams in river beds.* |

*Table 8: Identification of measures to remove barriers for complex capitalization of the trophic potential through interspecific polyculture*

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**2) Identification of measures to remove barriers for increasing the water flow of ponds used in polyculture**

| *Categories of barriers* | *Barrier* | *Measures* |
|---|---|---|
| *Economic and financial* | *Lack of financial sources and High cost of aquaculture operations (construction works to clean up and deepen the water supply channels of existing azuri)* | *Attracting funds through proposals to carry out the construction works of cleaning the channels from the accumulation of water, properly formulated.*<br>*Encouraging investments in river basin infrastructure and supporting actions to increase the efficiency of the use of water bodies used in aquaculture to become more resistant to drought and reduced amounts of water.*<br>*Supporting investments in systems and solutions that maintain water volume or reduce losses, through works to reduce the risk of water supply to fishponds.* |
| | *Lack of subsidies to fish producers including breeding farms and lack of a credit and subsidy mechanism in aquaculture resulting in fewer economic and financial benefits* | *Adequate economic and financial incentives to implement the promotion of climate technologies through subsidies for the introduction of good practices.*<br>*Granting financial assistance to support the initial cost of the ameliorative works and the adequate acceptability of farmers to the cleaning of the water supply channels of the ponds and to promote the use of the technology.* |
| *Policy, legal and regulatory* | *Patronage and inadequate commitment of government institutions. Inconsistency and ambiguity of regulatory policy in the field of transmission of aquaculture waters* | *Amendment of the normative acts on the rights and commitments of the users of the water basins, elaboration of the plan of corrective actions within the regulatory framework;*<br>*Creating policies and study profiles for the development of pond infrastructure and raising awareness of the importance of sustainable management of water bodies to facilitate increased funding* |
| | *The lack of an adequate legal authority for the protection and management of fish farms and therefore the lack of plans and strategies for the protection and management of resources.* | *Supporting the integrated management of water resources within the river basins of small rivers on which water bodies are cascaded, so that aquaculture has sufficient water (volume/quality);*<br>*Assisting the institutions responsible for enabling the preparation of programmes and plans for the proper management of fish farms.*<br>*Awareness-raising programs for government institutions to allow the assessment of the need for rehabilitation of ponds for socio-economic benefits.*<br>*Promote competitive aquaculture, support economically viable and socially and environmentally sustainable producer organisations and fish farms.* |
| | | *Strengthen the capacities of R&D institutions to support the introduction of technology and the implementation of activities related to technology and the efficient management of* |

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| | | *complex lakes; Conducting scientific research on adapting, improving and evaluating the efficiency of innovative technologies in order to disseminate the advantages and disadvantages.* |
| *Social, cultural and behavioral* | *Unsustainable practices (unplanned developments and projects) in ecosystems* | *Awareness - raising programmes for those involved in sustainable practices in fisheries to strengthen regulation; Develop new studies needed to substantiate the assessment of water resources at the level of river basins and sub-basins in the conditions of climate change.* |
| | *Limited integration of government institutions into development planning and guidelines and lack of coordination between them* | *Develop the cooperation mechanism, which will allow for the removal of barriers among stakeholders to the use of technology.* |
| *Institutional and organisational capacity* | *General lack of public appreciation/awareness of the uses/importance of the technology* | *Encouraging projects that help to rehabilitate fish farms and improve the infrastructure of ponds developed jointly with research institutions.*<br>*Conduct quantitative assessments of the water needs of different users and introduce them in the process of developing river basin management plans taking into account the expected impact of different climate change scenarios.* |
| | *Limited institutional R&D capacity to undertake practical experiments and pilot projects for demonstrations for farmers.* | *Stimulating research and development institutions in carrying out studies and developing projects.*<br>*Increasing water availability in water bodies as a result of ameliorative measures, improving management and monitoring of water bodies through research.* |
| *Human competences* | *Inadequately trained staff and experts to provide expertise* | *Facilities for the relevant institutions to allow for the regular updating of knowledge through training and research.*<br>*Develop mechanisms for maintaining the current trained staff in research institutions and provide budgetary provisions for the training of staff in research institutions and fish farms.* |
| *Information and awareness* | *Limited awareness of adaptation to climate change.* | *Improve the awareness and competence of fish producers about the potential benefits of selection programmes and their implementation.* |
| | *Inadequate awareness about the existence and usefulness of technology.* | *Improving access to technological information and encouraging the transfer of knowledge between specialists and the end user.* |
| | *The absence of a knowledge base on successful local case studies to demonstrate the impact of technology on water efficiency.* | *Increasing the efficiency of the training process in the field of technologies for adaptation to climate change, expanding trainings for farmers; Stakeholder conduct through media awareness-raising programmes involving industry experts;* |

| | | |
|---|---|---|
| | *General lack of appreciation/awareness of the public about the uses/importance of the technology* | *Strengthening information and awareness measures to solve the tasks of saving water resources, implementing projects, publishing recommendations, etc;*<br>*Ensuring technical skills in the maintenance of water supply channels for ponds by organizing/ conducting seminars, workshops and presentations.* |
| *Technical* | *Inadequate river basin management of small rivers* | *Establishing regulatory mechanisms for construction programs and developing zonal plans for the identification of water bodies that need to be rehabilitated by cleaning.*<br>*Updating the watershed management schemes of small rivers and implementing measures to rehabilitate the riverbeds that feed the ponds.*<br>*Improving capabilities and equipping with specialized technique in the process of water supply to incubators in the process of reproduction.* |
| | *Ignoring the protection of water resources by policymakers – the protection of water resources is not taken into account when making decisions about aquaculture, where the main objective is to generate revenue.* | *Development of new infrastructures, restoration, modernization and arrangement of ponds and lakes of complex use to ensure reserves in periods of flow deficit.*<br>*Develop new studies needed to substantiate the assessment of water resources at the level of river basins and sub-basins in the conditions of climate change.* |
| | *Lack of scientific data or adequate socio-economic analysis of technology at national level.* | *Assessment of the areas of water bodies that would actually benefit from improved water supply;*<br>*Training of water users and service providers in the design, operation and maintenance of water bodies. Develop practical guidelines for design and management.* |
| *Other barriers* | *Illegal practices of construction of dams within riverbeds* | *Removal of illegally built dams in riverbeds.* |

*Table 9: Identification of measures to remove barriers for increasing the water flow of ponds used in polyculture*

| 3) Identification of measures to remove barriers for the implementation of fish protection systems | | |
|---|---|---|
| *Categories of barriers* | ***Barrier*** | ***Measures*** |
| *Economic and financial* | *Inadequate financial assistance and high initial investment costs for the development, implementation of the effective protection and monitoring, forecasting and early warning system* | *Attract funds through duly formulated proposals on the adaptation, improvement and evaluation of technology efficiency, for different species in climatic conditions for the implementation of demonstration projects in fish farms; Allocate the necessary financial resources for the modernisation, extension and modernisation of climate monitoring, forecasting and early warning systems.* |
| | *High operational and maintenance costs of such a system.* | *Ensuring the necessary budgetary provisions for the regular costs of operation and maintenance of the system. Tax exemption for imported components.* |
| | *Lack of subsidies for farmers implementing climate technologies.* | *Elaboration of normative acts for the inclusion in the state subsidy system of fish producers and scientific institutions in aquaculture.* |
| | *Lack of financial sources for carrying out complex investigations of production areas in fish farms* | *Supporting research, development and innovation and stimulating the research-administration-producer partnership in order to achieve new or innovative technologies and management systems, in order to bring economic, social and environmental benefits;*<br>*Support investment in systems and solutions to promote climate technologies to reduce water losses in fish basins and actions to mitigate the risk of water insurance. Support of local authorities in carrying out the inventory and mapping* |
| | *Lack of support in the development and implementation of biosecurity plans on fish farms* | *The responsible state institutions must provide increased support for the development and implementation of biosecurity plans. In particular, the support would take the form of defined payments that would be directed to producers for the adoption of effective health management practices. The payments would focus primarily on practices to promote disease prevention measures (including the use of immune incentives and other measures that will increase immunity, either specific or non-specific), limiting the use of antibiotics and other veterinary medicines and adaptation to climate change. Development and implementation of biosecurity plans on fish farms.* |

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|---|---|---|
| *Policy, legal and regulatory* | *Inconsistency and ambiguity of regulatory policy – the Government's policy related to this sector is not consistent and long-term. Conditions may change depending on short-term interests.* | *Reforming public policies, improving the regulatory and governance process, transparency and accessibility in the aquaculture sector.*<br>*Updating the existing legal framework for the consolidation and development of climate change adaptation norms.*<br>*Developing the capacity to implement policies and technological innovations to address the adaptation of the aquaculture sector to the effects of climate change.*<br>*Amending the normative acts regarding the rights and commitments of water basin users, developing the plan of corrective actions in the regulatory framework regarding climate change.*<br>*Developing, updating policies, strategies and programs in the climate compatible aquaculture sector.* |
| | *Insufficient control over compliance with legislation and regulations in force* | *Carrying out permanent control and supervision over the compliance with the legislation and norms in force – the existing regulations and norms by the state and profile institutions; Develop and implement appropriate mechanisms to monitor the social effectiveness of the measures developed.* |
| | *The lack of an adequate legal authority for the protection and management of aquaculture and therefore the lack of management plans or programmes for the protection and management of these resources.* | *Assisting the institutions responsible to enable the preparation of programmes and plans for the proper management of fish farms.*<br>*Strengthening administrative capacity to carry out actions aimed at adapting the sector to climate change.*<br>*Elaboration of framework norms (guidelines, normative) on the basis of which the risk management plans for each fishery will be elaborated.*<br>*Promoting competitive aquaculture, supporting economically viable and environmentally sustainable producer organisations and fish farms.*<br>*Supporting development and innovation policies by strengthening the fish farming capacity, increasing the level of new and innovative knowledge, sustainable and participatory management of resources;*<br>*Encourage farmers' associations to increase their capacity to adapt at local level, allowing easier access to market information, technical expertise and aquaculture contributions.* |
| | *Lack of coordination between government institutions and fisheries* | *Strengthening the capacities of the association of fish farmers and cooperation in the sector.*<br>*Develop the cooperation mechanism, which will allow the removal of barriers among stakeholders to the use of technologies; Improve coordination and collaboration between national and international organizations and R&D institutions for the exchange of data and products and improve the relationship with other user organizations.* |
| | *Limited cooperation between relevant government agencies* | *Creating close cooperation with relevant international institutions for the exchange of knowledge, data – etc.; Strengthening the research and technical capacities of national institutions relevant for the development and application of the protection system.* |

| | | |
|---|---|---|
| | | *Promoting the exchange of data and research results between relevant stakeholders.*<br>*Ensuring the development of an efficient data communication and dissemination system.*<br>*Ensure the involvement of the community and local institutions in the use and dissemination of forecasts and early warnings to reduce losses caused by climate-related disasters.*<br>*Promote the exchange of data and research results between relevant stakeholders.* |
| | *Insufficient research on the adaptation, improvement and evaluation of technology efficiency* | *Strengthen local adaptation capacity to support climate-resilient management of aquaculture and alternative livelihoods to climate change.*<br>*Disseminating research results and improving the flow of information from scientific to farmer and ensuring the orientation of research towards farmers' requirements.*<br>*Greater participation of researchers, consultants and producers in informing about the positive influence of climate technologies.*<br>*Creating a partnership with external organizations to support climate change projects through financing, technical training and etc.*<br>*Developing and implementing specific measures to protect fish farms from disasters and pushing the research of hydrochemical, biological, ichthyopathological investigations within the implementation of the protection system.* |
| *Social, cultural and behavioral* | *Lack of information of specialists and population on the importance in the current conditions of development of aquaculture and compliance with measures to protect human health and ensure food safety.* | *Ensuring food security with competitive, safe and healthy food products adapted to the needs and demand of consumers; Harnessing the potential of aquatic biological resources by addressing the effects of climate change and managing the sustainable development of competitive aquaculture and supporting market development for aquaculture products; Reducing the vulnerability of the population to the impact of climate change by concentrating responses and identifying measures to adapt to the effects of climate change; Increasing the role of traditional fish farming in fish development as an activity generating opportunities for the development of the local economy (jobs in the countryside, capitalization of poorly productive land).* |

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|---|---|---|
| | *Insufficient demonstration of adaptation technology* | *Promoting appropriate climate-resilient technologies and approaches that enhance fisheries production and the livelihoods of the community in the face of the impact of climate change.*<br>*The government can provide the necessary financial support for its research and development and other relevant institutions to undertake the necessary pilot research and demonstration projects;*<br>*Relevant government institutions can conduct active information and awareness campaigns about the usefulness of these technologies.*<br>*Research and development institutions can be strengthened and tasked with preparing the long-term water and climate scenarios of the country by developing and disseminating specific measures against slow-onset events - drought, temperature rise, irregular precipitation.*<br>*Introduction and facilitation of economic activities through the introduction into the production of restructured and rebuilt farms.* |
| | *Low interest of the relevant institutions on the implementation of technological and sanitary measures that ensure adequate health management in fish farms* | *Government institutions responsible for aquaculture require to involve technological and sanitary measures that ensure proper management and sustainable protection of the health of fish production on the farm, including early diagnoses and preventive interventions that increase both fish welfare and product safety. In addition to measures to control fish diseases at national level, aquaculture farms should draw up their own biosecurity plans. Strengthen adaptive capacity to support resilient management and the implementation of technological and sanitary measures on fish farms and ensure the health of fish production.* |
| *Institutional and organizational* | *Insufficient regulations, by which the competent institutions cannot fully ensure the monitoring and transparency of the maintenance of the water basins capitalized on the uses/ importance of the technology* | *Encouraging projects that help to rehabilitate fish farms in research institutes.*<br>*Conduct quantitative assessments of the water needs of different users and introduce them in the process of developing river basin management plans taking into account the expected impact of different climate change scenarios.* |
| *Information and awareness* | *Limited access to information by fish producers on technologies for adaptation to climate change, their capacity and availability.* | *Sharing knowledge and experience on the interactions of aquaculture technological processes with the environment and adapting to climate change in fish farming networks; Development of consultancy and schooling services for water basin holders and young people interested in aquaculture, by creating advisory centers to increase competences in the fisheries field. Constructive dialogue and timely and improved exchange of information between researchers and fish producers.* |
| | *Low media interest in promoting climate technologies, with little participation of researchers,* | *Raising awareness of climate change and strengthening non-formal education programmes through the media, networking and partnerships; Organizing seminars for farmers interested in the use of technologies, with better coordination of activities between stakeholders and R&D and state institutions, involving* |

| | | |
|---|---|---|
| | *consultants and producers and a lack of information about the positive influence of climate technologies.* | *producers in decision-making; Strengthen measures to inform the population and aquaculture producers to solve the tasks of saving water resources, implement projects, publish recommendations, etc.* |
| | *Lack of awareness about climate change issues and technological solutions* | *Facilities for relevant institutions to allow regular updating of knowledge through training and research in the field of technologies for adaptation to climate change, extension of trainings for farmers; Educating farmers about the financial benefits of using these technologies;* |
| | *Lack of an information system on issues related to innovative climate technologies.* | *Creating an information system on issues related to innovative climate technologies; Aquaculture expansion services can be geared towards disseminating knowledge and appropriate awareness of the potential availability and benefits of using the technology (drought-resistant).* |
| *Human competences* | *Inadequately trained staff and experts to provide technology expertise* | *Development of mechanisms for maintaining the current trained staff and providing budgetary provisions for staff training within research institutions.*<br>*The government can provide financial support to institutions relevant to the training of staff - qualified technicians well trained in the implementation and maintenance of these technologies.* |
| *Technical* | *Insufficient research on adapting, improving and evaluating the efficiency of adaptation technologies.* | *Strengthening the capacity to implement measures to adapt to the effects of climate change in aquaculture on the fish protection system and increasing the welfare and health of fish.*<br>*Increasing the efficiency of fisheries production and combating the effects of climate change, ensuring the sustainability and resilience of systems, through available approaches and solutions to improve the situation in the sector.*<br>*Monitoring of water quality and the behaviour of fish during periods of high stress (temperature variations, unexpected weather changes) to prevent risks to fish health and to adopt good disease management practices to reduce risks.* |

*Table 10: Identification of measures to remove barriers for the implementation of fish protection systems*

# CHAPTER – 3 THE LIVESTOCK SUB-SECTOR

## 3.1 PRELIMINARY TARGETS FOR TECHNOLOGY TRANSFER AND DIFFUSION IN LIVESTOCK SUB-SECTOR

A study on the literature available on impacts of climate change on livestock sector was carried out by National Consultants in the context of the TNA and the results indicate that the sub-sector will be affected negatively by the warming climate and water scarcity. The general results of the study were that, relative to the baseline, the production of beef cattle and chickens will decline with rising temperatures, but that the probability of selecting dairy cattle, goats, and sheep will increase. Income per animal is also expected to decline across all livestock types, but most dramatic changes are already being observed for beef cattle, goats, and chickens. A model-based study mixed with literature trends shown a fall in income due to lower bodyweight gains for all livestock types with temperature increase of 2.5°C compared to last century's values. Rising temperatures, in general, lead to a response to reduce the predicted number of beef cattle and chickens on each farm, but increase the number of the other livestock types, especially free grazing animals. Drought and water stresses however, are responsible for a decreases in pasture's availability and quality, especially protein. This is why actions to adapt to these changes are essential also for the livestock sector.
The TNA prioritization phase looked at these climate stressors individually and derived a set of 14 technologies and practices, that have been preliminarily targeted to compose the Long List of Technologies. Pivotal aspect of this selection is the need to address the perceived decreased availability of feed produced domestically as a consequence of long-term changes in the precipitation patterns. Especially in the central and northern part of Moldova, grazing is becoming less attractive for livestock farmers as the quality and availability of this feed is decreasing due to shifts in precipitation patterns year round. Increasing areas under irrigation for feed production, especially maize silage, would represent a crucial improvement on the side of feed availability, however not one that comes without tradeoffs and barriers. Switching feed production towards crops that are less susceptible to dry conditions, such as sorghum instead of maize, might be a valuable alternative. Though, it is felt that Moldova in general lacks a certain level of capacity of livestock farmers to optimize the nutrition regime of their animals and maximise the efficiency of these systems. Extreme temperatures also cause damages to the productivity of livestock in Moldova, and key technologies to streamline shed designs and construction techniques have been preliminarily targeted. For free grazing livestock, the effects of climate change are obvious through the limited availability of water resources in the landscape, which due to extreme events such as increased frequency of droughts, are becoming a limiting factor for livestock production with this form of management. Preliminary targeted technologies also included actions directly aimed at addressing these issues. The full set of technologies preliminarily targeted by the TNA process is available in the table below.

| Climate Hazard | Climate Impact | Priority technologies |
|---|---|---|
| Precipitation pattern changes | Decrease availability of feed | 1. Increasing areas under irrigation for feed production |
| | | 2. Creation and modernization of irrigation systems |
| | | 3. The use of drought-resistant feed varieties |

| | | |
|---|---|---|
| | | 4. Optimizing livestock and poultry nutrition systems to fulfill their productive and adaptive potential, including the rational use of pastures |
| Increased average temperatures | Impact of more extreme temperatures on animal welfare and productivity | 5. Breeding and selection of breeds and hybrids of animals adapted to local soil and climate conditions. |
| | | 6. Improving and adapting to the requirements of livestock and poultry farming and maintenance systems. The construction of farms should be done based on projects developed by specialists in compliance with veterinary requirements. |
| | | 7. Energy efficiency. Thermal insulation of spaces where animals are kept, to ensure both protection from high temperatures and savings of heating costs. |
| | | 8. Ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and observance of the placement surfaces. |
| | | 9. Ensuring the necessary microclimate conditions through the construction and installation of cooling systems in spaces where animals are kept. |
| | | 10. Establishing protection belts. |
| | | 11. Training of farmers on the effects of climate change on farm animals. |
| Increased incidence of extreme climatic events including droughts, floods, etc. | Lack or shortage of drinking water | 12. Ensuring access to water for animals |
| | | 13. Cleaning of water basins |
| | Increased disease spreading, outbreaks of severe disease, new diseases appearance | 14. Training of veterinarians |

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*Table 11: The List of identified technologies for climate change resilience and adaptation of the livestock sub-sector of Moldova*

## 3.2 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR INCREASING AREAS UNDER IRRIGATION FOR THE PRODUCTION OF FEED FOR THE LIVESTOCK SUB-SECTOR

### 3.2.1 General description of technology, technology status in Moldova, and market characteristics

Food security is regularly affected by weather conditions. Drought, floods, and other extreme natural phenomena (torrential rains, hail, storms and frosts) occur regularly and have a significant impact on living standards and the rural economy as a whole. This has been felt acutely over the past 5-10 years, so the number of cattle has drastically decreased in both the private and individual sectors as a consequence of several factors, including the lack of quality and affordable feed. The annual harvest of maize silage is about 30-40 tons / Ha, but during drought years in Moldova an average 50% yield reduction is observed. At the same time, the use of irrigation systems for maize silage crops can increase the amount of product in dry years up to 25-35 tons/Ha. Similarly, the use of irrigation systems and agricultural technologies (fertilizers, crop rotation, etc.) would allow to increase productivity to about 50 t / ha in non-dry years. In Moldova, feed production is entirely rainfed, and increasing the irrigation infrastructure to reach forage crops production areas by about 5 -15 thousand hectares in the northern and south-eastern areas of the country, where cattle farms are concentrated (most susceptible to insufficiency of green fodder) is necessary.

### 3.2.2 Identification of barriers for increasing areas under irrigation for the production of feed for the livestock sub-sector

The livestock sector in the Republic of Moldova, as well as in many other countries, can be considered one of the most vulnerable sectors to climate change because it has a high exposure to climatic factors, with a significant direct or indirect impact on activities in this sector, with consequences on animal health, respectively on the effectiveness of animal production, as well as farmers' income, livestock farmers, thus affecting the entire food chain. The livestock sector plays an important role in Moldova's rural economy, and the impact of climate change can create economic instability in rural communities, but also throughout the country.

Reasons why the livestock sector can be considered vulnerable to climate change:

- Decreasing water resources: Climate change can lead to changes in rainfall patterns and rising temperatures, which can decrease the amount of water available to irrigate plant products used in animal feed and animal consumption. Lack of adequate drinking water can affect animal health and growth and productivity performance.
- Limited diet: Climate change can affect the availability and quality of feed, such as grasslands and forage crops, due to drought, floods or rising temperatures. This can lead to higher feed costs and affect their health and production.
- The increase in $CO_2$ concentration will affect the species composition of grasslands, having on the one hand a positive effect, because it will increase the productivity of biomaei, on the other hand it will lead to species competition for growth factors, which will limit or exclude the existence of species, respectively, with an effect on animal nutrition.
- Increasing disease incidence: Climate change can influence the spread of diseases transmissible to animals, especially those carried by vectors such as insects. Higher temperatures can create more favourable conditions for the development and spread of diseases, which can lead to significant losses in animal health and production.
- Heat stress and decreased animal performance: Extreme temperatures can lead to heat stress in animals, which can negatively affect their reproductive and production performance, as well as the quality of animal products (e.g. milk or meat). Heat waves also affect the thermal comfort of animals with an effect on their performance and production.

The links between technological barriers in the livestock sector were identified during the barrier analysis process in the workshops of the sectoral working group, so as to maximise synergies and optimise the effects of the recommended measures.

The main broad barrier categories identified for the implementation of this technology include: 1) Economic and financial; 2) Human competencies and capacity; 3) Policy, legal and regulatory. All barriers identified are summarized in Table 12 below. Economic barriers are the most important impediment to the development of a nationwide irrigation system for feed production, but technical difficulties and human capacity limitations should be regarded with much attention in order to enable the uptake of this technology. Policy and awareness barriers, also present, have a lower impact on the enabling environment for this technology, since if on the one hand is true that there is no supporting policy specifically designed to foster irrigation infrastructure investments for feed production, on the other hand there are no major authorization impediments to deploying these systems in the field. The various elements of each decomposed barrier have been considered individually and decomposed barriers were prioritized according to their significance (table 12). As a result of this exercise, the irrigation for feed production has a total of 6 barriers were considered "essential" to its implementation. These are:

1) Limited access to financial resources
2) Lack of active and sector-specific policies to adapt to impacts of climate change
3) Low degree of implementation of policy documents and regulatory frameworks in the field
4) Lack of workforce in livestock sector
5) Lack of associative structures (cooperatives, etc.) among livestock farmers
6) Limited knowledge and recognition of importance of science in livestock sector

| **Wide category of barriers** | **Barriers within a category** | **Elements of barriers** |
|---|---|---|
| Economic and financial | Limited access to financial resources | Low investment capacities of landowners and high installation costs for irrigation systems |
| | | Low profitability, long payback period |
| | | Maintenance needs and associated costs during the calendar year |
| Policy, legal and regulatory | Lack of active and sector-specific policies to adapt to impacts of climate change | Insufficient regulatory framework regarding feed supply |
| | Low degree of implementation of policy documents and regulatory frameworks in the field; | Lack of policy enforcement, both at active (e.g. extension services) and passive (regulators, law enforcement) |
| Human competencies and capacity | Lack of workforce in livestock sector | Shortage of personnel and expertise in the field of irrigation systems for fodder crops; |
| | | Low presence of modern technologies and equipment for irrigation systems for fodder crops |
| Institutional and organisational | Lack of associative structures (cooperatives, etc.) among livestock farmers | Cultural adversity towards associations, cooperatives, and unions of farmers |
| | | Low degree of consolidation of irrigated land. Dispersal of fields for growing fodder crops |
| | Limited knowledge and recognition of importance of science in livestock sector | Lack of institutional recognition of the value and contribution of scientific advancements to livestock sector |
| | | Poor knowledge in the field of irrigation systems for fodder crops |
| | | Insufficient collaboration of the livestock sector with university institutions |

*Table 12: Complete list of barriers identified for increasing areas under irrigation for the production of feed for the livestock sub-sector*

### 3.2.3 Economic and financial barriers

Inadequate financial assistance is a barrier that limits the widespread adoption and use of all prioritized technologies for the livestock sector although marked differences exist when quantifying financial requirements for each. Infrastructural technologies, like the expansion of irrigation areas for feed production, is linked to long-term investments that the Government alone can hardly sustain. In addition to the lack of National budget investment and limited financial resources of the private sector involved in financing activities in the livestock sector, also the scarcity of external financing sources such as grants and preferential loans for International Financing Institutions. Although over the last 10 years the government has identified the livestock sector as a priority sector in national development, de facto, the budgetary financial sources and subsidies that have been allocated to this key component of agriculture are not able to meet the requirements of the sector. Addressing this barrier will require the creation of an investment mechanism, determined by a combination of measures such as tax reductions (e.g. VAT rate changes), allocation of subsidies, partial grants attraction and preferential loans for investments in the livestock sector.

### 3.2.4 Non-financial barriers

The lack of policies and strategies in the zootechnical field that reflect the impact of climate change on the development of the sector, especially in feed production and manure management, prevents the relevant institutions from promoting a proactive approach in this field. The Ministry of Agriculture and Food Industry (MAFI) is responsible for administrative supervision and coordination of the livestock sector and it does not fully cover the regulatory framework and the institutional administration of the sector. Similarly, MAFI does not prioritize the impact of climate change on livestock farms in its agenda, thus contributing to the sector's sensitivity to climate change against the background of modest adaptive capacities. The shortage of workers in the livestock sector is another primary non-financial factor of reduced adaptive capacity at sector level, influencing subtle production capacities, which in turn leads to potential income losses for farmers and producers in the industry.
The shortage of workers may make it difficult to expand activities or diversify production to meet market demand. The low level of association between small farmers in the livestock sector can pose a significant problem in the development and promotion of this sector. Some small farmers may not be aware of the benefits of association and may consider individual efforts sufficient to achieve their goals. Reduced cooperation hinders the promotion of innovation and the sharing of beneficial experience, but also lessons learned from failures. Especially for landscape-wide approaches, like the expansion of the irrigation network for feed production, forms of associativism of farmers can create the critical mass necessary to request with increased negotiating power actions in this direction as well as to support and manage such interventions organically. Irrigation infrastructures require strong management skills, especially in a context of changing climate and reduced natural resources.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The

Problem Tree for the first prioritized technology for the livestock sector (Irrigation Systems for Feed production) is presented below, whereas the market mapping analysis follows.
The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 3.5).

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Problem Tree for: Increasing areas under irrigation for the production of feed

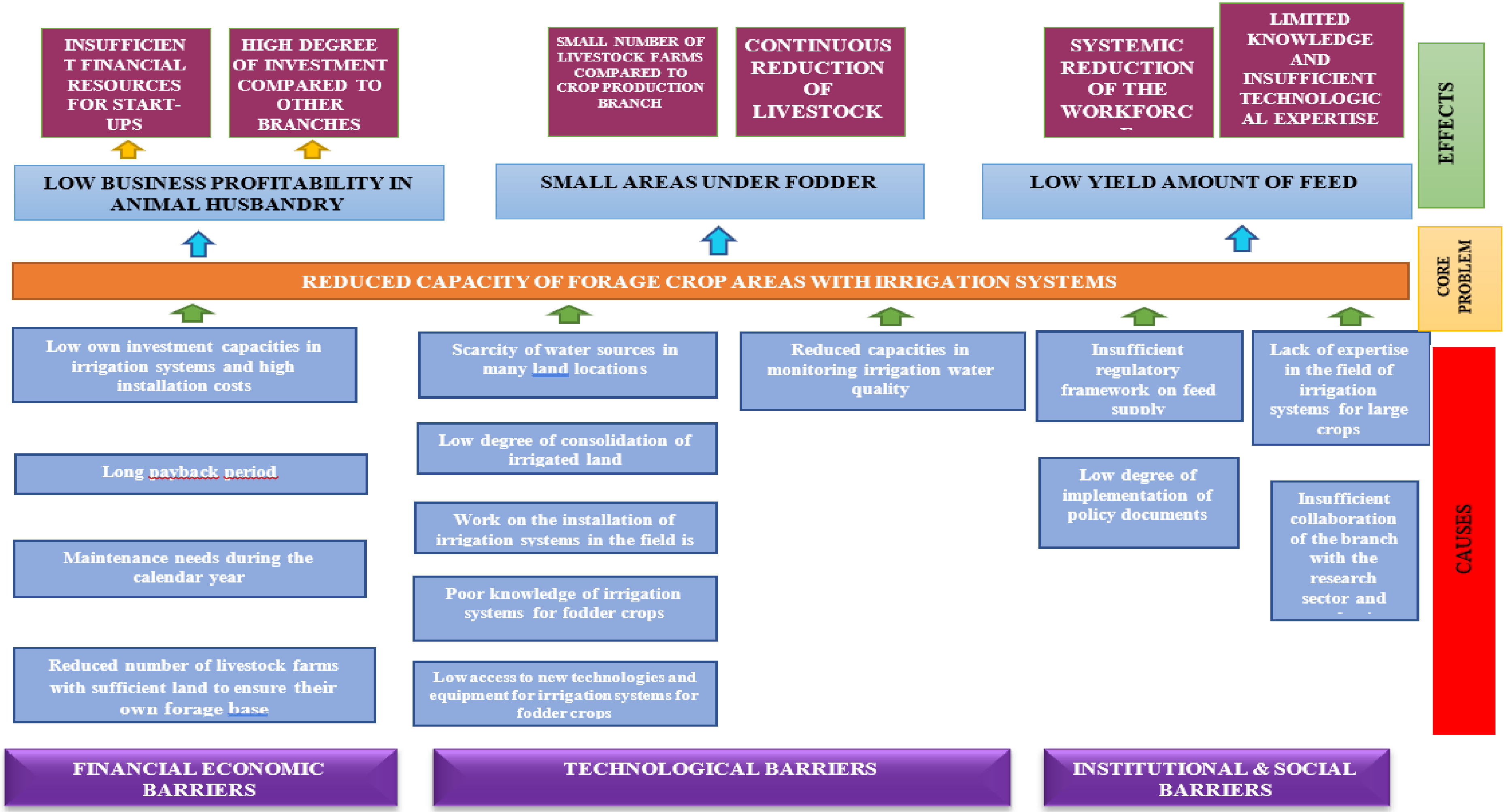


*Figure 9: Problem Tree for Increasing areas under irrigation for the production of feed*

Market Mapping for: Increasing areas under irrigation for the production of feed

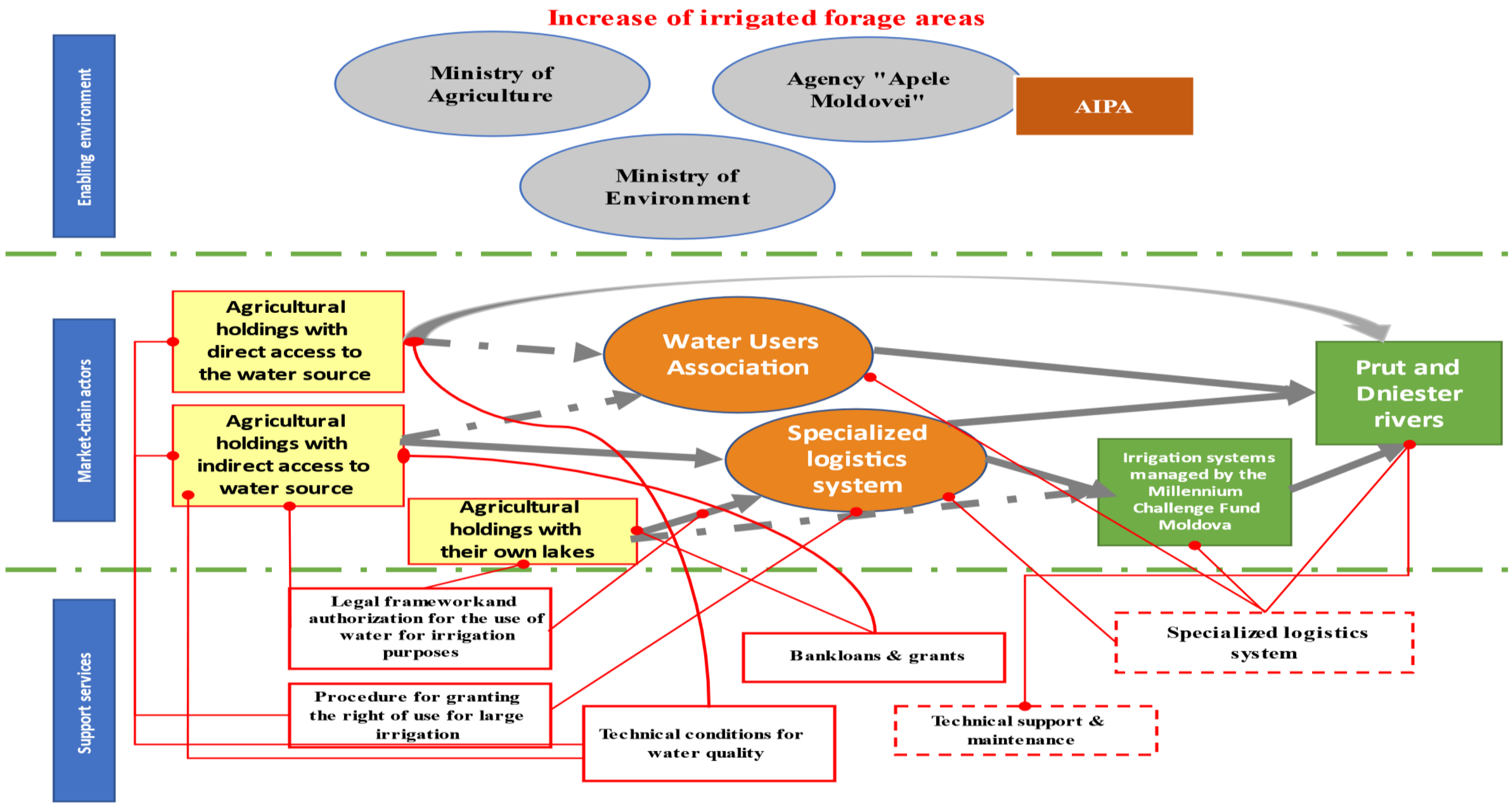


*Figure 10: Market Mapping for Increasing areas under irrigation for the production of feed*

## 3.3 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR ENSURING ADEQUATE CONDITIONS FOR ANIMAL WELFARE BY OPTIMIZING THE PARAMETERS REGARDING THE CONSTRUCTION REQUIREMENTS AND THE OBSERVANCE OF THE POPULATED AREAS OF THE ANIMALS FOR THE LIVESTOCK SUB-SECTOR

### 3.3.1 General description of technology, technology status in Moldova, and market characteristics

In the Republic of Moldova, most of the existing farms are rebuilt based on outdate farm structures, which were built until 1990. There are very few farms built from scratch in the last decade. Due to the high cost of designing stables and animal sheds, bureaucratic barriers to their approval and the lack of specialists in the field, most of the farms were rebuilt, rehabilitated, transformed from one type of farm to another type (for example, from cattle farm to poultry farm or vice versa). In most cases they were done without adequate projects to ensure animal welfare, thermal insulation (energy efficiency) and biosecurity of the farm. Also, in most cases, not all the EU normative acts on animal welfare that have been or are to be harmonized in the Republic of Moldova have been considered. Within the framework of the technology, it is proposed to equip the existing halls with cooling systems to ensure the necessary microclimate conditions for animals (according to welfare requirements) and to develop standard design plans (technological design) for livestock farms (depending on the species).
For each species of animals, a different design plan will be drawn up:
For dairy cattle - 20, 40, 60, 80 and 100 animals.
For fattening pigs – 100, 300, 500, 700 and 1000 animals.
For laying birds – 20 000 and 50 000 poultry.
For broiler chickens – 25 000, 50 000, 75 000 and 100 000 poultry.
The design plan should contain the animal-specific technology set ensuring biosecurity conditions and animal welfare in line with EU requirements. The engineering drawings must also be developed according to the latest requirements on energy efficiency (thermal insulation) and maximum automation, including climate control and monitoring of physico-chemical parameters inside stables and production halls such air circulation, CO2 and $NH_3$ levels, temperature, humidity, etc. The engineering drawings will be produced in CAD 2D and 3D format and offered to farmers who will adapt them to the conditions of location of the farm or land. These drawings will constitute the starting point for the design and development on climate improved livestock farms in Moldova.

### 3.3.2 Identification of barriers for ensuring adequate conditions for animal welfare by optimizing the parameters regarding the construction requirements and the observance of the populated areas of the animals

Several barriers have been listed during the stakeholder consultations held in the context of the Technology Needs Assessment. The prioritized barriers to the deployment of climate-proof shelters and structures for animal recovery are of financial and economic nature, because these investments are usually considered necessary only at the end of the lifetime of an existing stable or shelter, and retrofitting to enhance animal welfare is a cost that is seldom incorporated into the farm budget. Socio-cultural barriers connected with the traditional animal husbandry regime in various areas of Moldova also plays an important role in limiting the push towards the creation of climate-controlled structures for animal keeping. The identification process led to a list of essential barriers to be considered in the development of a technology action plan to implement improved animal sheds in Moldova.

| Wide category of barriers | Barriers within a category | Elements of barriers |
|---|---|---|
| Economic and financial | Limited availability of financial resources | Limited profits and overall low market value of livestock products |
| | | Small markets for the marketing of products of animal origin |
| | | Insufficient public capacity to financially support smallholder farmers |
| Policy, legal and regulatory | Lack of active and sector-specific policies to adapt to impacts of climate change | Bureaucratic barriers in obtaining permits and supporting documentation. |
| | Low degree of implementation of policy documents and regulatory frameworks in the field; | Regulatory framework not adapted to current conditions. Insufficiently harmonised legislation. |
| Human and Institutional Capacity | Lack of knowledge of technical specifications, requirements and modern designs of animal sheds in the context of Climate Change | Insufficient design and construction services specialized in livestock farms |
| | | Outdated design and construction school of thought |
| | | Lack of institutional and professional's recognition of the value and contribution of scientific advancements to livestock sector |
| | | Poor knowledge in the field of animal welfare |
| | | Insufficient collaboration of the livestock sector with university institutions |

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*Table 13: Complete list of barriers for the animal welfare technology for the livestock sector*

Four (4) barriers have been selected as essential for this technology. These have a total of 10 elements composing them, each with their own specific relevance. The barriers are:

1) Limited availability of financial resources.
2) Lack of active and sector-specific policies to adapt to impacts of climate change.
3) Low degree of implementation of policy documents and regulatory frameworks in the field.
4) Lack of knowledge of technical specifications, requirements and modern designs of animal sheds in the context of Climate Change

### 3.3.3 Economic and financial barriers

Economic and financial barriers to the deployment of improved thermally efficient animal sheds exist. The cost of the intervention is considerable when compared to the small margins that livestock farmers, especially smallholders, obtain from their work. Farmers do not dispose of funds to redesign and retrofit their stables and sheds that often times have been built by the previous generation of farmers and will not be rebuilt until complete failure or collapse. In a smallholder farm budget, immobilization costs for existing animal sheds and infrastructures are not commonly included. Individual costs would be estimated in the order of a few thousands to one hundred thousand EUR to completely climate-proof and convert the average size animal sheds in Moldova, but resources for this work are never allocated in any farm budget. External funding is therefore necessary in the various available forms, including grants for the smallest sheds to loans for more productive large-scale farms.

### 3.3.4 Non-financial barriers

Policy barriers include lack of mandated requirements in terms of animal welfare and lack of enforcement. Currently in the country there is no legal mandate to develop or retrofit animal sheds to comply with improved climate-control standards, including thermal insulation and cooling, and therefore the lack of any drive to apply such changes to the existing structures. Possibly the main barrier to the diffusion of such technology in the country is the lack of recognition of its value for animal welfare and related productivity gains attainable through improved living conditions of the animals. Aside from large scale farms (poultry and pigs predominantly), farm owners do not understand the impacts of climate change on productivity and therefore on their farm costs through reduced production rates. This lack of human capacity is in turn worsened by the accompanying lack of institutional capacity to support such change in perception, through increased provision of information and training from extension agents and other forms of institutional support to farmers.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The Problem Tree for the first prioritized technology for the livestock sector (Animal Welfare) is presented below, whereas the market mapping analysis follows.
The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 3.5).

Problem Tree for: Animal Welfare

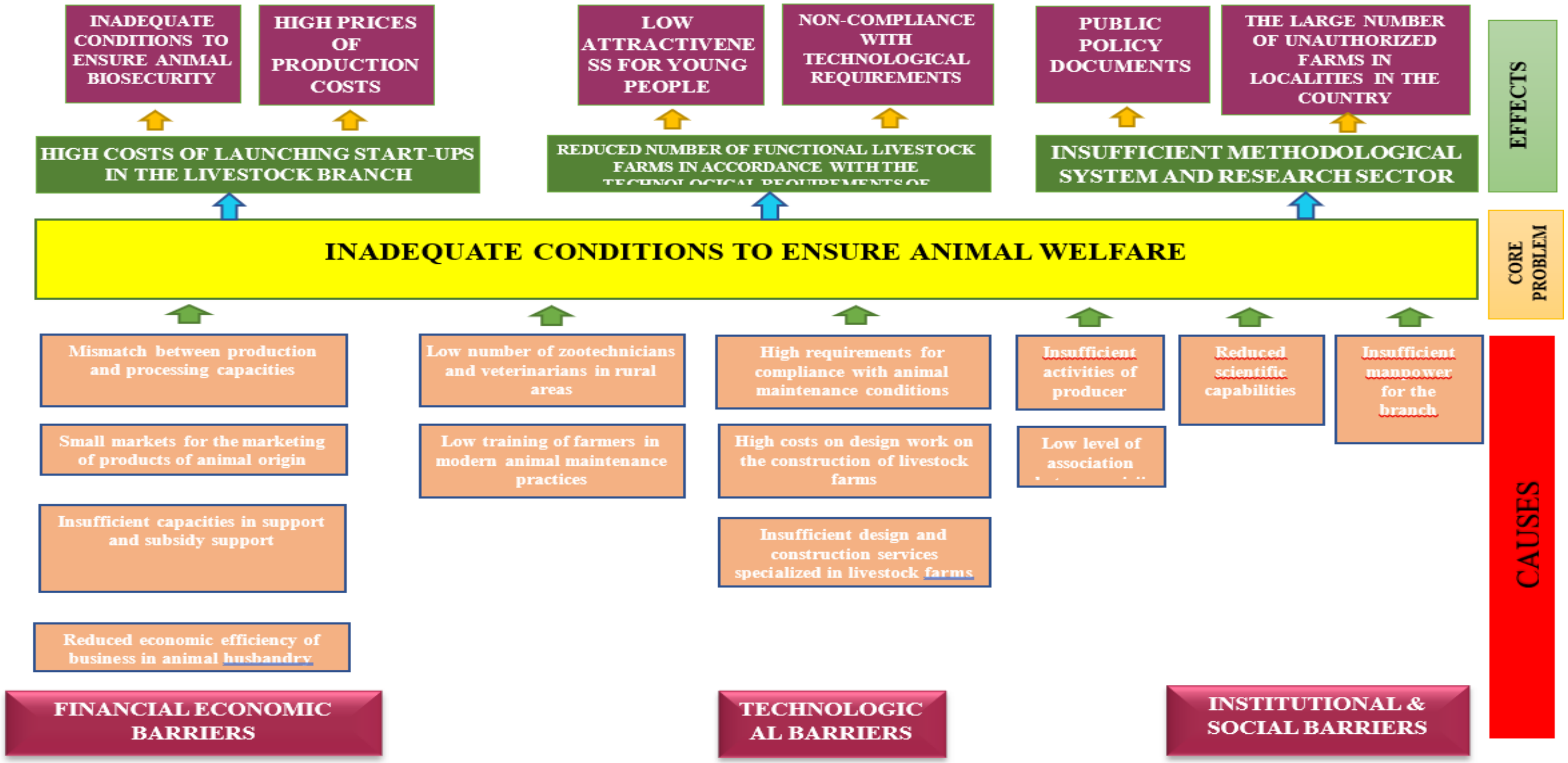


*Figure 11: Problem Tree for Increasing animal welfare*

Market Mapping for: Increasing Animal Welfare

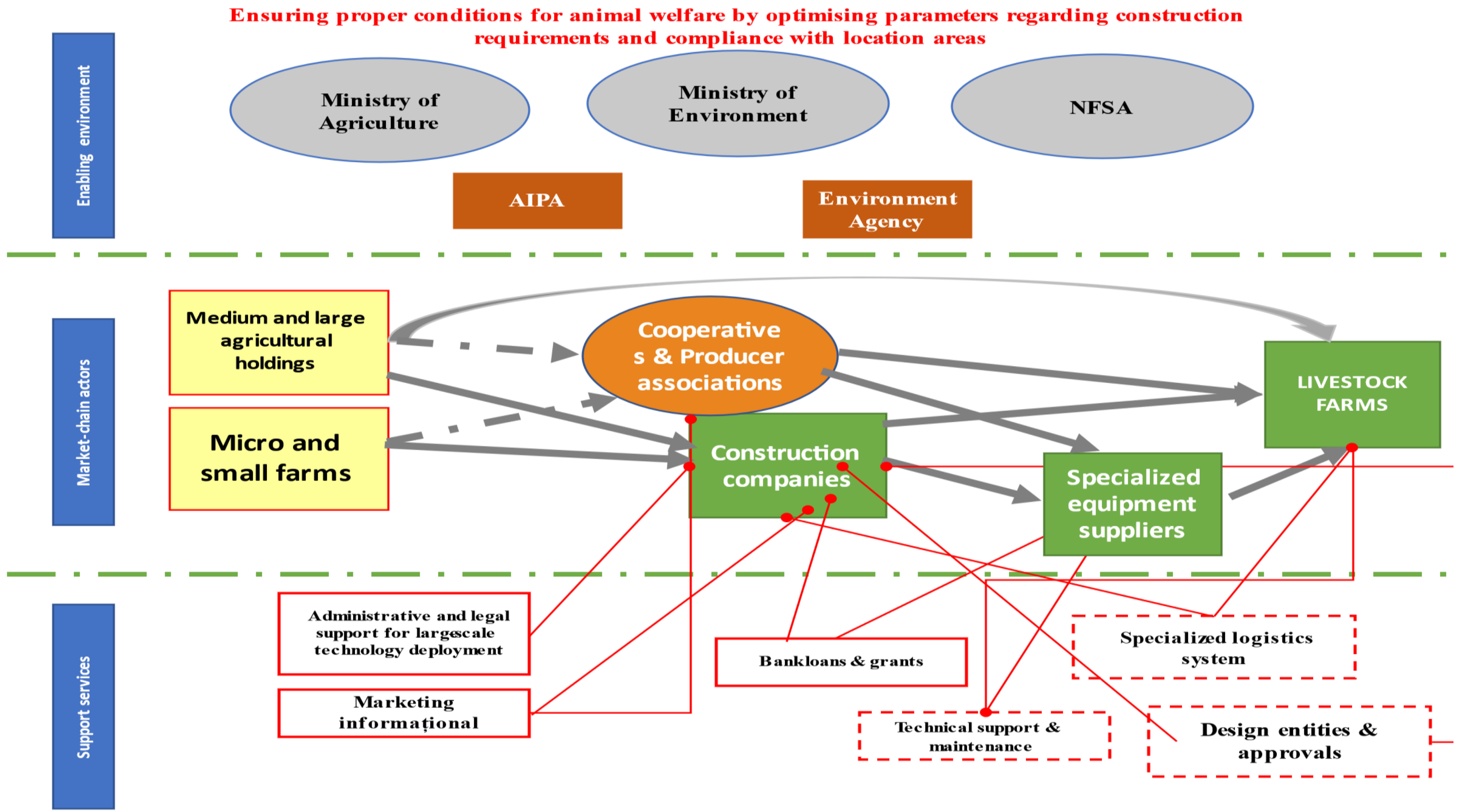


*Figure 12: Market Mapping for Increasing animal welfare*

## 3.4 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR THE CONSTRUCTION OF PLATFORMS FOR THE PRODUCTION OF ORGANIC FERTILIZERS FOR THE LIVESTOCK SUB-SECTOR

### 3.4.1 General description of technology, technology status in Moldova, and market characteristics

Improved organic fertilizers are scarcely used in Moldova, whereas crops (including feed and fodder) are grown relying solely on synthetic fertilizers. In a context of climate change impacts however, it was observed how soil quality and related productive capacity of the land in Moldova, is decreasing. Organic fertilizers (manure, etc.) have been widely demonstrated to have climate adaptation potentials in addition to mitigation potential due to the substitution of chemical N fertilizers, as their addition to the soil can enhance water retention capacity and biodiversity conservation of soil microfauna. In Moldova however, organic fertilizers are not produced due to lack of capacity and appropriate technologies. Platforms for the maturation of manure on small and medium-sized farms in the country are proposed as a technological solution to the problem of lack of organic fertilizers for the production of feed. The use of manure after processing the frames on the fields where the fodder crops will be grown, will have a positive influence on yields, especially long-term yield potential.

### 3.4.2 Identification of barriers for the construction of platforms for the production of organic fertilizers

As in the case of the other prioritized technologies for the livestock sector, several barriers have been listed during the stakeholder consultations held in the context of the Technology Needs Assessment. Economic and financial barriers impede the development of organic fertilizer's plants associated to livestock farms. These are disaggregated into consumer barriers (e.g. relatively high organic fertilizer production and above all transportation costs against lower comparable costs for synthetic fertilizers) as well as producer barriers, including the lack of resources for the construction of the platforms for manure treatment and maturation. Economic barriers are therefore the main limiting factor to the deployment of these technologies, but non-economic barriers also play a role, including policy. In fact, the lack of clear and predictable state policies in the use of manure limit the investments in these technologies.

| Wide category of barriers | Barriers within a category | Elements of barriers |
|---|---|---|
| Economic and financial | Limited availability of financial resources | Limited demand due to high costs of organic fertilizers in the current market |
| | | High manure transport and logistic costs |
| | | High costs for the construction of organic fertilizer's production structures |
| Policy, legal and regulatory | Lack of active and sector-specific policies to adapt to impacts of climate change | Lack of clear and predictable state policies in the use of manure |
| Human and Institutional Capacity | Lack of knowledge of correct manure management techniques | Lack of recognition of market actors, including farmers, of the beneficial role of organic fertilizer use |

*Table 14: Complete list of barriers for the construction of platforms for the production of organic fertilizers*

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### 3.4.3 Economic and financial barriers

Economic and financial limitations for organic fertilizer production and use from the livestock sector exist both at demand as well as at the supply level. At demand level, the high costs of organic fertilizers compared to synthetic fertilizers, especially nitrogen rich urea, undermine the development of a robust market for these products and as a consequence, limit the expansion of production technologies. Transporting organic fertilizers has also comparatively higher costs than for synthetic fertilizers due to the increased moisture content of the former and much higher nutrient content in the composition of the latter (2% N in manure vs 46% N in urea). At the supply level then, high costs for the production equipment limits the diffusion of the technology and does not allow price drops for the products, thus fueling the initial vicious circle.

### 3.4.4 Non-financial barriers

Mostly, non-financial barriers consist of policy barriers, or lack of supportive and mandating policies to sustain the deployment of organic fertilizer production equipment and the lack of policies to mandate the use of their products in agriculture. Lack of human and institutional capacity is also an issue, although the barrier analysis for this technology in general revealed that non-economic barriers are not a major concern.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The Problem Tree for the first prioritized technology for the livestock sector (construction of platforms for the production of organic fertilizers) is presented below, whereas the market mapping analysis follows.
The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 3.5).

Problem Tree for: construction of platforms for the production of organic fertilizers

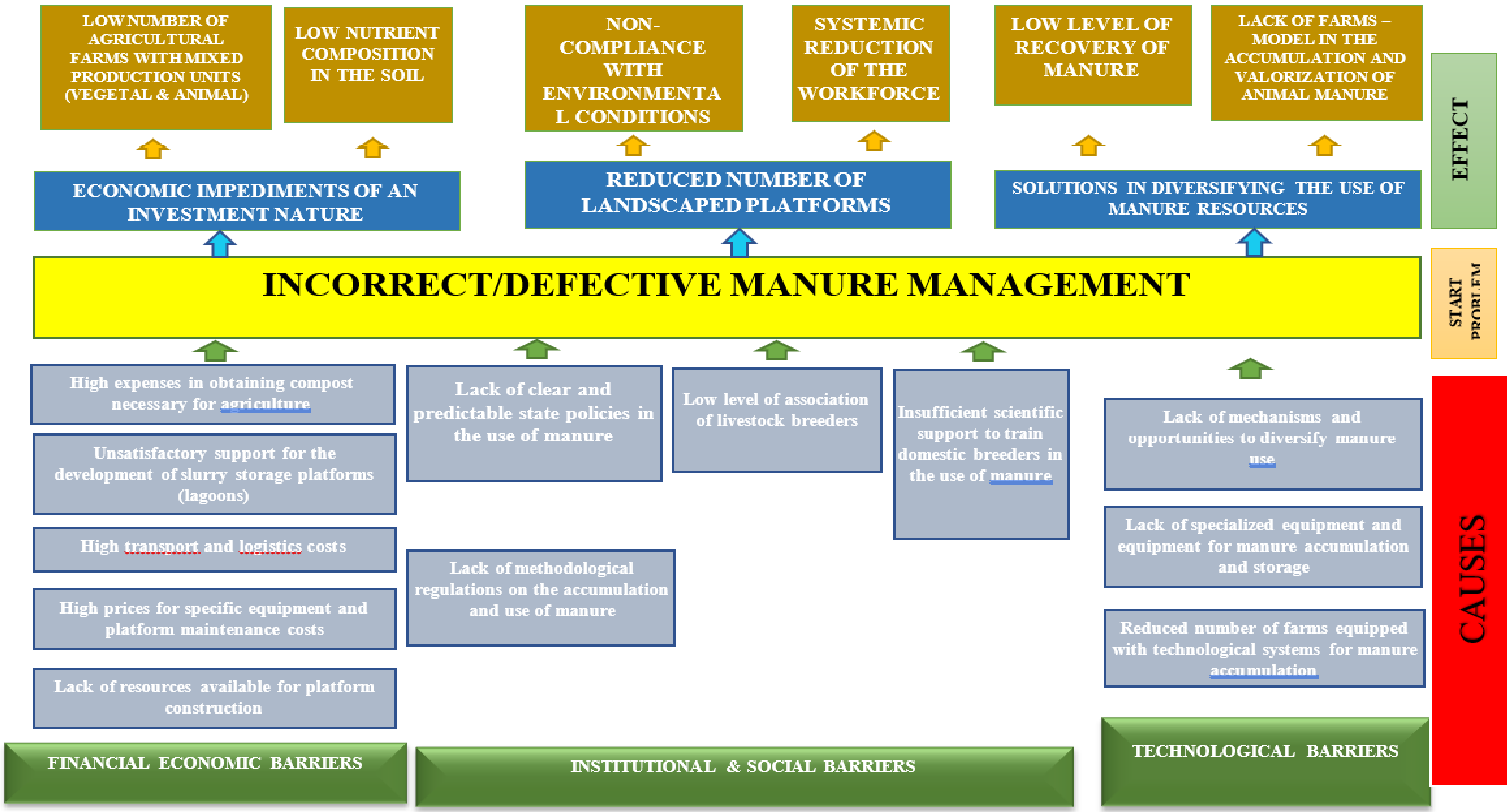


*Figure 13: Problem Tree for construction of platforms for the production of organic fertilizers*

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GREEN CLIMATE FUND

Market Mapping for: construction of platforms for the production of organic fertilizers

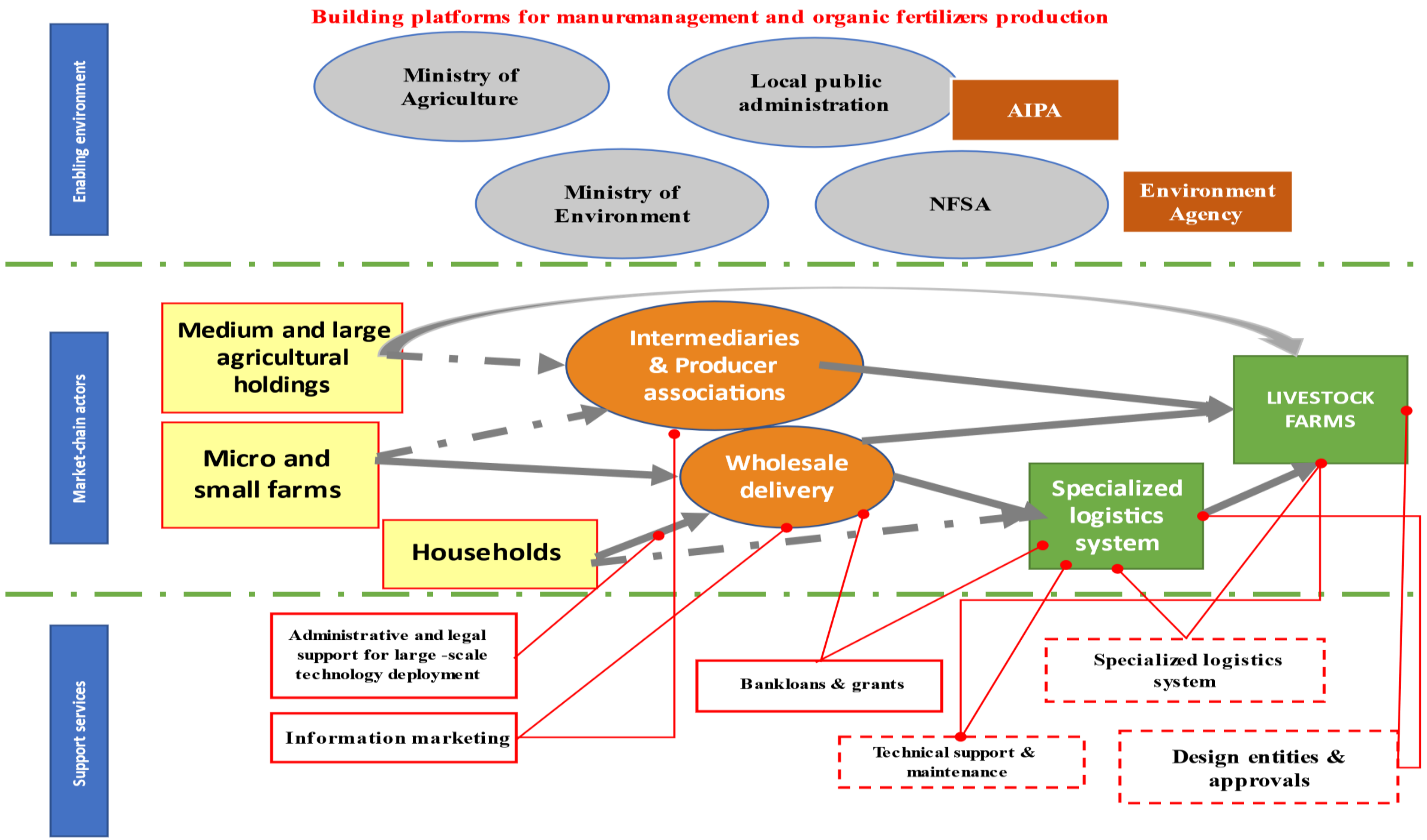


*Figure 14: Market Mapping for construction of platforms for the production of organic fertilizers*

## 3.5 IDENTIFIED MEASURES:

In order to overcome common barriers and effectively tackle climate change in the livestock sector, it is essential to create an enabling framework that promotes adaptation action and sustainable development of this industry. A literature review and discussions with stakeholders, researchers and farmers, has shown that creating and strengthening the enabling environment to support technology depends on many key elements that are linked to the policy, regulatory and other institutional and organisational capacity-building arrangements.

***1) Identification of measures to remove barriers for the implementation of increasing areas under irrigation for the production of feed for the livestock sub-sector***

| *Categories of barriers* | ***Barrier*** | ***Measures*** |
|---|---|---|
| *Economic and financial* | *Low investment capacities of landowners and high installation costs for irrigation systems* | *Provision of special grants or subsidy on initial cost of installation emerged as necessary spark for all technologies deployment in the livestock sector. Farmers would benefit from a a starter installation grant or incentive scheme for all technologies  Access to such a grant for a starter installation would assist the farmer to improve productivity and earning which would, in turn, facilitate further investment by the farmer and the ultimate expansion of farm output from the remaining sections of the property. The value of such a grant would be site/region-specific, but an average could probably be calculated by the MAFI and related agencies. Another measure to overcome financial barriers in the livestock sector would include the provision of low interest or interest-free loans for purchase and installation of equipment. The provision of tax incentives and the reduction of import duties on component parts for systems to reduce capital costs for adoption and installation.* |
| | *Low profitability, long payback period* | *A financial mechanism would require specific financial tools to be applied to smallholder farmers, perhaps through forms of association into cooperatives or producer organizations. These mechanisms specifically designed for smallholder farmers would include guarantees to farmers that purchase technologies with proven adaptation potential that have long payback periods.* |
| | *Maintenance needs and associated costs during the calendar year* | *The provision of technical assistance in the early phases of implementation is necessary to abate maintenance costs, whereas expenditures linked to parts and consumables should be included in a detailed business model as operational costs, thus these costs would be born by the associations of producers/cooperatives or farmers at the end of a grace period as part of the revenues/increased sales.* |
| *Policy, legal and regulatory* | *Insufficient regulatory framework regarding feed supply* | *Regulatory policies to encourage farmers to adopt sustainable agricultural practices, such as conservation agriculture, efficient management of water resources and responsible use of pesticides and fertilisers, should be developed and enacted. These practices can help protect the environment and increase the sector's* |

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| | | *resilience to climate change and create the enabling environment for the uptake of the prioritized technologies.* |
| | *Lack of policy enforcement, both at active (e.g. extension services) and passive (regulators, law enforcement)* | *Active policy enforcement should be strengthened by providing capacity building to extension services and funds to support their additional workload, especially if coupled with ad-hoc developed sectoral policies. Law enforcement actors, would require a re-organization over the territory of their functions and should categorize their contribution to maintenance of correct management and supervision of farmer's activity in the context of irrigation for feed production.* |
| *Institutional and organizational* | *Limited knowledge and recognition of importance of science in livestock sector* | *Governments, the private sector, non-governmental organisations and researchers should work together and form partnerships to address climate change in the livestock sector. Addressing this complex challenge requires a coordinated and integrated approach. The establishment of Communities of Practice would present a way of sharing science-based successes stories and previous experiences of implementing technologies and practices that contribute to climate change adaptation.* |
| | *Lack of associative structures (cooperatives, etc.) among livestock farmers* | *By partnering in the face of climate challenges, farmers can become more resilient to extreme weather changes or climate crises and better prepared to face them. By collaborating and sharing best practices, farmers can learn to use resources more efficiently. For example, animal feed and manure management techniques to reduce methane emissions from digestion or save water, and precision feeding to reduce environmental impact. Within an association, farmers can work together to access funds and resources for research and development of innovative technologies that help reduce the impact of the livestock sector on climate change. The creation of farmer associations, by nature only have modest upfront costs as much of the work is carried out on a voluntary basis by the farmers themselves.* |
| *Information and awareness* | *Lack of institutional recognition of the value and contribution of scientific advancements to livestock sector* | *Workshops with policymakers and government agencies are necessary to discuss at high level the possible contribution of scientific innovation to the sustainability of the livestock sector in Moldova. Through a series of discussions, conferences and events, relevant Ministry Staff can be familiarized with the concepts and the techniques to enhance the resilience of the livestock sector to climate change and learn about what role they can play to shape such future.* |
| | *Poor knowledge in the field of irrigation systems for fodder crops* | *It is important to educate farmers and rural communities about the impacts of climate change and the importance of adapting to it. Awareness and education can encourage voluntary adoption of more sustainable practices and adaptation measures. Educational activities include field visits, study tours, farmers field schools, and exchanges with peers. These activities must have a concrete and specific character at the local level, so that communities have an understanding of their needs and ways to address them.* |

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| | *Insufficient collaboration of the livestock sector with university institutions* | *The lack of connection between university and research centers and livestock sector operators requires structural and long-term exchange programmes, including study tours to familiarize farmers with the scientific community and gain trust. Subsequently, universities and research centers should develop pilot projects together with livestock farmers to exchange knowledge on the subject. These collaborations should be favored by local extension services and sponsored by private sector entities working with universities (e.g. feed-producing companies) and for farmers.* |
| *Human competences* | *Lack of workforce in livestock sector* | *Attracting specialized workforce to be employed in the livestock sector in general requires the creation of competitive conditions for the employees. Wages in agricultural activities in Moldova are among the lowest in Europe and these should be raised based on premiums paid at the end of the year as a result of increased production efficiency. More importantly, the informal and seasonal nature of agricultural and livestock-related work should be altered by building up a training facility especially for young workers to be enrolled in permanent positions as irrigation systems workforce connected to the irrigation facility manager institution, thus ensuring a stable and long-term source of income after the training. These would be state jobs for those parts of the irrigation infrastructure that are publicly owned, or through private companies for the share of irrigation facilities managed by the private sector.* |
| *Technical* | *Difficult, cumbersome assembling and management processes for extensive irrigation systems in open fields* | *Traditional irrigation technology in Moldova requires heavy duty equipment and complex labour operations to lay the main pipes and to connect the secondary piping system. Improved design equipment and piping systems have to be introduced to reduce technical barriers for construction and maintenance, as well as supporting heavy duty equipment capable of mitigating the technical difficulties of burring the piping system.* |

*Table 15: Identified Measures for increasing areas under irrigation for the production of feed for the livestock sub-sector*

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| **2) Identification of measures to remove barriers for the implementation of animal welfare by optimizing construction of sheds and stables** | | |
| *Categories of barriers* | ***Barrier*** | ***Measures*** |
| *Economic and financial* | *Low investment capacities of landowners and high installation costs for irrigation systems* | *Provision of special grants or subsidy on initial cost of installation emerged as necessary spark for all technologies deployment in the livestock sector. Farmers would benefit from a a starter installation grant or incentive scheme for all technologies. Access to such a grant for a starter installation would assist the farmer to improve productivity and earning which would, in turn, facilitate further investment by the farmer and the ultimate expansion of farm output from the remaining sections of the property. The value of such a grant would be site/region-specific, but an average could probably be calculated by the MAFI and related agencies. Another measure to overcome financial barriers in the livestock sector would include the provision of low interest or interest-free loans for purchase and installation of equipment. The provision of tax incentives and the reduction of import duties on component parts for systems to reduce capital costs for adoption and installation.* |
| | *Low profitability, long payback period* | *A financial mechanism would require specific financial tools to be applied to smallholder farmers, perhaps through forms of association into cooperatives or producer organizations. These mechanisms specifically designed for smallholder farmers would include guarantees to farmers that purchase technologies with proven adaptation potential that have long payback periods.* |
| | *Maintenance needs and associated costs during the calendar year* | *The provision of technical assistance in the early phases of implementation is necessary to abate maintenance costs, whereas expenditures linked to parts and consumables should be included in a detailed business model as operational costs, thus these costs would be born by the associations of producers/cooperatives or farmers at the end of a grace period as part of the revenues/increased sales.* |
| *Institutional and organizational* | *Limited knowledge and recognition of importance of science in livestock sector* | *Governments, the private sector, non-governmental organisations and researchers should work together and form partnerships to address climate change in the livestock sector. Addressing this complex challenge requires a coordinated and integrated approach. The establishment of Communities of Practice would present a way of sharing science-based successes stories and previous experiences of implementing technologies and practices that contribute to climate change adaptation.* |

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| | *Lack of associative structures (cooperatives, etc.) among livestock farmers* | *By partnering in the face of climate challenges, farmers can become more resilient to extreme weather changes or climate crises and better prepared to face them. By collaborating and sharing best practices, farmers can learn to use resources more efficiently. For example, animal feed and manure management techniques to reduce methane emissions from digestion or save water, and precision feeding to reduce environmental impact. Within an association, farmers can work together to access funds and resources for research and development of innovative technologies that help reduce the impact of the livestock sector on climate change. The creation of farmer associations, by nature only have modest upfront costs as much of the work is carried out on a voluntary basis by the farmers themselves.* |
| *Policy, legal and regulatory* | *Lack of active and sector-specific policies to adapt to impacts of climate change* | *Reforming public policies, improving the regulatory and governance process, transparency and accessibility in the livestock sector. Policies need updating and consolidation concerning the importance of climate change adaptation norms, like ensuring animal welfare conditions in the context of a changing climate. Policy implementation should also be strengthened by building the capacity of local extension services and animal health experts like public services, veterinaries, extension services.* |
| | *Low degree of implementation of policy documents and regulatory frameworks in the field;* | *Carrying out permanent control and supervision over the compliance with the legislation and norms in force – the existing regulations and norms by the state and profile institutions; Develop and implement appropriate mechanisms to monitor the effectiveness of the measures developed.* |
| *Information and awareness* | *Lack of institutional recognition of the value and contribution of scientific advancements to livestock sector* | *Workshops with policymakers and government agencies are necessary to discuss at high level the possible contribution of scientific innovation to the sustainability of the livestock sector in Moldova. Through a series of discussions, conferences and events, relevant Ministry Staff can be familiarized with the concepts and the techniques to enhance the resilience of the livestock sector to climate change and learn about what role they can play to shape such future.* |
| | *Poor knowledge in the field of animal welfare and its importance* | *It is crucial to educate farmers and rural communities about the impacts of climate change and the importance of relieving animals from suboptimal living conditions caused by climate change. Awareness and education can encourage voluntary adoption of more sustainable practices and adaptation measures like designing thermally insulated, efficient animal sheds and stables. Educational activities targeting farmers should include field visits, study tours, farmers field schools, and exchanges with peers. These activities must have a concrete and specific character at the local level, so that communities have an understanding of their needs and ways to address them. These should be conveyed to local trainers by either the academia or experienced Ministry staff, under the supervision of International Experts, and conveyed to local livestock farms owners.* |

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| | *Insufficient collaboration of the livestock sector with university institutions* | *The lack of connection between university and research centers and livestock sector operators requires structural and long-term exchange programmes, including study tours to familiarize farmers with the scientific community and gain trust. Subsequently, universities and research centers should develop pilot projects together with livestock farmers to exchange knowledge on the subject. These collaborations should be favored by local extension services and sponsored by private sector entities working with universities (e.g. feed-producing companies) and for farmers.* |
| *Human competences* | *Lack of knowledge of technical specifications, requirements and modern designs of animal sheds in the context of Climate Change* | *Through dedicated training activities, local engineers and designers should be trained by national and international experts on the correct design of animal sheds that maximise their resilience to the impacts of climate change, such as increased mean temperatures, extreme heatwaves and climatic events. These training activities require the exchange of information on the basics of animal welfare design approaches, and specific sections dedicated to each key livestock species present in Moldova, and how to adapt these different buildings to different climatic extreme in each climatic zone of the country.* |
| *Technical* | *Difficult, cumbersome assembling and management processes for extensive irrigation systems in open fields* | *Traditional irrigation technology in Moldova requires heavy duty equipment and complex labour operations to lay the main pipes and to connect the secondary piping system. Improved design equipment and piping systems have to be introduced to reduce technical barriers for construction and maintenance, as well as supporting heavy duty equipment capable of mitigating the technical difficulties of burring the piping system.* |

*Table 16: Identification of measures to remove barriers for the implementation of animal welfare by optimizing construction of sheds and stables*

***3) Identification of measures to remove barriers for the construction of platforms for organic fertilizer production***

| *Categories of barriers* | ***Barrier*** | ***Measures*** |
|---|---|---|
| *Economic and financial* | *Low investment capacities of landowners and high installation costs for irrigation systems* | *Provision of special grants or subsidy on initial cost of installation emerged as necessary spark for all technologies deployment in the livestock sector. Farmers would benefit from a a starter installation grant or incentive scheme for all technologies. Access to such a grant for a starter installation would assist the farmer to improve productivity and earning which would, in turn, facilitate further investment by the farmer and the ultimate expansion of farm output from the remaining sections of the property. The value of such a grant would be site/region-specific, but an average could probably be calculated by the MAFI and related agencies. Another measure to overcome financial barriers in the livestock sector would include the provision of low interest or interest-free loans for purchase and installation of equipment. The provision of tax incentives and the reduction of import duties on component parts for systems to reduce capital costs for adoption and installation.* |
| | *Low profitability, long payback period* | *A financial mechanism would require specific financial tools to be applied to smallholder farmers, perhaps through forms of association into cooperatives or producer organizations. These mechanisms specifically designed for smallholder farmers would include guarantees to farmers that purchase technologies with proven adaptation potential that have long payback periods.* |
| | *Maintenance needs and associated costs during the calendar year* | *The provision of technical assistance in the early phases of implementation is necessary to abate maintenance costs, whereas expenditures linked to parts and consumables should be included in a detailed business model as operational costs, thus these costs would be born by the associations of producers/cooperatives or farmers at the end of a grace period as part of the revenues/increased sales.* |
| *Institutional and organizational* | *Limited knowledge and recognition of importance of science in livestock sector* | *Governments, the private sector, non-governmental organisations and researchers should work together and form partnerships to address climate change in the livestock sector. Addressing this complex challenge requires a coordinated and integrated approach. The establishment of Communities of Practice would present a way of sharing science-based successes stories and previous experiences of implementing technologies and practices that contribute to climate change adaptation.* |

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| | *Lack of associative structures (cooperatives, etc.) among livestock farmers* | *By partnering in the face of climate challenges, farmers can become more resilient to extreme weather changes or climate crises and better prepared to face them. By collaborating and sharing best practices, farmers can learn to use resources more efficiently. For example, animal feed and manure management techniques to reduce methane emissions from digestion or save water, and precision feeding to reduce environmental impact. Within an association, farmers can work together to access funds and resources for research and development of innovative technologies that help reduce the impact of the livestock sector on climate change. The creation of farmer associations, by nature only have modest upfront costs as much of the work is carried out on a voluntary basis by the farmers themselves.* |
| *Policy, legal and regulatory* | *Lack of active and sector-specific policies to adapt to impacts of climate change* | *Reforming public policies, improving the regulatory and governance process, transparency and accessibility in the livestock sector. Policies need updating and consolidation concerning the importance of climate change adaptation norms, like ensuring animal welfare conditions in the context of a changing climate. Policy implementation should also be strengthened by building the capacity of local extension services and animal health experts like public services, veterinaries, extension services.* |
| | *Low degree of implementation of policy documents and regulatory frameworks in the field;* | *Carrying out permanent control and supervision over the compliance with the legislation and norms in force – the existing regulations and norms by the state and profile institutions; Develop and implement appropriate mechanisms to monitor the effectiveness of the measures developed.* |
| *Information and awareness* | *Lack of institutional recognition of the value and contribution of scientific advancements to livestock sector* | *Workshops with policymakers and government agencies are necessary to discuss at high level the possible contribution of scientific innovation to the sustainability of the livestock sector in Moldova. Through a series of discussions, conferences and events, relevant Ministry Staff can be familiarized with the concepts and the techniques to enhance the resilience of the livestock sector to climate change and learn about what role they can play to shape such future.* |
| | *Poor knowledge in the field of animal welfare and its importance* | *It is crucial to educate farmers and rural communities about the impacts of climate change and the importance of relieving animals from suboptimal living conditions caused by climate change. Awareness and education can encourage voluntary adoption of more sustainable practices and adaptation measures like designing thermally insulated, efficient animal sheds and stables. Educational activities targeting farmers should include field visits, study tours, farmers field schools, and exchanges with peers. These activities must have a concrete and specific character at the local level, so that communities have an understanding of their needs and ways to address them. These should be conveyed to local trainers by either the academia or experienced Ministry staff, under the supervision of International Experts, and conveyed to local livestock farms owners.* |

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| | *Insufficient collaboration of the livestock sector with university institutions* | *The lack of connection between university and research centers and livestock sector operators requires structural and long-term exchange programmes, including study tours to familiarize farmers with the scientific community and gain trust. Subsequently, universities and research centers should develop pilot projects together with livestock farmers to exchange knowledge on the subject. These collaborations should be favored by local extension services and sponsored by private sector entities working with universities (e.g. feed-producing companies) and for farmers.* |
| *Human competences* | *Lack of knowledge of technical specifications, requirements and modern designs of animal sheds in the context of Climate Change* | *Through dedicated training activities, local engineers and designers should be trained by national and international experts on the correct design of animal sheds that maximise their resilience to the impacts of climate change, such as increased mean temperatures, extreme heatwaves and climatic events. These training activities require the exchange of information on the basics of animal welfare design approaches, and specific sections dedicated to each key livestock species present in Moldova, and how to adapt these different buildings to different climatic extreme in each climatic zone of the country.* |
| *Technical* | *Difficult, cumbersome assembling and management processes for extensive irrigation systems in open fields* | *Traditional irrigation technology in Moldova requires heavy duty equipment and complex labour operations to lay the main pipes and to connect the secondary piping system. Improved design equipment and piping systems have to be introduced to reduce technical barriers for construction and maintenance, as well as supporting heavy duty equipment capable of mitigating the technical difficulties of burring the piping system.* |

*Table 17: Identification of measures to remove barriers for the construction of platforms for organic fertilizer production*

# CHAPTER – 4 THE HORTICULTURE SUB-SECTOR

## 4.1 PRELIMINARY TARGETS FOR TECHNOLOGY TRANSFER AND DIFFUSION IN HORTICULTURE SUB-SECTOR

Fruit and vegetable production in Moldova consists of many horticultural products, and makes up a relevant share of the GDP of the Agriculture sector. Apples and grapes, but also walnuts, are among the woody plants most commonly cultivated in the country and their product are consumed in both domestic and export markets. Tomato, beets and many other vegetables are also produced to a large extent during specific growing seasons, nevertheless these represent an important part of the agricultural activities carried out in specific regions of the country. Climate change is expected, among other things, to reduce crop yields across the three agro-ecozones by 10–30% by 2050 (relative to 2013 yields), considering no adaptation measure and given the current water challenges (World Bank, 2019). However, higher temperatures could shift grape cultivation towards the country's northern border and may improve grape quality, by increasing sugar content, which could significantly boost wine quality. Apples however, are more likely to be impacted mainly negatively by these climate change-induced effects. Although the share of national arable land cultivated with tomatoes and apples is low (0.3% and 2.9% respectively) these crops have high added value and relatively competitive productivity but late frosts and hails events have been causing growing concerns for a sustainable future of the sub-sector. The main climate stressors responsible for the impacts mentioned above are again, as in the case of aquaculture and livestock sector, a combination of increased temperatures, changes in the precipitation pattern and extreme events including droughts in summer, but also late frost and hail storms in spring, when horticultural products in Moldova have an important phenological stage. Key technologies prioritized for this sector ranged widely from advanced climate-control systems in greenhouse farming settings, to pollinator's management techniques, as climate change is impacting biodiversity and with it the fertilization capacity of flowering horticultural plants. The intensity of sun irradiation and increasing temperatures call for actions to adapt cropping systems to these changes, through the use of technologies like agri-photovoltaics and agroforestry solutions.
The complete list of preliminarily targeted technologies and transfer solutions is available in the table below.

| Climate Hazard | Climate Impact | Priority technologies |
|---|---|---|
| Increased temperatures | Reduced productivity | 1. High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency |
| | | 2. Agroforestry solutions, intercropping and other nature-based practices to reduce heat stress during summer |
| | Damage to leaves and plant parts. Difficult plant development | 3. Agri-photovoltaics for shading horticultural crops, climate control and renewable energy generation |
| | | 4. Set up next-generation national horticulture breeding systems |

| | | |
|---|---|---|
| | Biodiversity impacts on pests and beneficial fauna | 5. Implementation of Climate-Smart Pest Management and biological control of macrothermal pests |
| | | 6. Pollinator's management, supporting and protecting natural bee colonies |
| Change in the precipitation regime and forms (e.g. hail) | Damage to plants as a consequence of hail, frost and sunburns | 7. Use of anti-hail netting, anti-frost film and anti-reflective material in horticultural plantations |
| | Increased damage from pests | 8. Precision Agriculture including use of drones for pest and disease management |
| Extreme phenomena – drought | Water stresses and lack of irrigation water | 9. Rainwater harvesting systems |
| | Soil quality loss | 10. Soil moisture management through nature-based solutions including biochar, compost, green mulching |
| | | 11. Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.) |
| | | 12. Sustainable soil management in horticulture and fruit production |
| | | 13. Crop diversification towards more drought-tolerant vegetables (e.g. artichokes, beans, peas, etc) and fruits (e.g. figs, plums, pomegranate, etc.) |
| | Decreased resilience of existing horticulture plant-practice systems | 14. Hydroponics with recyclable solutions |
| | | 15. Promotion of biocontrol through the use of bacteria, fungi and oomycetes |
| | | 16. Technologies for seed quality leading to higher germination rate and increased yield capacity, |
| | | 17. Grafting nurseries for improved tomato production |
| | | 18. Automation for crop production through digitalization and remote control via app |

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*Table 18: complete list of preliminarily targeted technologies and transfer solutions*

## 4.2 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR HIGH-TECH GREENHOUSES WITH ENHANCED CLIMATE CONTROL CHARACTERISTICS AND IMPROVED ENERGY EFFICIENCY FOR THE HORTICULTURE SUB-SECTOR

### 4.2.1 General description of technology, technology status in Moldova, and market characteristics

Low-tech greenhouses are single-span pad and fan-cooled tunnels. The medium-tech greenhouses are tall, multi-span, glass-covered greenhouses with a soilless growing system, a heating system usually diesel or natural gas-fired, and a controllable shade screen. The Medium-tech greenhouses are also pad and fan-cooled. Modern High-Tech greenhouses are made of advanced thermal efficiency materials, including a plethora of different double or triple-glazed glass panels, or even cutting-edge phase-change materials (PCM). These greenhouses use renewable energy systems to provide heat and cooling. Making best use of available agricultural residues (such as pruning waste, post-harvest waste biomass etc.) these greenhouses are equipped with biomass burners, that can dry and filter the exhaust gases to deliver only CO2 to growing vegetables. Hi-Tech greenhouses are also equipped with heat-pump air conditioning systems, and the structure can be completely sealed from the outside air. Because of this sealed environment, biogenic CO2 injection can be used to promote production and displace fossil fuels. PCM are highly innovative applications. As all breakthrough inventions these need demonstration also through pilots and different adaptations to the specific context. These have been created to mitigate high temperatures during hot periods (e.g. summer) as well as to release such heat during colder times (e.g. at night or during low sun irradiation). Coupled with rarefied air sandwiches of polycarbonated alveolar panel this technology can offer the best available thermal insulation of greenhouses. High-tech greenhouses also use proven yet innovative ancillary technologies, like climate control management systems based on Artificial Intelligence, the Internet of Things and Domotics controls. These allow data-driven management choices in greenhouse farming and result in higher productivity and cost-efficiency. Increasing thermal efficiency and climate control inside greenhouses can have tremendous impacts on productivity and crucially diversification of products to be grown in the greenhouse year round. Greenhouse farming can increase crop production because you can create the optimal climate conditions needed for plant growth and grow more plants per square foot than growing crops in an open field. Being in an enclosed space prevents crops from suffering damage from extreme climate-related events such as sudden increases or drops in temperature. It can also keep crops away from birds and other animals that may harm crops. Studies suggest that profits per crop per square foot can be two to three times as big when executing greenhouse farming instead of open-field agriculture when combining the practice with other approaches such as hydroponics. By utilizing resources more efficiently, you create less waste, which can translate into bigger profits. Greenhouses can prevent problems such as pests as well as provide more control against other diseases. The enclosed space can be restricted to only the essential staff, and fewer people going in and out means a lesser risk of bringing unwanted elements close to the crops. It also allows you to isolate problems should they occur. A greenhouse is a relatively independent climate-controlled space, allowing the growing crops all year-round instead of just seasonally. Even in the harsh winter cold or intense summer heat, high-quality crops can be grown, provided you have the necessary technology to create the right climate inside the greenhouse. Since outside conditions don't necessarily impact plants or workers, the greenhouse's protected environment provides a safe and stable working environment, this is particularly relevant for gender-sensitive considerations, as most harvesting of vegetables is carried out by women who sometimes work in strenuous conditions.

### 4.2.2 Identification of barriers for high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency

Barriers have been listed by the horticulture National Consultant during stakeholder consultations held in the context of the Technology Needs Assessment. As the horticulture sector prioritized predominantly equipment and machinery type of technologies rather than practice-based technological solutions like the rest of the TNA prioritization exercise, economic barriers to the acquisition of such equipment are the main aspect of relevance. Economic and financial barriers may severely impede the deployment of high-tech greenhouses in Moldovan farms. These are disaggregated into consumer barriers (e.g. relatively high domestic product costs against lower comparable costs for imported vegetables) as well as producer barriers, including the lack of resources for the construction of the greenhouses. Economic barriers are therefore the main limiting factor to the deployment of these technologies, but non-economic barriers also play a role, including policy and especially human capacity.

| Wide category of barriers | Barriers within a category | Elements of barriers |
|---|---|---|
| Economic and financial | Capex cost of high-tech greenhouse equipment | Low investment capacity of horticulture farmers to purchase high tech greenhouse equipment |
| | | Imported goods and equipment are paid in foreign currency and exchange rates is often unfavorable to Moldovan enterprises |
| Policy, legal and regulatory | Lack of understanding of authorization processes for high-tech horticulture activities | Information with reference to regulations and decisions issued by some elements of the central and local authorities are not accessible or fully disclosed, or not explained thoroughly enough. |
| | | High costs for accessing all available documentation, need for dedicated support (e.g. lawyers) |
| | Lack of consistency between governmental choices and policies concerning horticulture development | Fluid evolution of the implementation framework in horticulture makes it difficult to plan long-term investments in the sector |
| Human competencies and capacity | Lack of workforce | Lack of qualified workforce, specialized to operate high-tech greenhouses effectively |
| Institutional and organisational | Poor specialists qualifications | Lack of dedicated training programs for horticulture operators, students, experts |
| | Low remuneration of specialists and workers in the horticulture sector | Low salaries paid to horticulture operators |
| | Low credibility of horticulture actors when engaging in large budget projects | Corruption and poor image of horticulture staff and managers |

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*Table 19: Complete list of barriers identified for the technology high-tech greenhouses*

### 4.2.3 Economic and financial barriers

High-tech greenhouses have an upfront cost for any farmer or horticulture entrepreneur that depending on the size of its operations may quickly escalade. Affordability is an issue linked to lack of capital and savings, as well as on difficulties in accessing to finance. Moreover, greenhouse equipment is imported into Moldova from foreign countries and currency exchanges may exacerbate the inability to afford the necessary initial investments. Increased capital costs for equipment is likely to transmit to the price of the horticultural products, with the risk that importing vegetables from other countries would be a more affordable option for local buyers.

#### 4.2.4 Non-financial barriers

Policy, legal and regulatory barriers exist for this technology's implementation in the country. Regulatory barriers, such as the difficult bureaucracy landscape surrounding authorizations to build structures and import equipment, may constitute a relevant impediment to the deployment of these technologies in Moldova. The fast changing, fluid situation at policy level in this regard is another obstacle to be considered and overcome. Difficulties are also represented by the lack of human capacity and knowledge available in the country to use high-tech greenhouses to produce horticultural products efficiently and sustainably, the lack of skilled workforce and the generally low salaries in the sector that do not attract specialized workers.
Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The Problem Tree for the first prioritized technology for the horticulture sector (high-tech greenhouses with enhanced climate control characteristics) is presented below, whereas the market mapping analysis follows. The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 4.5).

Problem tree for: high-tech greenhouses with climate control

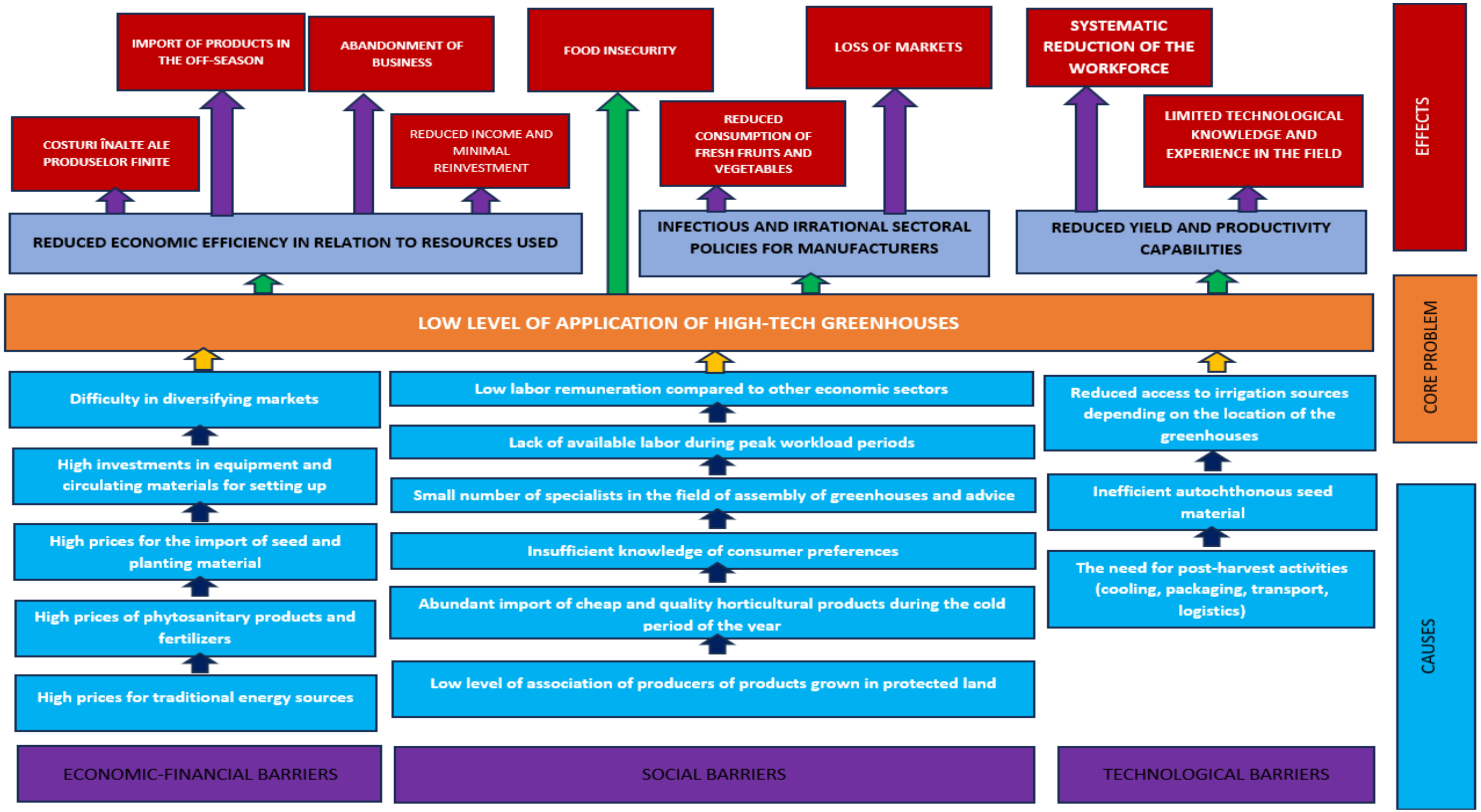


*Figure 15: Problem tree for high-tech greenhouses with climate control*

Market Mapping for: high-tech greenhouses with climate control

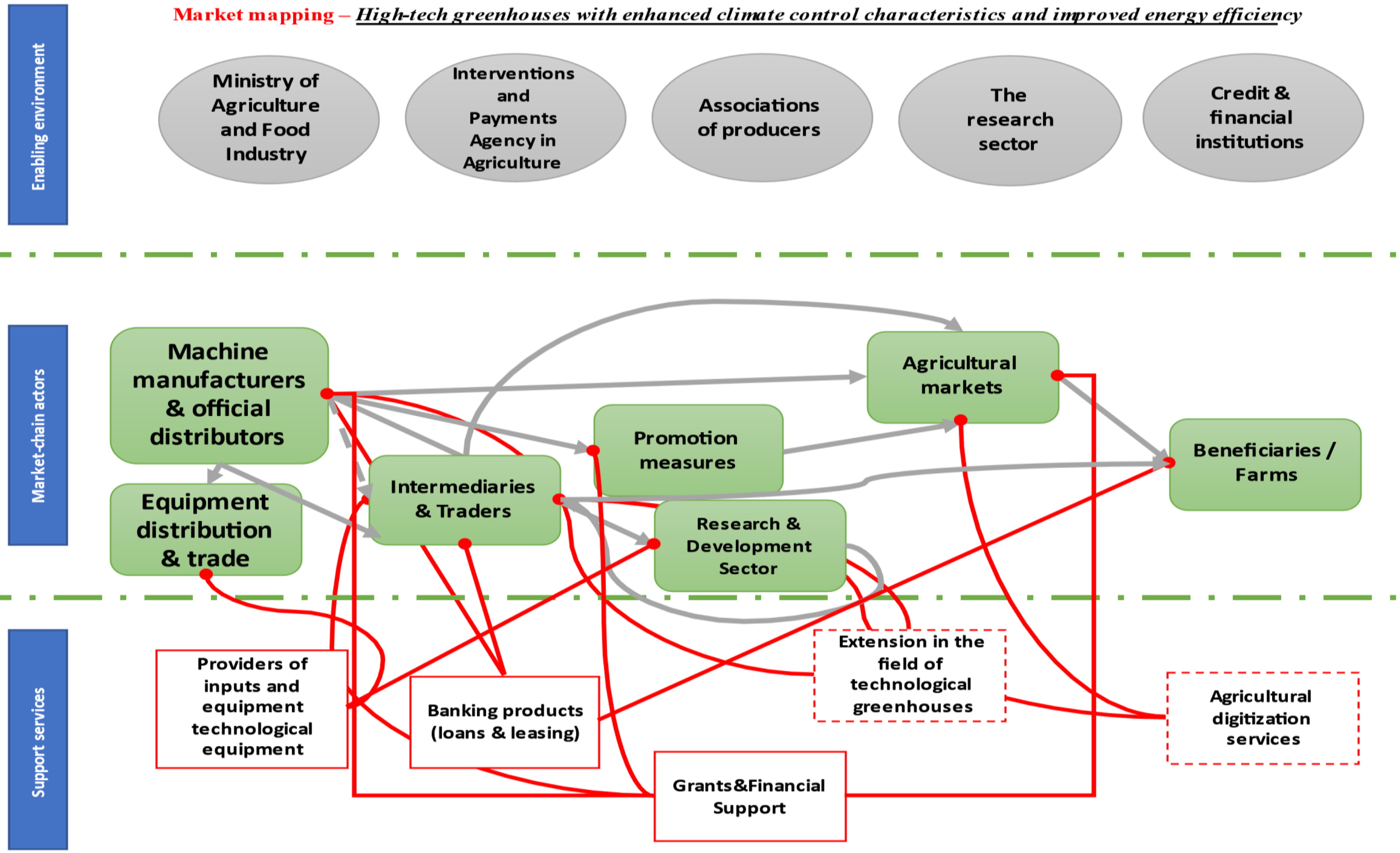


Figure 16: Market Mapping for greenhouses with climate control

## 4.3 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR MODERN IRRIGATION SYSTEMS FOR THE HORTICULTURE SUB-SECTOR

### 4.3.1 General description of technology, technology status in Moldova, and market characteristics

Reliable, efficient, and environmentally friendly irrigation systems are needed to support sustainable intensification of agriculture in the content of adaptation to climate impacts in Moldova. Water and energy are important resources for economic and social development as well as for environmental integrity, while both are essential to irrigation. One approach for improving water use efficiency is to replace surface irrigation systems with more efficient pressurized (sprinkler and drip) systems to significantly reduce water application on the farm scale, thereby increasing water and land productivity, but also increasing energy and investment requirements. The energy used by pumping stations generates significant greenhouse gas (GHG) emissions, which then contribute to accelerating climate change, therefore modern irrigation systems necessarily need to rely on technologies that maximise both water use efficiency (e.g. drip irrigation) as well as energy efficiency. Maximizing water efficiency means finding the best combination of technologies and practices to return the highest water-use efficiency of crop production. This can happen both at national infrastructural level, as well as at farm level. At the national infrastructural level, monitoring and maintaining the hydraulic network is essential to avoid water leakages and losses before irrigation starts in the field. Technologies to update the national irrigation infrastructure include sensors and instrument to monitor pressures and identify potential losses, as well as improved valves and tubing junctions, made of flexible yet robust materials that have very long lifespans. Drip irrigation systems have higher capital costs than traditional systems, moreover, they require significant pumping power to operate. However, novel low-pressure drip irrigation systems can operate at 20 to 30 kPa. This pressure can be obtained by placing the irrigation tank or reservoir 3 metres above the height of the drippers. Drippers can also be buried into the soil to deliver more efficient water to the rootzone of the plants, this will increase the differential. At 25 kPa pressure an 8 litre per hour (lph) dripper will discharge about 3.4 lph. It is a good idea to use the 8 lph dripper as this will provide the maximum flow path size and be less resistant to clogging. Ideally the system should incorporate an inline filter, however this comes at a cost by creating a pressure drop as the filter traps contaminants. This is why it is advisable to use low-pressure drip irrigation systems always in conjunction with sedimentation tanks, so that particles will tend to settle in the bottom of the tank and if the outlet is above the sediment line filtering can be much less obstructive. The only downside to using gravity (low pressure) for drippers is that they can be more susceptible to clogging as the turbulent flow path is more laminar in performance. This should always be considered when using gravity pressure systems. When gravity pressure is not sufficient, or large filters are necessary, the low-pressure drippers can be hooked to a renewable energy powered pumping system. Small to large scale renewable energy plants can be deployed to sustain the irrigation facility. The electricity can be generated for instance by an Agri-photovoltaic systems as direct current (DC) and employed as such by DC pumps. When pumping power exceeds 10 kW, three-phase pumps are needed, thus specific inverters are needed but these can still be operated by PV or other renewable energy systems. At the field level, drip irrigation is a powerful technology that can reduce water consumption by 20-40% while increasing crop yield by 20-50% compared to surface irrigation or sprinklers, depending on the crop grown. Drip irrigation can enable farmers to grow crops under conditions where they otherwise could not and adapt to the impacts of climate change. Drip also allows farmers to grow a wider array of crops, increase crop yield, and save on labor and fertilizer costs.

### 4.3.2 Identification of barriers for modern irrigation systems

Barriers have been listed by the horticulture National Consultant during stakeholder consultations held in the context of the Technology Needs Assessment. All prioritized technologies, being predominantly modern equipment and machinery type of technologies rather than practice-based technological solutions, share similar barriers to their successful deployment in Moldova. Economic barriers include high costs for the acquisition of such equipment. Economic and financial barriers may severely impede the deployment of modern irrigation systems in Moldovan farms. Non-economic barriers also play a role, including technical and human capacity although concerning drip irrigation systems these barriers are felt as less of a burden. In general, this technology brings along increased costs for the functioning of the systems (higher pressure pumps) than conventional irrigation systems, as well as maintenance issues – particularly the correct maintenance of filters – that can alter the correct flow of water in the pipe system. Technical barriers are therefore coupled with human capacity barriers, whereas organizational and institutional barriers play a minor role in the context of the implementation of modern drip irrigation systems.

| **Wide category of barriers** | **Barriers within a category** | **Elements of barriers** |
|---|---|---|
| Economic and financial | Capex and Opex cost of modern irrigation systems | Low investment capacity of horticulture farmers to purchase drip irrigation equipment |
| | | Electricity/running costs for the pumping systems |
| Technical | Clogging, filtering system's lifetime, maintenance requirements | Modern irrigation systems require filtered water to be used efficiently otherwise clogging of the sprinkler can occur |
| | | Water impurities calcify the outlets of each sprinkler damaging the delicate nozzles |
| Human competencies and capacity | Lack of workforce | Lack of qualified workforce, specialized to operate high-tech greenhouses effectively |
| Institutional and organisational | Poor specialists qualifications | Lack of dedicated training programs for horticulture operators, students, experts |
| | Low remuneration of specialists and workers in the horticulture sector | Low salaries paid to horticulture operators |
| | Integration of drip irrigation systems into organizational management of horticultural farms | Planning the horticultural operations (e.g. surface tillage) based on the presence of irrigation systems that could be damaged by machinery |

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*Table 20: Complete list of barriers for the technology Modern Irrigation Systems*

#### 4.3.3 Economic and financial barriers

Just like any other modern technology to be introduced, drip irrigation systems have an upfront cost for any farmer or horticulture entrepreneur that depending on the size of its operations may be unsustainable. Affordability is an issue linked to lack of capital and savings, as well as on difficulties in accessing to finance. Moreover, it is likely the as for greenhouse equipment, also drip irrigations systems are imported into Moldova from foreign countries and currency exchanges may exacerbate the inability to afford the necessary initial investments. Increased capital costs for equipment are likely to transmit to the price of the horticultural products, with the risk that importing vegetables from other countries would be a more affordable option for local buyers.

#### 4.3.4 Non-financial barriers

Apart from the cost of the equipment, technical and human capacity are the two main barriers for the deployment of modern irrigation systems in Moldova. Drip irrigation systems work efficiently when the water is well filtered and no impurities are left. If sediments, especially clayey solids are contained in the irrigation water, these tend to clog the nozzles of the irrigation system thus increasing the risk of failures and malfunctioning, including breaking of nozzles, pipe or even pumps. Th lack of human capacity and knowledge available in the country to use these systems and the low salaries paid to operators in the sector that do not attract specialized workers, further exacerbating technical barriers of these systems. Lastly, the need for a diversified management of the horticultural activities (tillage, fertilization, harvesting) is complicated by the presence of a fixed piping system composing modern drip irrigation systems. This in turn will pose a burden on the execution of activities and therefore elapse the time spent working in the field.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The Problem Tree for the first prioritized technology for the horticulture sector (modern irrigation systems) is presented below, whereas the market mapping analysis follows.

The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 4.5).

Problem tree for: modern irrigation systems

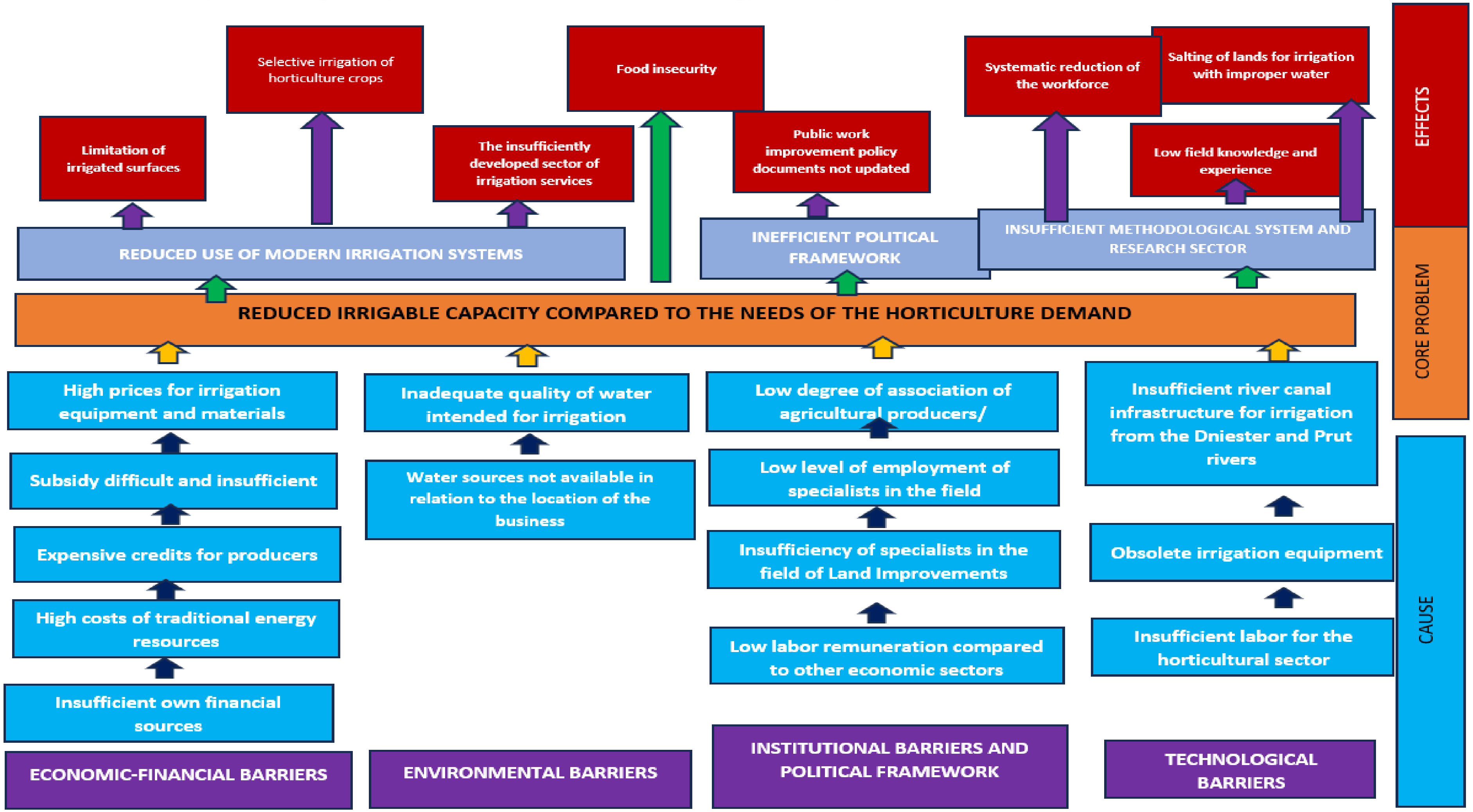


*Figure 17: Problem Tree for modern irrigation systems*

Market Mapping for: modern irrigation systems

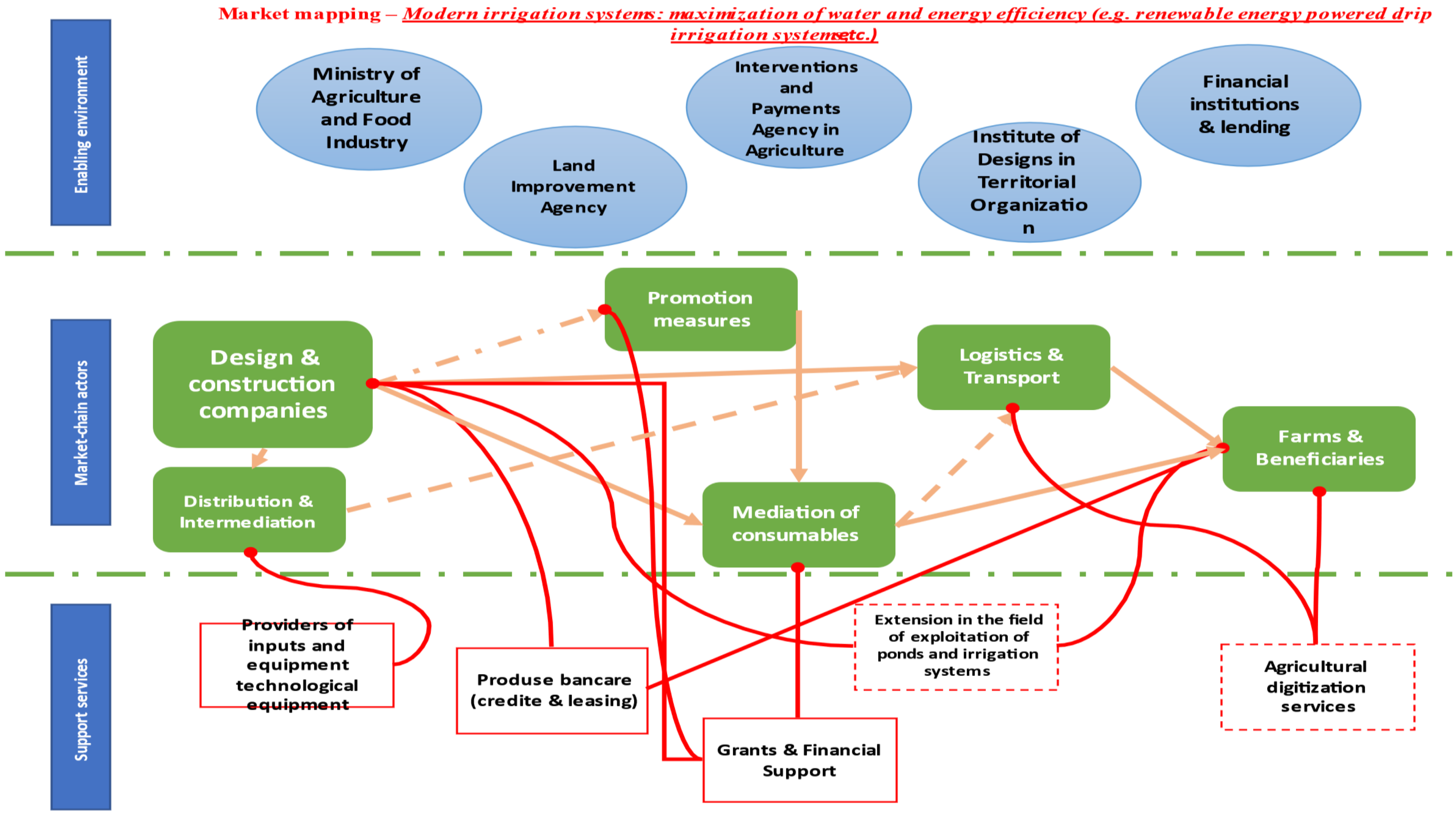


Figure 18: Market Mapping for modern irrigation systems

## 4.4 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR HYDROPONICS WITH RECYCLABLE SOLUTIONS FOR THE HORTICULTURE SUB-SECTOR

### 4.4.1 General description of technology, technology status in Moldova, and market characteristics

Hydroponics is a method of growing plants in water, or in an inert media, without soil and using mineral nutrient solutions in a water solvent to supply complete nutrition for plant growth. Hydroponics can give precise control over plant growth parameters which can lead to yield and quality improvement. In principle, nutrient solutions used in hydroponics can either be reused or discarded. Nowadays, the cultivation of leafy vegetables, medicinal herbs, and other plants with pharmaceutical value are commercially grown under recycled hydroponics with controlled environments. In recycled hydroponics, nutrient solutions passed through the growing medium are collected into a reservoir and reused repeatedly. In this system, both water and mineral nutrients are used efficiently and therefore minimizes the wastage of fertilizer and the environmental damage. Hydroponic systems are commonly associated with high-tech greenhouses or other controlled environment agriculture (CEA) facilities. Additional control over growth parameters is ensured by using artificial grow lights, such as light-emitting diodes (LED), climate control and nutrient dosing with real-time measurements. Hydroponics may however be challenged by the accumulation of root exudates that affect plant growth and reduce crop yield and quality. Lower growth and yield performance of several crops including lettuce, strawberry, several leafy vegetables, and ornamentals have been reported in recycled hydroponics. There are two main types of recycled hydroponics systems: the Nutrient Film Technique (NFT) and the Deep Flow Technique (DFT).

### 4.4.2 Identification of barriers for Hydroponics with recyclable solutions

As in the case of the other technologies for the horticulture sector, barriers have been listed by the National Consultant during stakeholder consultations. Hydroponics systems require initial costs to set up the facility that will house the water tanks and piping systems. Economic barriers include high costs for the acquisition of such equipment and facility. Virtually the same non-economic barriers identified for the high-tech greenhouses and for drip irrigation systems are going to apply to hydroponics as well, though are also felt as less of an obstacle than initial and operation costs. In general, this technology brings along human capacity barriers being the hydroponics not well established in Moldova, and limitations of organizational nature concerning the arrangement of farm structures and facilities.

| **Wide category of barriers** | **Barriers within a category** | **Elements of barriers** |
|---|---|---|
| Economic and financial | Capex and Opex cost of hydroponics systems | Low investment capacity of horticulture farmers to purchase hydroponics equipment |
| | | Electricity/running costs for the pumping systems |
| Technical | Maintenance requirements | Hydroponics systems require frequent and efficient maintenance to ensure smooth operations |
| Human competencies and capacity | Lack of workforce | Lack of qualified workforce, specialized to operate advanced horticulture technologies effectively |
| Institutional and organisational | Poor specialists qualifications | Lack of dedicated training programs for horticulture operators, students, experts |
| | Low remuneration of specialists and workers in the horticulture sector | Low salaries paid to horticulture operators |

| | | |
|---|---|---|
| | Integration of hydroponics systems into organizational management of horticultural farms | Reconversion of horticulture farms to hydroponics requires substantial organizational work |

.

*Table 21: Complete list of barriers for the technology Hydroponics with recyclable solutions*

### 4.4.3 Economic and financial barriers

Just like any other modern technology to be introduced, hydroponics systems have an upfront cost for any farmer or horticulture entrepreneur that depending on the size of its operations may be unsustainable. Affordability is a key issue linked to lack of capital and savings, as well as on difficulties in accessing to finance. Moreover, it is likely that these systems are imported into Moldova from foreign countries and currency exchanges may exacerbate the inability to afford the necessary initial investments. Increased capital costs for equipment are likely to transmit to the price of the horticultural products, with the risk that importing vegetables from other countries would be a more affordable option for local buyers.

### 4.4.4 Non-financial barriers

Apart from the cost of the equipment, technical and human capacity are the two main barriers for the deployment of hydroponics systems in Moldova. The lack of human capacity and knowledge available in the country to design, build and operate these systems and the low salaries paid to operators in the sector that do not attract specialized workers, constitute relevant technical barriers of these systems. Lastly, the need for a diversified management and planning of the horticultural farms is complicated by the presence of a fixed piping system and a dedicated facility.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The Problem Tree for the first prioritized technology for the horticulture sector (hydroponics with recyclable solutions) is presented below, whereas the market mapping analysis follows.

The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 4.5).

Food and Agriculture Organization of the United Nations

GREEN CLIMATE FUND

Problem tree for: hydroponics with recyclable solutions

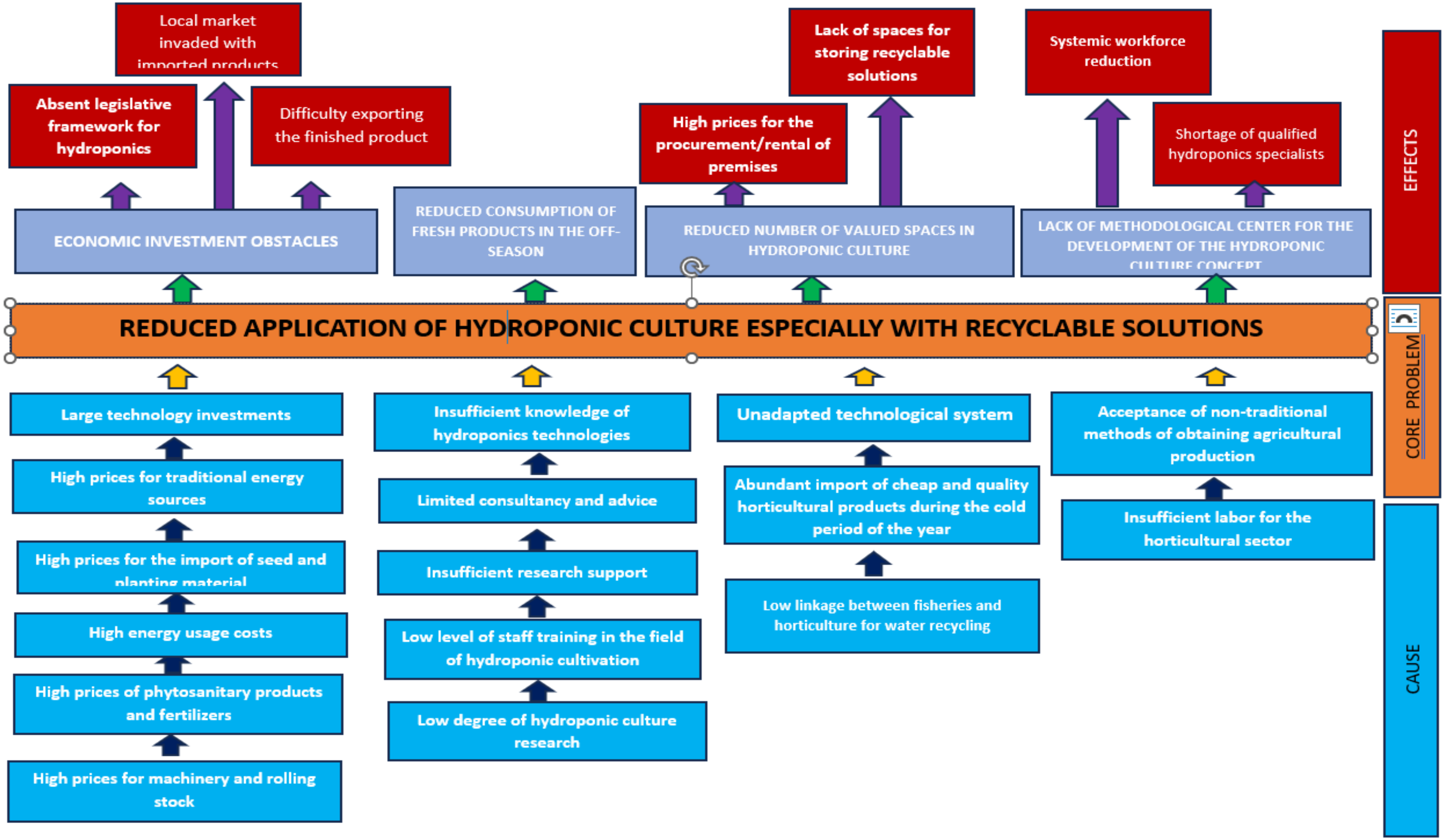


*Figure 19: Problem tree for hydroponics with recyclable solutions*

Market Mapping for: hydroponics with recyclable solutions

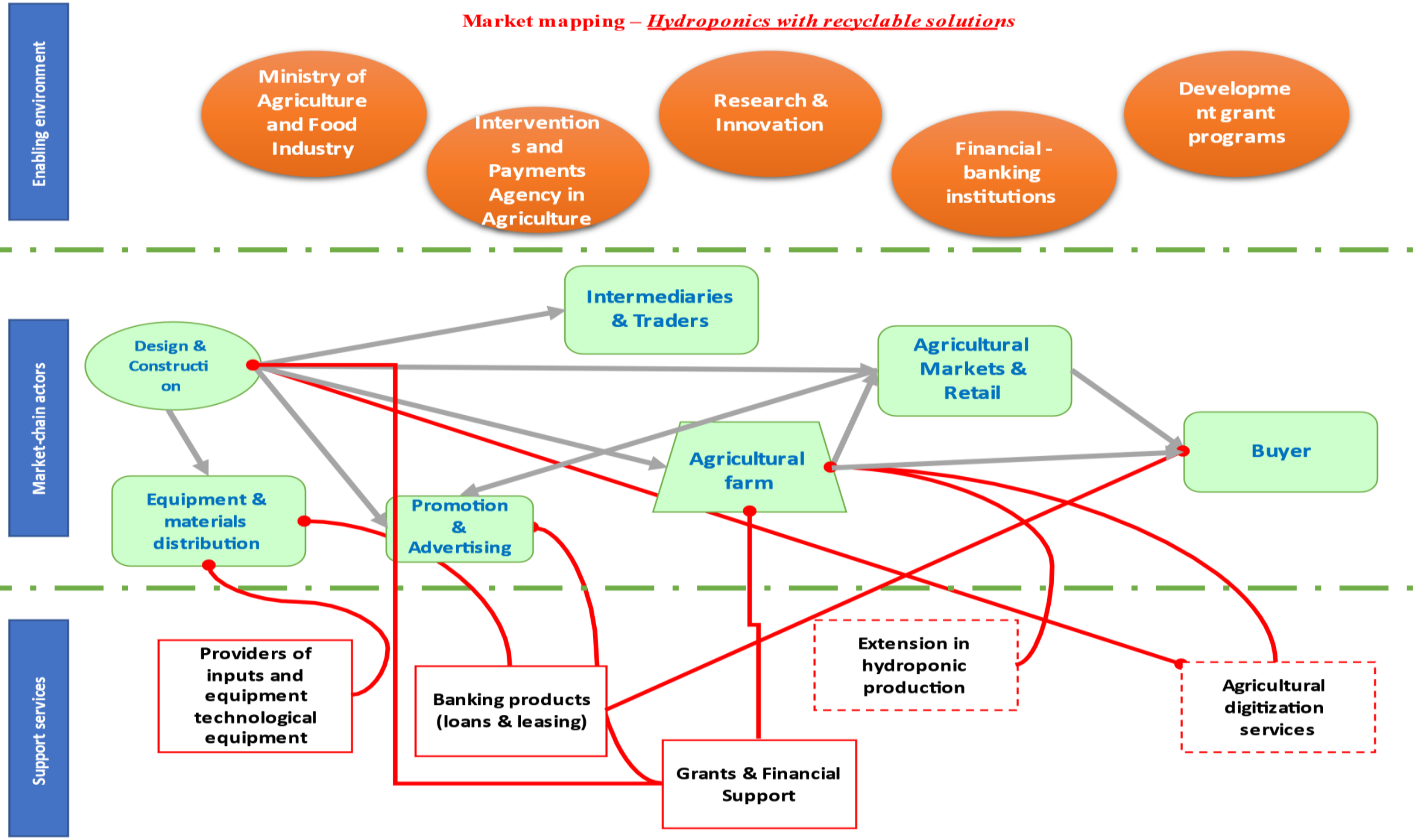


*Figure 20: Market Mapping for hydroponics with recyclable solutions*

## 4.5 IDENTIFIED MEASURES:

The National Consultant on horticulture presented in the context of a multistakeholder discussion the findings of the barrier analysis summarized in the chapters above. Policymakers, researchers and farmers convened that creating the enabling environment to support technology deployment in the horticulture sector depends on many key elements that are linked to financial support, but also to policy, regulatory and other institutional and organisational capacity-building arrangements. In order to understand better the implications of each barrier presented, the National Consultant prepared Problem Trees (Annex 1) and Market Mapping (Annex 2) for the technologies studied. On the basis of the barrier analysis supported by the annexed documents, the SWG could target specific and general measures to overcome the barriers, including the roles and the portion of the value chain where these actions should take place. The result of the exercise is a set of targeted and specific measures identified by the relevant members of the TNA team in consultation with the SWG which apply to all prioritized technologies.

Measures to remove the barriers and create the enabling environment for future deployment of the prioritized technologies:

| | | |
|---|---|---|
| ***1)Identification of measures to remove barriers for high-tech greenhouses*** | | |
| *Categories of barriers* | ***Barrier*** | ***Measures*** |
| *Economic and financial* | *Capex cost of high-tech greenhouse equipment* | *Economic incentives and various forms of support are necessary to enable early off-takers to adopt the prioritized technologies. Depending upon the scale of operations, these technologies might have considerable upfront costs and the incentive scheme has to be planned in a way that it aligns with the expected benefits in terms of increased and sustained agricultural production. Firstly, funds for pilot installations are likely to come in the form of grants from development banks (e.g. EBRD), donor countries, or adaptation-related funding opportunities like the Green Climate Fund, the Adaptation Fund and similar entities. The creation of an enabling environment should couple these grant-based forms of pilot support with a public incentive mechanism that expands the attractiveness of the proven technologies beyond the context of pilot installations, covering up to 10 – 30% of total potential horticulture businesses in the country. Based on the verified results of such medium-term project, a long-term strategy based on primary data – particularly on market response to climate change-adapted vegetable products – should adjust the incentive scheme proposed. Specific actions proposed by the SWG included detaxation of energy sources, especially renewable energy sources, employed in the production cycle.* |
| *Institutional and organizational* | *Poor specialists qualifications* | *The organization of farm activities is expected to change with the introduction of the prioritized technologies and therefore the management and labour force employed in the horticulture farm should be opportunely trained to re-organize their contributions to fit the need for human support to technological effectiveness. To this end, dedicated training programs for horticulture operators, students, experts need to be provided by extension services or international support organizations like FAO.* |
| | *Low remuneration of specialists and workers in the horticulture sector* | *A key action to enable the deployment of sustainable advanced horticulture technologies is the revision of the normative framework regarding labor remuneration in the horticultural sector. Current wages are particularly low and make engaging in horticultural activities unattractive. Increasing the salary level of highly qualified personnel participating in high-tech horticultural activities is an action that can guarantee long-term stability of the workforce employed in a modern greenhouse or in a hydroponics farm.* |

| | | |
|---|---|---|
| | *Low credibility of horticulture actors when engaging in large budget projects* | *Increasing the credibility of the horticulture sector in engaging in large budget projects requires attentive scrutiny and background checks of companies enrolled in the development projects. These should be carried out be third-party, independent auditors, on a periodic basis. Stringent requirements for private sector companies will be mandated before enrolling in any demonstration project, as this measure is the only solution to incentivizing good conduct and professional behavior of private sector operators. Through demonstrations of their impeccable conduct they will rehabilitate their image as serious and reliable professionals.* |
| *Policy, legal and regulatory* | *Lack of understanding of authorization processes for high-tech horticulture activities* | *The unclear regulatory framework regarding authorization of advanced technological structures (modern greenhouses, hydroponics systems, etc.) affects the capacity of the sector to uptake these technologies at a fast pace. Policy work is necessary to define clear and much simplified authorization processes that can be fully deployed by local administrative units (e.g. District or better at municipality level). In addition, the fluid evolution of the implementation framework in horticulture makes it difficult to plan long-term investments in the sector.* |
| | *Lack of consistency between governmental choices and policies concerning horticulture development* | *Accurate policymaking shall target 1) a reduction of the existing, and often contradicting, statutes on authorization of infrastructures and buildings for farm necessities, and 2) consolidate with the broadest consensus possible these revised pieces of legislation in order to ensure long-term reliability towards the same policy. These two actions are necessary to remove policy-related barriers for the deployment of horticultural technologies in Moldova.* |
| *Human competences* | *Lack of workforce* | *Workforce shortage in the horticulture sector of Moldova is a known problem for the subsector. In general, the sector is poorly organized, seasonal workers are mainly wanted for manual, highly repetitive, low-skill labour work, such as planting or harvesting whereas very little demand in the current conditions of the sector exist for skilled workers to apply deep and complex knowledge to their work. The introduction of modern technologies such as advanced greenhouses, drip irrigation systems, hydroponics (and other high-tech operations of management) will require the provision of capable workforce, and adequate compensations. This barrier shall be removed with a training and capacity development campaign in association with major national agricultural universities and extension services to shape professional figures able to be employed in advanced horticulture farms in Moldova. A program at university level should prepare highly qualified professionals that can run smoothly the daily operations of advanced greenhouses, with competences spanning from agronomic, botany, to electrical and energy engineering, to ensure that climate control conditions are effectively understood and maintained inside the greenhouses as well as that the technical aspects of the systems are maintained efficiently up and running.* |

*Table 22: Identification of measures to remove barriers for high-tech greenhouses*

***2). Identification of measures to remove barriers for modern irrigation systems***

| *Categories of barriers* | ***Barrier*** | ***Measures*** |
|---|---|---|
| *Economic and financial* | *Capex and Opex cost of modern irrigation systems* | *Economic incentives and various forms of support are necessary to enable early off-takers to adopt the prioritized technologies. Depending upon the scale of operations, these technologies might have considerable upfront costs and the incentive scheme has to be planned in a way that it aligns with the expected benefits in terms of increased and sustained agricultural production. Firstly, funds for pilot installations are likely to come in the form of grants from development banks (e.g. EBRD), donor countries, or adaptation-related funding opportunities like the Green Climate Fund, the Adaptation Fund and similar entities. The creation of an enabling environment should couple these grant-based forms of pilot support with a public incentive mechanism that expands the attractiveness of the proven technologies beyond the context of pilot installations, covering up to 10 – 30% of total potential horticulture businesses in the country. Based on the verified results of such medium-term project, a long-term strategy based on primary data – particularly on market response to climate change-adapted vegetable products – should adjust the incentive scheme proposed. Specific actions proposed by the SWG included detaxation of energy sources, especially renewable energy sources, employed in the production cycle.* |
| *Institutional and organizational* | *Integration of drip irrigation systems into organizational management of horticultural farms* | *The organization of farm activities is expected to change with the introduction of the prioritized technologies and therefore the management and labour force employed in the horticulture farm should be opportunely trained to re-organize their contributions to fit the need for human support to technological effectiveness. To this end, dedicated training programs for horticulture operators, students, experts need to be provided by extension services or international support organizations like FAO.* |
| | *Low remuneration of specialists and workers in the horticulture sector* | *A key action to enable the deployment of sustainable advanced horticulture technologies is the revision of the normative framework regarding labor remuneration in the horticultural sector. Current wages are* |

| | | |
|---|---|---|
| | | *particularly low and make engaging in horticultural activities unattractive. Increasing the salary level of highly qualified personnel participating in high-tech horticultural activities is an action that can guarantee long-term stability of the workforce employed in a modern greenhouse or in a hydroponics farm.* |
| | *Low credibility of horticulture actors when engaging in large budget projects* | *Increasing the credibility of the horticulture sector in engaging in large budget projects requires attentive scrutiny and background checks of companies enrolled in the development projects. These should be carried out be third-party, independent auditors, on a periodic basis. Stringent requirements for private sector companies will be mandated before enrolling in any demonstration project, as this measure is the only solution to incentivizing good conduct and professional behavior of private sector operators. Through demonstrations of their impeccable conduct, they will rehabilitate their image as reliable professionals.* |
| *Human competences* | *Lack of workforce* | *Workforce shortage in the horticulture sector of Moldova is a known problem for the subsector. In general, the sector is poorly organized, seasonal workers are mainly wanted for manual, highly repetitive, low-skill labour work, such as planting or harvesting whereas very little demand in the current conditions of the sector exist for skilled workers to apply deep and complex knowledge to their work. The introduction of modern technologies such as advanced greenhouses, drip irrigation systems, hydroponics (and other high-tech operations of management) will require the provision of capable workforce, and adequate compensations. This barrier shall be removed with a training and capacity development campaign in association with major national agricultural universities and extension services to shape professional figures able to be employed in advanced horticulture farms in Moldova. A program at university level should prepare highly qualified professionals that can run smoothly the daily operations of advanced greenhouses, with competences spanning from agronomic, botany, to electrical and energy engineering, to ensure that climate control conditions are effectively understood and maintained inside the greenhouses as well as that the technical aspects of the systems are maintained efficiently up and running.* |
| *Technical* | *Clogging, filtering system's lifetime, maintenance requirements* | *Although modern and efficient, some of these systems are quite a novelty, especially in Moldova, and the need for additional support by technology providers is expected to remove technical barriers associated with modern and complex technologies deployed. Considering maintenance actions – like frequent filters substitution, periodic cleaning of nozzles with specific products, and water analysis to determine concentration of salts (especially calcium salts) that can clog the nozzles is necessary to mitigate technical barriers.* |

*Table 23: Identification of measures to remove barriers for modern irrigation systems*

| | | |
|---|---|---|
| ***3). Identification of measures to remove barriers for hydroponics with recyclable solutions*** | | |
| *Categories of barriers* | ***Barrier*** | ***Measures*** |
| *Economic and financial* | *Capex and Opex cost of hydroponics systems* | *Economic incentives and various forms of support are necessary to enable early off-takers to adopt the prioritized technologies. Depending upon the scale of operations, these technologies might have considerable upfront costs and the incentive scheme has to be planned in a way that it aligns with the expected benefits in terms of increased and sustained agricultural production. Firstly, funds for pilot installations are likely to come in the form of grants from development banks (e.g. EBRD), donor countries, or adaptation-related funding opportunities like the Green Climate Fund, the Adaptation Fund and similar entities. The creation of an enabling environment should couple these grant-based forms of pilot support with a public incentive mechanism that expands the attractiveness of the proven technologies beyond the context of pilot installations, covering up to 10 – 30% of total potential horticulture businesses in the country. Based on the verified results of such medium-term project, a long-term strategy based on primary data – particularly on market response to climate change-adapted vegetable products – should adjust the incentive scheme proposed. Specific actions proposed by the SWG included detaxation of energy sources, especially renewable energy sources, employed in the production cycle.* |
| *Institutional and organizational* | *Integration of hydroponics systems into organizational management of horticultural farms* | *The organization of farm activities is expected to change with the introduction of the prioritized technologies and therefore the management and labour force employed in the horticulture farm should be opportunely trained to re-organize their contributions to fit the need for human support to technological effectiveness. To this end, dedicated training programs for horticulture operators, students, experts need to be provided by extension services or international support organizations like FAO.* |
| | *Low remuneration of specialists and workers in the horticulture sector* | *A key action to enable the deployment of sustainable advanced horticulture technologies is the revision of the normative framework regarding labor remuneration in the horticultural sector. Current wages are particularly low and make engaging in horticultural activities unattractive. Increasing the salary level of highly qualified personnel participating in high-tech horticultural activities is an action that can guarantee long-term stability of the workforce employed in a modern greenhouse or in a hydroponics farm.* |
| | *Poor specialists qualifications* | *The inclusions of advanced technologies like hydroponics with recyclable solutions in Moldovan horticulture farms will require substantial changes in the organizational setting of these enterprises with restructuring of* |

| | | |
|---|---|---|
| | | *personnel, new staff to be hired, existing staff to be trained, new markets to be accessed and products to be sourced and purchased. To enable all that, a thorough knowledge transfer activity is necessary not only at the technical level (capacity building) but also at managerial level via a purpose-built programme to train with the support of delegated Universities (including international ones) potential enterprise managers by offering Masters of Business Administration enrollment via grants or through Memorandum of Understandings between involved entities.* |
| *Human competences* | *Lack of workforce* | *Workforce shortage in the horticulture sector of Moldova is a known problem for the subsector. In general, the sector is poorly organized, seasonal workers are mainly wanted for manual, highly repetitive, low-skill labour work, such as planting or harvesting whereas very little demand in the current conditions of the sector exist for skilled workers to apply deep and complex knowledge to their work. The introduction of modern technologies such as advanced greenhouses, drip irrigation systems, hydroponics (and other high-tech operations of management) will require the provision of capable workforce, and adequate compensations. This barrier shall be removed with a training and capacity development campaign in association with major national agricultural universities and extension services to shape professional figures able to be employed in advanced horticulture farms in Moldova. A program at university level should prepare highly qualified professionals that can run smoothly the daily operations of advanced greenhouses, with competences spanning from agronomic, botany, to electrical and energy engineering, to ensure that climate control conditions are effectively understood and maintained inside the greenhouses as well as that the technical aspects of the systems are maintained efficiently up and running.* |

*Table 24: Identification of measures to remove barriers for hydroponics with recyclable solutions*

# CHAPTER – 5 THE CEREALS SUB-SECTOR

## 5.1 PRELIMINARY TARGETS FOR TECHNOLOGY TRANSFER AND DIFFUSION IN CEREALS SUB-SECTOR

Wheat, barley and maize, are key food crops produced in Moldova. The assessment carried out estimated that these crops cover the majority of the agricultural land in the country and make up the majority of the production of agricultural commodities (source FAOSTAT, 2022). Wheat and Maize are the two most common crops in Moldova by surface area, with about 17 and 22% of total harvested agricultural land respectively, cumulatively making up to one third of all arable land in the country. That being said, their productivity levels are rather low, especially if compared to neighboring Ukraine. Soil quality in Moldova is decaying, and the cultivation of these annual crops through tillage and erosion deplete the organic carbon content of the soils. This fact is not a direct consequence of climate change, as farming practices adopted since the Soviet Union's times have led to the drastic reduction of soil organic matter and with it, of soil functions, as a consequence of excessive use of inputs and tillage.

Harvesting of the winter cereal crops, mainly wheat, is finalized in the month of August, while harvesting of spring crops, mainly maize, is concluded by late November. A severe drought affected crop yields in the 2021/22 season. In addition, very high fertilizer and fuel prices constrained farmers' access to agricultural inputs, with a reduction of fertilizer application rates and a negative impact on yields. As a result the 2022 aggregate cereal output is estimated at about 1.8 million tonnes, 46 percent below the five-year average level and the lowest volume on record for the country. Wheat output is set at 872 000 tonnes, over 20 percent below average, and production of maize is estimated at 761 000 tonnes, 60 percent below the average level.

Planting of the 2023 winter cereal crops took place in October 2022. Near-average rainfall amounts in August and September 2022 partially restored moisture reserves in the arable layer of the soil, but severe moisture deficits persisted, as of October, in the lower soil layers, with likely adverse effects on the start of the 2022/23 cropping season.

**Cereal Production**

| | 2017-2021 average | 2021 | 2022 estimate | change 2022/2021 |
|---|---|---|---|---|
| | | 000 tonnes | | percent |
| Maize | 1 911 | 2 793 | 761 | -72.8 |
| Wheat | 1 139 | 1 565 | 872 | -44.3 |
| Barley | 190 | 253 | 126 | -50.4 |
| Others | 35 | 46 | 24 | -48.3 |
| Total | 3 276 | 4 658 | 1 782 | -61.7 |

Note: Percentage change calculated from unrounded data.

Source: FAO/GIEWS Country Cereal Balance Sheet.

*Figure 21: Cereal Production in Moldova between 2017 to 2022*

The changing climate is exacerbating the negative situation by reducing the opportunities of soils to restore their productive potential. Cereals, especially wheat, is growingly being cultivated in poorly planned rotations, the logic being the product market price of the season rather than the long-term preservation of the productive potential of the land. As a result of these factors, necessary actions are needed for the cereals sector to be more resilient to long-term impacts of mismanagement and climate determinants. The set of technologies and knowledge transfer targeted included the Long List of Technologies in the table below. Climate-smart agriculture, especially the careful interpretation of correct rotations for the specific conditions of the soil coupled with minimal tillage and soil structure destructive actions (e.g. tillage) have been prominently proposed by the TNA Team. Continuous cover crops and perennial forage in intercropping schemes or in extended rotations were two additional key practices considered to have a high potential to adapt this sub-sector to the changing climate. Reduced fertility of cereal crop's flowers is another consequence of increased temperature observed in Moldova and extreme climatic events, which in addition also weaken growing plants and expose them to more aggressive pathogens.

| Climate Hazard | Climate Impact | Priority technologies |
|---|---|---|
| Precipitation pattern changes | Soil quality decay | 1. Climate-smart rotations and wheat predecessor programmes |
| | | 2. Conservation agriculture (including no- and minimum tillage, continuous soil cover, etc) |
| | | 3. Soil C monitoring at farm and landscape level |
| | | 4. Network of shelter belts, agroforestry, and ponds for increasing the humidity of the air |
| Increased incidence of extreme climatic events including droughts, floods, etc. | Increased rates of soil organic matter mineralization | 5. Including perennial legumes and grasses in farm mosaics |
| | | 6. Integration of crops and animals for recycling of nutrients in each crop rotation |
| | | 7. Increased production and use of organic fertilizers and amendants (e.g. compost, biochar, green manure) |
| | | 8. Improve soil structure by increasing the input of carbon in soil and reduced rates of mineralization |
| | Increased water stress | 9. Real-time wireless soil moisture monitoring system |
| | | 10. In-vitro isolated pollen methods to obtain and use double haploid lines in plant breeding |
| Increased average temperatures | Increased pest outbreaks and virulence, increased weed infestations | 11. Integrated Pest Management |
| | | 12. Integrated Nutrient Management |

*Table 25: complete list of technologies for the cereals sub-sector*

## 5.2 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR CONSERVATION AGRICULTURE FOR THE CEREALS SUB-SECTOR

### 5.2.1 General description of technology, technology status in Moldova, and market characteristics

In drought conditions winter wheat crops suffer as a consequence of unnatural soil moisture deficit, especially in deeper soil layers. Moldovan farmers are starting to consider additional intensification techniques, including irrigation of winter wheat, to reduce the negative impacts of drought. Such short-sighted solution would likely deliver a decent crop over the short term, but it is proven that over time the consequences of irrigation on chernozem soils are negative. This is due to salinity buildups and to intensified decomposition of soil organic matter as a consequence of irrigation in conditions of insufficient application of carbon with fresh organic residues. Plowing increases soil compaction in cropping systems of Moldova while perennial herbaceous crops capable of improving soil structure are neglected. Irrigation of such compacted soils worsens both soil erosion and deficit of soil moisture. A paradigm shift in soil quality management for cereals production is necessary in Moldova to cope with the existing sustainability issues of Business-As-Usual. Improving soil management practices together with more sustainable technologies is the key objective of the TNA for the cereals sub-sector. Conservation Agriculture (CA) is a farming system that can prevent losses of arable land while regenerating degraded lands. It promotes maintenance of a permanent soil cover, minimum soil disturbance, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production. CA principles are universally applicable to all agricultural landscapes and land uses with locally adapted practices. Soil interventions such as mechanical soil disturbance are reduced to an absolute minimum or avoided, and external inputs such as agrochemicals and plant nutrients of mineral or organic origin are applied optimally and in ways and quantities that do not interfere with, or disrupt, the biological processes. CA facilitates good agronomy, such as timely operations, and improves overall land husbandry for rainfed and irrigated production. Complemented by other known good practices, including the use of quality seeds, and integrated pest, nutrient, weed and water management, etc., CA is a base for sustainable agricultural production intensification. It opens increased options for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes.

### 5.2.2 Identification of barriers for conservation agriculture

As in the case of the other prioritized technologies for the other subsectors, several barriers have been listed during stakeholder consultations held in the context of the Technology Needs Assessment. The specific conditions of the cereals subsector however differ from those of other components of the agricultural landscape of Moldova. Conservation Agriculture's underrepresentation in farming practices in the country is predominantly due to non-economic barriers, particularly those linked to awareness and knowledge, human and institutional capacity, and only to a lesser extent economic and financial barriers impede the deployment of this technology. The lack of long-term strategies to manage holistically agricultural soils in Moldova is the main barrier to the deployment of CA practices, as a simplistic approach is dominant at any level in the sector, from farmers to decision makers. Human and institutional capacity barriers further exacerbate such situation, lack of advanced knowledge of soil quality dynamics in the context of climate change is a main determinant of the continued decay of productive capacity of Moldovan arable lands. Policy and cadaster laws also limit the diffusion of long-term sustainability practices implementation since common short-term leasing concessions and fragmentation of land parcels are applied. Economic aspects do have a certain role to play as the switch to CA is seen as a likely constraint factor in terms of profitability, due to the need for additional and somewhat different equipment (like direct sowing machinery), while no premium price of offered by market operators purchasing conventional produce or cereals grown with CA measures.

| Wide category of barriers | Barriers within a category | Elements of barriers |
|---|---|---|
| Economic and financial | Limited access to financial resources | Low investment capacities of smallholders to purchase direct drilling machineries |
| | | Low short-term profitability, long payback period |
| Policy, legal and regulatory | Lack of a clear national strategy for the development of sustainable agriculture | Insufficient regulatory framework regarding sustainable agriculture |
| | Low degree of implementation of shadow prices policies, which internalize externalities caused by conventional agricultural practices | Lack of holistic policies that embrace complex issues with comprehensive solutions |
| Human competencies and capacity | Simplistic (reductionist) approach to farm management instead of systemic (holistic) approach | Lack of operator's recognition of impacts that agriculture has on the changing climate and lack of evidence that best agricultural practices can reverse the trend while still providing competitive yields and quality at harvest. |
| Institutional and organisational | Excessive fragmentation of the land | Cultural adversity towards associations, cooperatives, and unions of farmers |
| | | Low degree of consolidation of long-term leasing programmes, guarantees and support instruments for agricultural entrepreneurs |
| | Lack of a state monitoring system for land exploitation and soil quality (soil health) and related legislative measures | Lack of institutional recognition of the impacts of conventional practices on long-term sustainable utilization of land |
| | | Poor knowledge in the field of CA |
| | | Insufficient public extension services and insufficient interaction and cooperation with private landowners |

*Table 26: Complete list of barriers for Conservation Agriculture*

### 5.2.3 Economic and financial barriers

The procurement of CA-specific machinery, such as direct drillers, has a cost. These are factual, although not unbearable by large and established agriholding, this economic aspect becomes a barrier when coupled with the highly fragmented land mosaic for cereal and other annual crop production in Moldova. Individual smallholder farmers rarely have specialized machinery, whereas third party tillage operators do not see a sufficient demand for CA equipment able to justify their investments.

### 5.2.4 Non-financial barriers

More importantly, however, during SWG consultations with the NC it clearly emerged that non-financial barriers play the lion's role in the jungle of intricate reasons that impede the diffusion of Conservation Agriculture practices in cereals production. Excessive fragmentation of the land, lack of interdisciplinary research and educational programs, monitoring system for land exploitation and soil quality, and lack of a long-term strategy for agricultural development of the country are all institutional, capacity and policy barriers that hold back the diffusion of CA in the country.

Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The Problem Tree for the first prioritized technology for the cereals sector (conservation agriculture) is presented below, whereas the market mapping analysis follows.
The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 5.5).

Problem tree for Conservation Agriculture

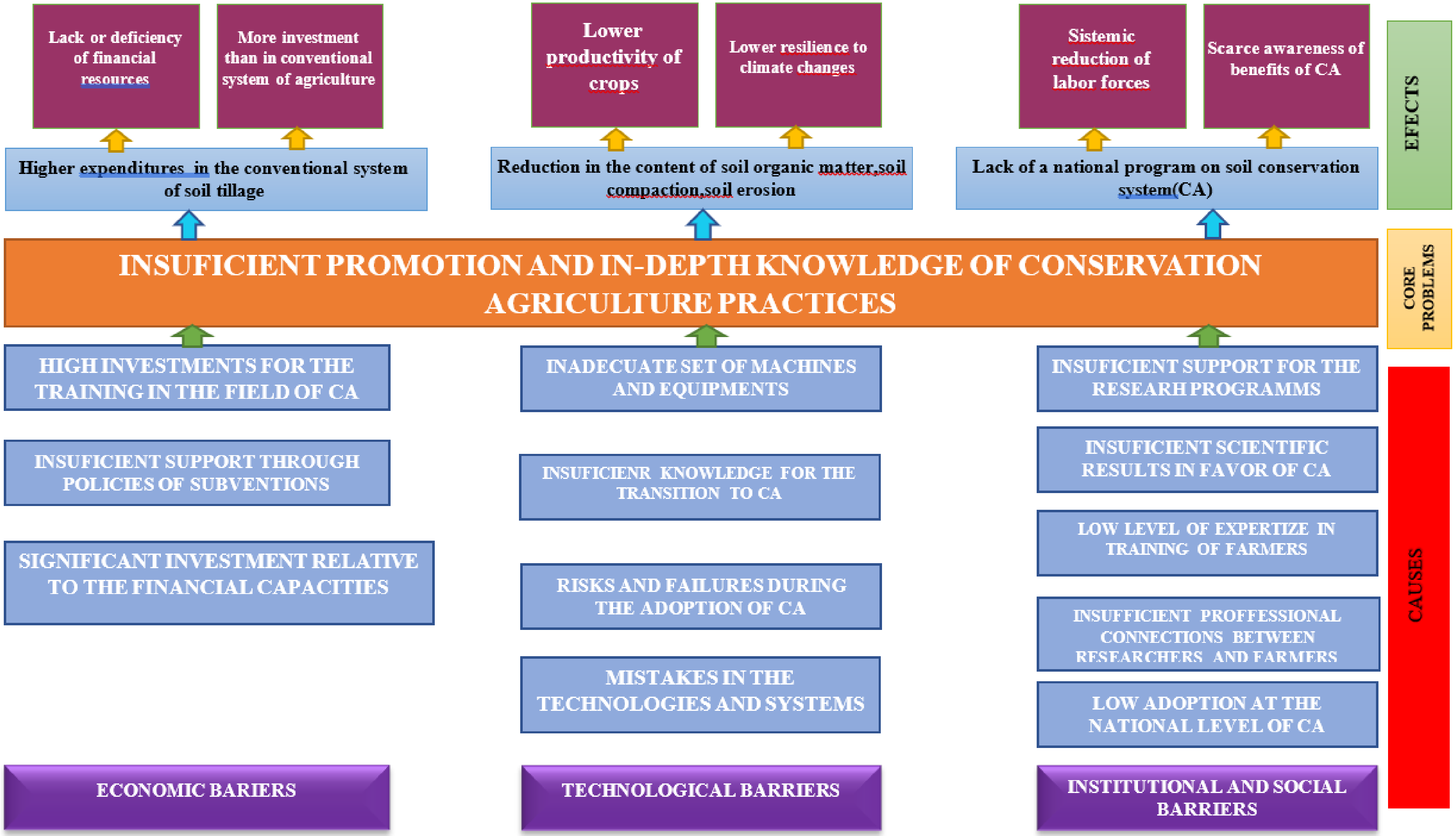


*Figure 22: Problem tree for conservation agriculture*

Market Mapping for Conservation Agriculture

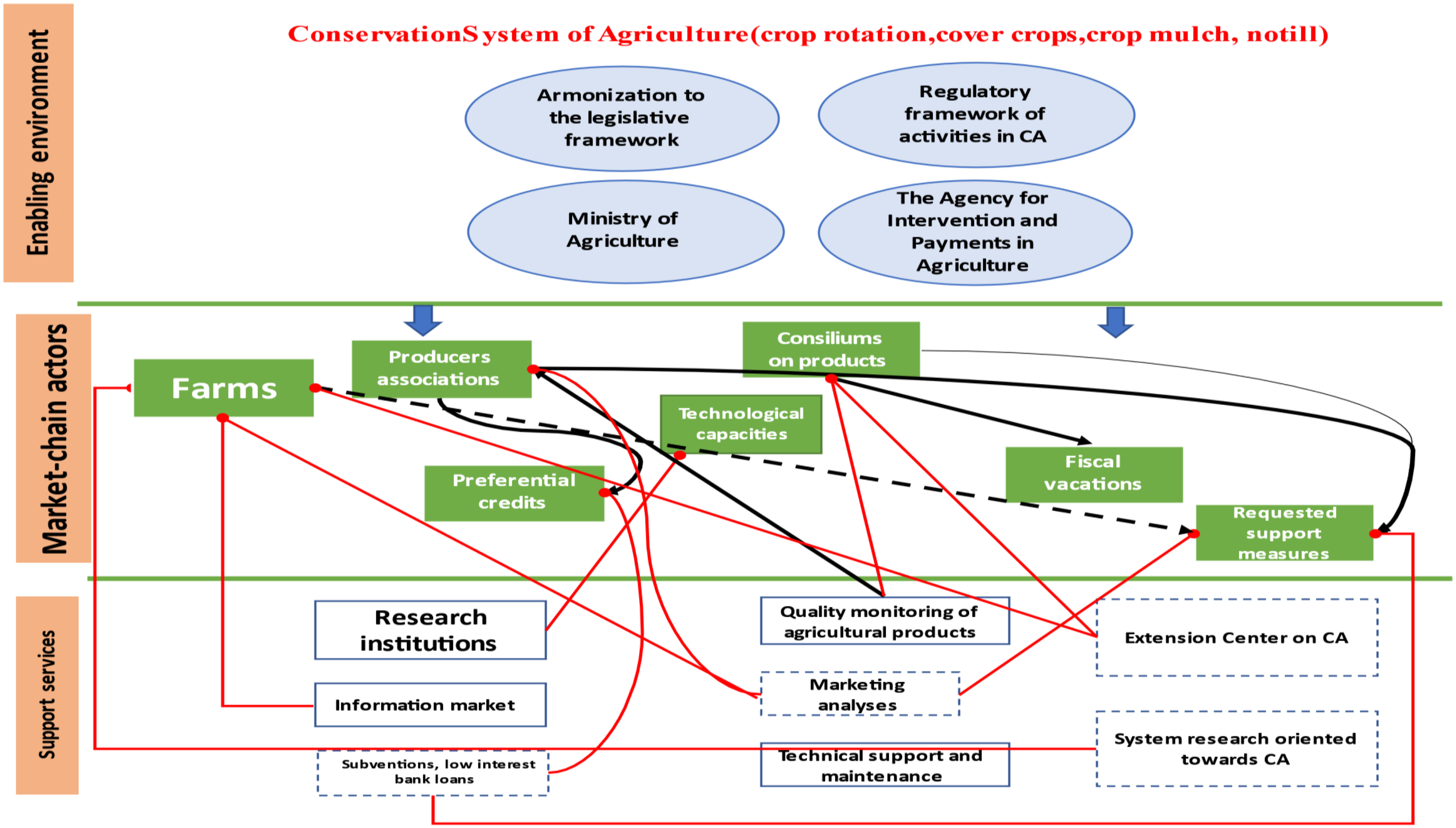


*Figure 23: Market Mapping for conservation agriculture*

## 5.3 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR CLIMATE-SMART ROTATIONS, WHEAT PREDECESSOR PROGRAMMES, AND ORGANIC FERTILIZER PRODUCTION FOR THE CEREALS SUB-SECTOR

### 5.3.1 General description of technology, technology status in Moldova, and market characteristics

Climate-smart crop rotations and cereals predecessor programmes which include mixtures of perennial legumes and grasses together with cover crops without mechanical disturbance of the soil provide a positive balance of soil organic matter. In addition to green manure however, supplementary application of farmyard manure is the best solution for maintaining SOC in soils and with them adapt the cereals sector of Moldova to climate change. Returning of alfalfa in crop rotation will allow to use nitrogen from the biological fixation, but in the same time the above ground biomass of alfalfa for fermentation and biogas production. This technology works in close cooperation with the production of mature manure in the livestock sector to maximise the return of organic carbon to soils for the production of cereals as well as for animal feed.

### 5.3.2 Identification of barriers for Climate-smart rotations, wheat predecessor programmes, and organic fertilizer production

During the era of the "green revolution" the long-term effects of the industrial inputs, especially synthetic fertilizers, from nonrenewable sources have been underestimated. Technological approaches to farm intensification led to severe environment and social consequences. Discrepancies in prices for inputs and agricultural products finally led to recognize the importance of agronomic practices including crop rotations, integrated nutrients management etc. In Steppe conditions the limiting factor for yield formations is soil moisture, which can't be replaced by extra amount of chemicals, plowing or irrigation. Predecessors for crops and measures for restoration of soil fertility are crucial for sustainable development of agriculture. The barriers that have been identified for the correct introduction of the paradigm shift in agricultural practices that accompany climate-smart rotations and organic fertilizer use, include therefore human capacity as well as long-lasting cultural behaviors. The assessment of the barriers has been carried out by the National Consultant and findings have been presented to the SWG, discussions on each barrier took place and a selection of the most representative and limiting ones is presented.

| Wide category of barriers | Barriers within a category | Elements of barriers |
|---|---|---|
| Economic and financial | Limited access to financial resources | Low investment capacities of smallholders to purchase necessary machineries |
| | | Low short-term profitability, long payback period |
| | | Large size machinery compared to average farm size in Moldova |
| Policy, legal and regulatory | Lack of a new strategy for the development of sustainable agriculture | The domination of reductionistic approach to farm intensification |
| | Negligence of the externalities caused by conventional agriculture | Lack of holistic policies |
| Human competencies and capacity | Misunderstanding of causes and consequences in agriculture.<br>The dominance of control methods instead of preventing methods | Lack of recognition of the importance of soil health in providing ecosystem and social services |
| Institutional and organizational | Excessive fragmentation of the land and imperfect methods of land leasing | Cultural adversity towards associations, cooperatives and unions of farmers |

| | | |
|---|---|---|
| | Lack of a state monitoring system for land exploitation and soil quality (soil health) and related legislative measures | Lack of the extension service |
| | | Poor understanding of CA principles |
| | | Lack of research and educational programs on agroecology |

*Table 27: Complete list of barriers for the climate-smart rotations and organic fertilizers technology*

### 5.3.3 Economic and financial barriers

Procurement of specific machinery is more problematic for small, highly fragmented individual farms. In the meantime, the production of equipment for small farms allows them to practice the innovative farming system capable to prevent many negative challenges faced by modern agriculture in Moldova. Small scale farms have little capital to invest in retrofitting their machinery pool. Using organic fertilizers instead of synthetic fertilizers requires different equipment (manure spreaders, biodigestate injection-seeders, etc) and different organization of farm activities year-round, when compared to traditional agricultural management techniques. These machinery is also hardly available in the small size necessary to the Moldovan average farm surface and this makes the investment even more difficult to justify for a farmer.

### 5.3.4 Non-financial barriers

The main obstacles in promoting organic fertilizers in the context of climate-smart rotations in Moldova are non-financial and include the excessive fragmentation of the land, the lack of interdisciplinary research and educational programs, the lack of the extension services, the lack of monitoring systems for land exploitation and soil quality, and the lack of a long-term strategy for the agricultural development of the country. The situation has worsened dramatically after the beginning of the military conflict between Russia and Ukraine. Problem trees have been used to assess the causes of the barriers impeding the implementation of each technology proposed and understand the impacts these have. The creation of the enabling environment for a specific technology to be implemented requires a second level of understanding of the issue: its localization along the value chain or reference system. Such identification is carried out via a market mapping exercise, in which all market actors surrounding the prioritized technology are mapped out and interactions among them identified. With the problem tree on the one hand and the market mapping on the other, it is possible to cross check which problems cause or effect can be mitigated by which action targeting what component of the market, including policymakers, technology retailers, loan institutions, scientific support actors. The Problem Tree for the first prioritized technology for the cereals sector (climate-smart rotations and organic fertilizers production) is presented below, whereas the market mapping analysis follows.
The result of the discussions of the SWG on the identified barriers, their causes and effects (Problem Tree) and their market mapping, led to the formulation of identified measures to mitigate the barriers (chapter 5.5).

Problem tree for climate-smart rotations and organic fertilizers technology

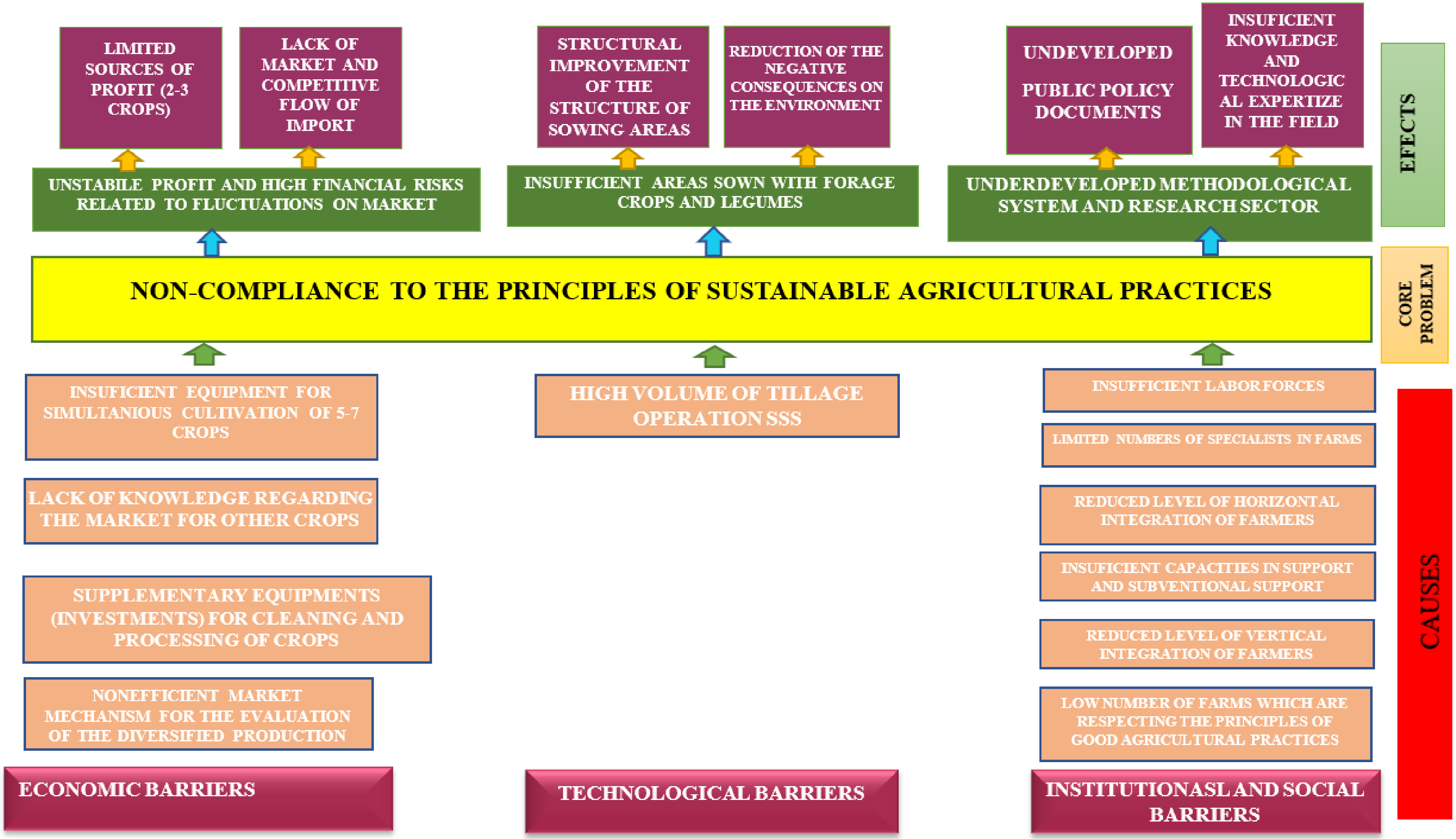


*Figure 24: Problem tree for climate-smart rotation and organic fertilizers use*

Market Mapping for Climate-smart rotations and organic fertilizers use

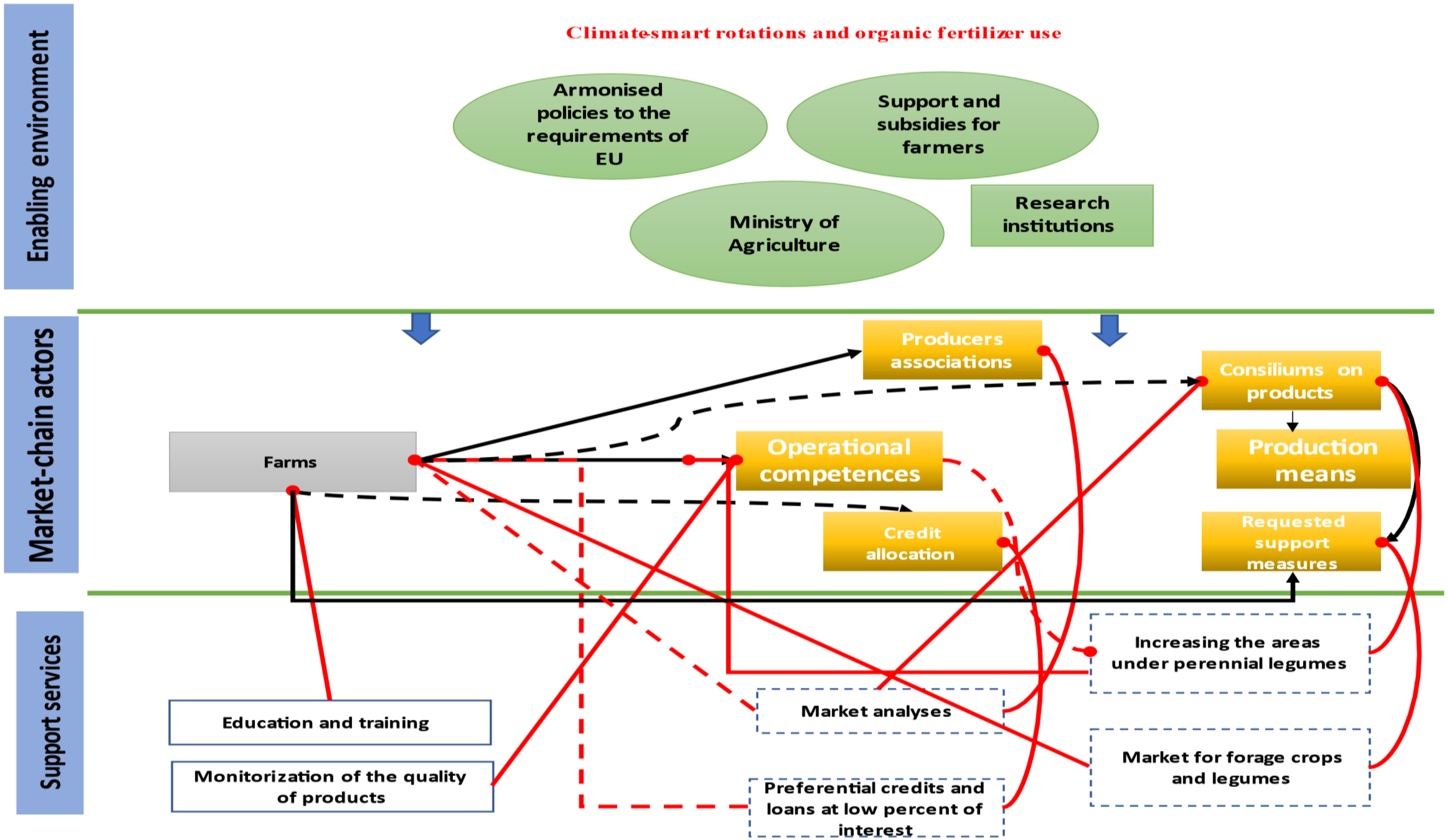


*Figure 25: Market Mapping for for climate-smart rotation and organic fertilizers use*

## 5.4 BARRIER ANALYSIS AND POSSIBLE ENABLING MEASURES FOR NETWORK OF SHELTER BELTS, AGROFORESTRY, AND PONDS FOR INCREASING THE HUMIDITY OF THE AIR FOR THE CEREALS SUB-SECTOR

### 5.4.1 General description of technology, technology status in Moldova, and market characteristics

Increased soil erosion as a consequence of climate change has been observed in Moldovan arable land. Most soils in the country have low levels of organic matter and have very thin topsoils. These topsoils take a very long time to form and can be eroded by even slight winds, when moisture content is reduced due to climate change. Shelterbelts can provide a relatively cheap and long-term option for reducing wind erosion on farms. Shelterbelts are used to decrease windspeed within the sheltered zone and reduce the erosion of fertile soils on agricultural land. This can increase the productivity of agricultural land by protecting this valuable topsoil and nutrients. Green shelter belts should cover about 5% of the surface of arable land. From the total area of arable land in the Republic of Moldova - 1,7 mln ha – the resulting shelter belts extension should be approximately 85 000 ha. Shelter belts should be 20 meters wide and present trees at a planting density of 2,5 m x 1 m. The main genus of trees apt to be used for shelter belts in Moldova include Quercus; Fraxinus; Tilia; Sofora; Acer; Alnus; and Seringa. The proposed practice involves the planning and implementation of a network of shelterbelts to counteract erosion and to work in synergy with other practices to fix carbon in the soil to maximise the efficacy of these efforts.

### 5.4.2 Identification of barriers for network of shelter belts, agroforestry, and ponds for increasing the humidity of the air

Shelter belts and ponds networks at the landscape level are a phenomenal aid in contributing to adapting agriculture and especially annual crops productions (like cereals but also oilseeds) to the changing climate. Unfortunately land privatization reforms in Moldova did not take into consideration the necessity of planning at the landscape level in order to prevent the negative effect of soil erosion and droughts. Fragmented private ownership on the land is one of the main barriers now for introducing ecosystem-based approaches like shelterbelts and pond mosaics for air moisture maintenance.

| Wide category of barriers | Barriers within a category | Elements of barriers |
|---|---|---|
| Economic and financial | Limited access to financial resources | Low investiment capacities of smallholders to purchase direct drilling machines and seedlings of trees |
| | | Low short-term profitability, long payback period |
| Policy, legal and regulatory | Neglecting the externalities caused by conventional agriculture | Lack of holistic approach regarding sustainable development of agriculture |
| | Lack of a long-term strategy for sustainable development | Insuficient regulatory framework concerning sustainable agriculture |
| Human competencies and capacity | Reductionistic approach instead of holistic approach to farm and land management | Lack of recognition of the importance of sustainable soil management for providing ecosystem and social services |
| Institutional and organisational | Excessive fragmentation of the land | Cultural adversity towards associations, cooperatives, and unions of farmers |
| | | Lack of incentives for long-term leasing programs |

| | | |
|---|---|---|
| | Lack of a state monitoring system for land exploitation and soil quality (soil health) and related legislative measures | Poor understanding of the principles of CA |
| | | Lack of the extension services |
| | | Lack of a research and educational program |

*Table 28: Complete list of barriers to the adoption of shelterbelts and ponds for increasing the humidity of the air*

### 5.4.3 Economic and financial barriers

As in previous cases, construction works and planting of the shelterbelts require considerable financial expenditures up-front, while long-term gains are attainable and thus it is difficult to obtain loans for such a type of investment, and when possible, interest rates are particularly unfavorable.

### 5.4.4 Non-financial barriers

The main non-financial barriers emerged from the assessment of barriers for the construction of shelterbelts and a system of ponds to maintain air moisture are shared with all other prioritized technologies for the sector and include the lack of interdisciplinary research and educational programs, the lack of a monitoring system for soil quality, and the lack of a strategy for sustainable agriculture intensification.

**Problem tree** for shelterbelts and ponds for increasing the humidity of the air

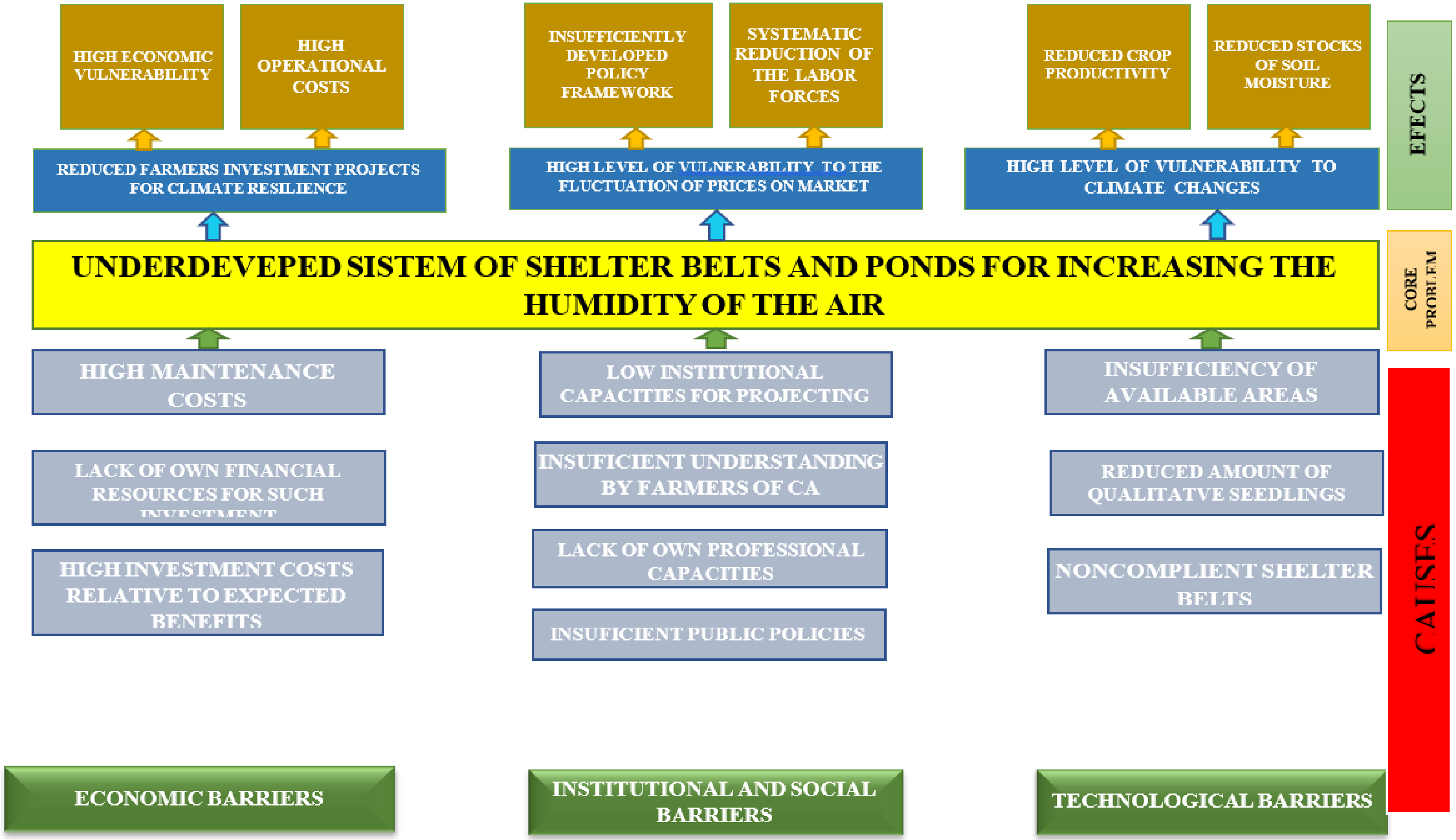


*Figure 26: Problem tree for network of shelterbelts and ponds to increase the humidity of the air*

Market mapping for shelterbelts and ponds for increasing the humidity of the air

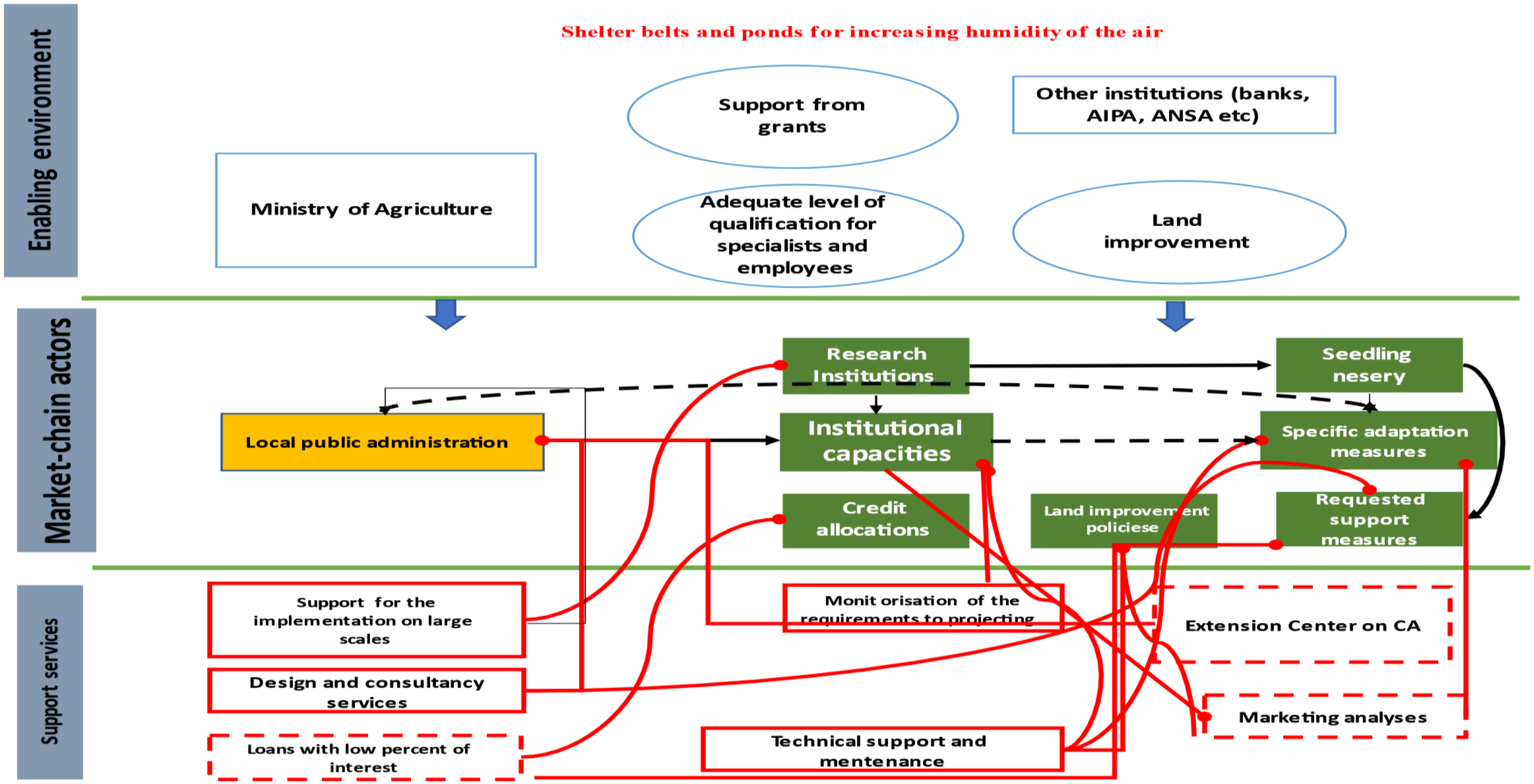


*Figure 27: Market Mapping for network of shelterbelts and ponds to increase the humidity of the air*

## 5.5 IDENTIFIED MEASURES:

In order to overcome common barriers and effectively tackle climate change in the cereals sector, it is essential to create an enabling framework that promotes adaptation action and sustainable development of this subsector of agriculture. A literature review and discussions with stakeholders, researchers and farmers, has shown that creating and strengthening the enabling environment to support technology depends on many key elements that are linked to the policy, regulatory and other institutional and organisational capacity-building arrangements. In order to understand better the implications of each barrier presented, the National Consultant prepared Problem Trees (Annex 1) and Market Mapping (Annex 2). On the basis of these two documents, the multistakeholder discussions could target specific and general measures to overcome the barriers, including the roles and the portion of the value chain where these actions should take place. The result of the exercise is a set of targeted and specific measures identified by the relevant members of the TNA team in consultation with the SWG. For ease of reference, the prioritized technologies are recapped and each identified measure is listed next to them.

1) **Identification of measures to remove barriers for conservation agriculture**
2) **Identification climate-smart rotations and organic fertilizers production**
3) **Identification of measures to remove barriers for the implementation of networks of shelterbelts, agroforestry and ponds**

The nature of the prioritized technologies for the cereals sub-sector is highly complementary. As a consequence, barriers have been identified for each technology and found to be crosscutting among all three. The identified measures therefore are presented jointly for all three technologies since the previous sub-chapters proved the tight intercorrelation among their defining barriers.

| ***1). Identification of measures to remove barriers for Conservation Agriculture*** | | |
|---|---|---|
| *Categories of barriers* | ***Barrier*** | ***Measures*** |
| *Economic and financial* | *Low investment capacities of smallholders to purchase direct drilling machineries* | *A state program should be adopted with incentives for farmers which are promoting sustainable and resilient farming systems capable to provide ecosystem and social services. A premium price system should be developed to translate such incentives into practical actions on the ground, so that farmers that can enroll in the program receive a premium for their products.* |
| | *Low short-term profitability, long payback period* | *Grant-based programs should be developed with international support to provide early off-takers with the initial capital necessary to switch their equipment pool to a CA suitable set of machinery.* |
| *Institutional and organizational* | *Excessive fragmentation of the land* | *Consolidation of land use should be done in accordance with the landscape particularities of the territory in order to prevent degradation of soils in the conditions of regular manifestation of wind and water erosions.* |

| | | |
|---|---|---|
| | | *The duration of land leasing should equal the duration of one crop rotation – rather than equal the length of a growing season – with a higher diversity of crops, including perennial herbaceous crops, which have contributed to the formation of chernozem soils.* |
| | *Lack of a state monitoring system for land exploitation and soil quality (soil health) and related legislative measures* | *A necessary measure to remove this barrier is the formation of an interdepartmental state body responsible for sustainable land management in accordance with agroecology principles, irrespective of the size and forms of land ownership. Data received by this agency should be used as one of the providing subsidies to farmers, through a system of credits through which premium prices are paid as an incentive scheme. Only farmers verified to abide to such sustainability principles can provide ecosystem and social services, and will be rewarded according to their contribution in terms of land under CA practices, as well as on a system that evaluates ancillary and compensation-based measures, like the integration of multiple best agricultural practices. In this respect is crucial to promote soil Resolution and the Law of Soil Quality, but also reforms in the way biodiversity impacts are considered in the country.* |
| *Policy, legal and regulatory* | *Lack of a clear national strategy for the development of sustainable agriculture* | *A regulatory framework regarding sustainable agriculture should be developed learning lessons from neighboring country's regulations, in turn inspired by European Union Directives and instruments together with a set of holistic policies that embrace complex issues with comprehensive solutions.* |
| | *Low degree of implementation of shadow prices policies, which internalize externalities caused by conventional agricultural practices* | *Develop amendments to supportive policies that subsidize conventional agriculture to incorporate externalities as a limiting factor in obtaining subsidies and divert those subsidies to farmers who employ CA techniques.* |
| *Human competences* | *Simplistic, reductionist approach to farm management* | *The acceptance of a new vision of agro-ecological agricultural intensification, instead of the dominant concept of green revolution based on using nonrenewable sources of energy and their derivates for increasing productivity and profit. The latter is proving unable to provide a sustainable and resilient agriculture as it has taken natural resources endless availability for granted, while neglecting the ecosystem and social services provided by natural and agrifood ecosystems. Such acceptance can be mediated by systemic capacity building programs that encompass aspects of sustainability at any level of the cereals value chain but that are primarily targeted at conserving the characteristics of soils to enhance their resilience against climate change.* |

*Table 29: Identified measures to remove barriers for Conservation Agriculture*

| | | |
|---|---|---|
| ***2). Identification of measures to remove barriers for Climate-Smart rotations and organic fertilizers use*** | | |
| *Categories of barriers* | ***Barrier*** | ***Measures*** |
| *Economic and financial* | *Low investment capacities of smallholders to purchase direct drilling machineries* | *A state program should be adopted with incentives for farmers which are promoting sustainable and resilient farming systems capable to provide ecosystem and social services. A premium price system should be developed to translate such incentives into practical actions on the ground, so that farmers that can enroll in the program receive a premium for their products.* |
| | *Low short-term profitability, long payback period* | *Grant-based programs should be developed with international support to provide early off-takers with the initial capital necessary to switch their equipment pool to a CA suitable set of machinery.* |
| *Institutional and organizational* | *Excessive fragmentation of the land* | *Consolidation of land use should be done in accordance with the landscape particularities of the territory in order to prevent degradation of soils in the conditions of regular manifestation of wind and water erosions. The duration of land leasing should equal the duration of one crop rotation – rather than equal the length of a growing season – with a higher diversity of crops, including perennial herbaceous crops, which have contributed to the formation of chernozem soils.* |
| | *Lack of a state monitoring system for land exploitation and soil quality (soil health) and related legislative measures* | *A necessary measure to remove this barrier is the formation of an interdepartmental state body responsible for sustainable land management in accordance with agroecology principles, irrespective of the size and forms of land ownership. Data received by this agency should be used as one of the providing subsidies to farmers, through a system of credits through which premium prices are paid as an incentive scheme. Only farmers verified to abide to such sustainability principles can provide ecosystem and social services, and will be rewarded according to their contribution in terms of land under CA practices, as well as on a system that evaluates ancillary and compensation-based measures, like the integration of multiple best agricultural practices. In this respect is crucial to promote soil Resolution and the Law of Soil Quality, but also reforms in the way biodiversity impacts are considered in the country.* |
| *Policy, legal and regulatory* | *Lack of a clear national strategy for the development of sustainable agriculture* | *A regulatory framework regarding sustainable agriculture should be developed learning lessons from neighboring country's regulations, in turn inspired by European Union Directives and instruments together with a set of holistic policies that embrace complex issues with comprehensive solutions.* |

| | | |
|---|---|---|
| | *Low degree of implementation of shadow prices policies, which internalize externalities caused by conventional agricultural practices* | *Develop amendments to supportive policies that subsidize conventional agriculture to incorporate externalities as a limiting factor in obtaining subsidies and divert those subsidies to farmers who employ CA techniques.* |
| *Human competences* | *Simplistic, reductionist approach to farm management* | *The acceptance of a new vision of agro-ecological agricultural intensification, instead of the dominant concept of green revolution based on using nonrenewable sources of energy and their derivates for increasing productivity and profit. The latter is proving unable to provide a sustainable and resilient agriculture as it has taken natural resources endless availability for granted, while neglecting the ecosystem and social services provided by natural and agrifood ecosystems. Such acceptance can be mediated by systemic capacity building programs that encompass aspects of sustainability at any level of the cereals value chain but that are primarily targeted at conserving the characteristics of soils to enhance their resilience against climate change.* |

*Table 30: Identified measures to remove barriers for Climate-Smart rotations and organic fertilizers use*

| | | |
|---|---|---|
| ***3). Identification of measures to remove barriers for network of shelterbelts and ponds to increase the humidity of the air*** | | |
| *Categories of barriers* | ***Barrier*** | ***Measures*** |
| *Economic and financial* | *Low investment capacities of smallholders to purchase direct drilling machineries* | *A state program should be adopted with incentives for farmers which are promoting sustainable and resilient farming systems capable to provide ecosystem and social services. A premium price system should be developed to translate such incentives into practical actions on the ground, so that farmers that can enroll in the program receive a premium for their products.* |
| | *Low short-term profitability, long payback period* | *Grant-based programs should be developed with international support to provide early off-takers with the initial capital necessary to switch their equipment pool to a CA suitable set of machinery.* |
| *Institutional and organizational* | *Excessive fragmentation of the land* | *Consolidation of land use should be done in accordance with the landscape particularities of the territory in order to prevent degradation of soils in the conditions of regular manifestation of wind and water erosions. The duration of land leasing should equal the duration of one crop rotation – rather than equal the length of* |

| | | |
|---|---|---|
| | | *a growing season – with a higher diversity of crops, including perennial herbaceous crops, which have contributed to the formation of chernozem soils.* |
| | *Lack of a state monitoring system for land exploitation and soil quality (soil health) and related legislative measures* | *A necessary measure to remove this barrier is the formation of an interdepartmental state body responsible for sustainable land management in accordance with agroecology principles, irrespective of the size and forms of land ownership. Data received by this agency should be used as one of the providing subsidies to farmers, through a system of credits through which premium prices are paid as an incentive scheme. Only farmers verified to abide to such sustainability principles can provide ecosystem and social services, and will be rewarded according to their contribution in terms of land under CA practices, as well as on a system that evaluates ancillary and compensation-based measures, like the integration of multiple best agricultural practices. In this respect is crucial to promote soil Resolution and the Law of Soil Quality, but also reforms in the way biodiversity impacts are considered in the country.* |
| *Policy, legal and regulatory* | *Lack of a clear national strategy for the development of sustainable agriculture* | *A regulatory framework regarding sustainable agriculture should be developed learning lessons from neighboring country's regulations, in turn inspired by European Union Directives and instruments together with a set of holistic policies that embrace complex issues with comprehensive solutions.* |
| | *Neglecting the externalities caused by conventional agriculture* | *Develop amendments to supportive policies that subsidize conventional agriculture to incorporate externalities as a limiting factor in obtaining subsidies and divert those subsidies to farmers who employ CA techniques.* |
| *Human competences* | *Simplistic, reductionist approach to farm management* | *The acceptance of a new vision of agro-ecological agricultural intensification, instead of the dominant concept of green revolution based on using nonrenewable sources of energy and their derivates for increasing productivity and profit. The latter is proving unable to provide a sustainable and resilient agriculture as it has taken natural resources endless availability for granted, while neglecting the ecosystem and social services provided by natural and agrifood ecosystems. Such acceptance can be mediated by systemic capacity building programs that encompass aspects of sustainability at any level of the cereals value chain but that are primarily targeted at conserving the characteristics of soils to enhance their resilience against climate change.* |

*Table 31: Identified measures to remove barriers for network of shelterbelts and ponds to increase the humidity of the air*

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# TECHNOLOGY ACTION PLANS and PROJECT IDEAS REPORT (3)/TAP


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# EXECUTIVE SUMMARY

## Background and Methodology

The Technology Needs Assessment (TNA) in Moldova, aligned with the UNFCCC framework and technology mechanism, prioritizes climate adaptation technologies for agriculture sub-sectors, including aquaculture, livestock, horticulture, and cereals. Through the process key barriers to adoption of these technologies were identified, including economic, financial, policy, regulatory, institutional, and technical , alongside limited human capacity and insufficient knowledge transfer. It was emphasised that farmers face difficulties accessing loans, policy support, and reliable information, compounded by institutional weaknesses. Economic barriers require incentives and low-interest loans, while policy gaps demand targeted sectoral policies and stronger regulatory enforcement. Building human capacity involves promoting knowledge transfer and education, and addressing institutional weaknesses.

The **Technology Action Plan (TAP**) methodology defines ambitions, identifies barriers, and outlines actions and activities for each prioritized technology. Short-term ambitions (by 2030) focus on demonstrating technology adoption and creating an enabling environment, while long-term ambitions (by 2050) target national scale-up to align with policies like NAPs and NDCs. TAP includes stakeholder mapping, timelines, financial estimates, and capacity-building needs, assessed at both demonstration and full-scale implementation levels. The TAPs establishe a foundation for a climate-resilient agricultural sector in Moldova, turning challenges into opportunities and aligning with global climate goals. With strategic stakeholder engagement, effective management, and capacity building, Moldova can achieve a sustainable and resilient agricultural future.

**Aquaculture.** Moldova's abundant water resources face challenges in aquaculture development, worsened by climate change. The 1-stTechnology Action Plan (TAP) targets unlocking aquaculture's potential for local economies and biodiversity. It proposes transforming 37 ponds (6,770 ha) into polyculture systems, increasing fish species from 3 to 6 and boosting annual harvests from 3,720 to 4,670 tons by introducing pikeperch, European wells, and European bream. Efforts focus on governance, technical support, capacity building, and awareness campaigns for climate-resilient aquaculture. With $2.5M funding over 60 months, key stakeholders like the Ministry of Agriculture (MAFI) and the National Association of Aquaculture Producers lead implementation. Risks, including political shifts and cost volatility, are mitigated through stakeholder collaboration and contingency plans.
The 2-nd TAP addresses water flow management in aquaculture ponds. A demonstration in 30 ponds aims to increase water volume by 20-25%, with full-scale implementation covering 2,400 ponds (~400,000 ha). A National Water Flow Management Program will oversee mapping, desilting, and drainage activities, leveraging extracted materials for revenue. Estimated at $80.9M over 72 months, the TAP emphasizes multi-stakeholder participation to mitigate medium risks like material costs and climate events.
The 3-d TAP focuses on establishing a Fish Protection System (FPS) for safe and sustainable fish production. Covering 6,000 water bodies and 1,000 fish farms, the FPS involves nationwide surveys and real-time monitoring of fish health and water quality. With $2.93M funding over 48 months, the TAP prioritizes capacity building and participatory policymaking led by FAO, MAFI, and fish farming associations. Risks, such as resource constraints, are addressed through contingency measures like early planning and secure funding.

**Livestock**. Moldova’s livestock sector faces declining production, exacerbated by climate change and limited investments. The 1-st TAP aims to enhance feed resilience through irrigation. A demonstration on 13 farms in northern Moldova will irrigate 15,000 hectares, increasing yields for alfalfa and maize silage. Full-scale implementation covers 100 farms, with $14.9M over 54 months targeting Sustainable Irrigation Programs and capacity building. Risks, including political shifts and cost fluctuations, are mitigated by early procurement and insurance.

The 2-nd TAP focuses on organic fertilizer production. At the demonstration level, five farms will produce 5,500 tons of composted manure, while full-scale implementation targets 100 farms, producing 941,000 tons annually. With $2.1M funding over 54 months, activities include constructing manure platforms and logistics planning. Policymaking and farmer training ensure effective implementation, with low risks mitigated by proactive measures.

The 3-d TAP addresses animal welfare under climate change by retrofitting and constructing shelters for livestock. Demonstration projects include modernizing six farms across Moldova, focusing on poultry and dairy production during heatwaves. Full-scale implementation targets 100 farms with $7M over 54 months. Activities include creating national guidelines and capacity-building programs. Risks are low, ensuring a comprehensive approach to sustainable livestock management.

**Horticulture.** Horticulture, vital to Moldova's economy, faces reduced yields due to climate change. The 1-st TAP prioritizes deploying 25 high-tech greenhouses with advanced climate controls. These structures will enhance year-round production for crops like tomatoes, cucumbers, and strawberries. The $11.5M TAP spans 48 months, emphasizing policymaking, capacity building, and women's empowerment in agriculture. Risks, including political instability, are mitigated through strategic amendments and international support.

The 2-nd TAP focuses on modern irrigation systems for horticulture. A demonstration on four farms will restore yields, with full-scale implementation covering 30 farms and 3,000 hectares. The $11.8M TAP addresses water management barriers through infrastructure development, capacity building, and forming Water Management Consortia. Risks include price volatility and technical challenges, mitigated by early procurement and policy integration.

The 3-rd TAP proposes constructing 50 hydroponic greenhouses in disadvantaged regions. With $16.4M funding, the initiative targets year-round vegetable production, using renewable energy systems for efficiency. Capacity building and policy adjustments ensure implementation, with risks managed through precise amendments and international collaboration. The TAP envisions a climate-resilient horticulture sector through technology, gender inclusion, and sustainable practices.

**Cereals.** Wheat, barley, and maize, essential to Moldova's food security, are vulnerable to climate change and soil degradation. The 1st TAP promotes Conservation Agriculture (CA) to enhance resilience. Demonstration projects on 20 farms (58,000 ha) aim to increase yields by 20%. Full-scale implementation targets 340,000 hectares, producing 1.56M tons annually. With $60M funding, the TAP focuses on machinery access, capacity building, and policy support. Risks like financial volatility are mitigated by stable partnerships with international banks.

The 2-nd TAP addresses climate-smart crop rotations and organic fertilizer use. Demonstration projects on two farms (500 ha each) aim to improve soil quality and yields for winter wheat, maize, and sunflower. Full-scale implementation targets 200 farms annually, with $40.3M funding for policies, training, and infrastructure. Risks include climatic variability and fertilizer market dynamics, addressed through supply agreements and robust financial mechanisms.

The 3-rd TAP combats soil erosion with shelterbelts and ponds. Covering 170,000 ha, the plan includes mapping high-risk areas, developing nurseries, and deploying erosion control measures. With $96.2M funding over 12 y., TAP emphasizes collaboration among ministries, research institutions, and farmers. Risks like extended timelines and political shifts are mitigated by public funding and stakeholder engagement. The TAP aims to improve soil health, biodiversity, and water resources, ensuring sustainable cereal production.

These comprehensive TAPs across aquaculture, livestock, horticulture, and cereals align Moldova's agricultural sector with climate resilience goals. By addressing barriers, leveraging advanced technologies, and fostering collaboration among stakeholders, these plans lay the groundwork for a sustainable and productive future.

This report includes four annexes with summary Gantt charts for each proposed TAP under the relevant sub-sectors of agriculture

# CHAPTER – 1 INTRODUCTION

## 1.1 Background

The Technology Needs Assessment (TNA) is one of the foremost critical steps towards identifying and assessing climate change adaptation challenges within the United Nations Framework Convention on Climate Change's (UNFCCC) technology mechanism on technology development and transfer. For a climate-vulnerable country such as Moldova, the TNA has an added significance for aligning its adaptation needs and opportunities with goals and objectives of its sustainable development programs.

In Moldova, the project on Technology Needs Assessment (TNA) was initiated in collaboration with FAO, as a part of the Ag SAP project funded by the Green Climate Fund. The purpose of the TNA project is to assist Moldova in the identification of its priority adaptation needs for specific sub-sectors of agriculture, followed by the prioritization of technologies in these sub-sectors. This will form the basis for development of environmentally sound technology projects and programs to facilitate transfer and diffusion of these priority technologies. The main objectives of the project are to:

1. Identify and prioritize, through country driven participatory processes, the technologies that can contribute to adaptation goals of Moldovan's agriculture sector.
2. Identify barriers hindering the acquisition, deployment and diffusion of prioritized technologies; and
3. Develop Technology Action Plans (TAP) specifying activities and enabling framework to overcome the barriers and facilitate the transfer, adoption and diffusion of selected technologies in the priority areas with national relevance.

The TNA project's implementation is composed of three stages (see Figure 1 below), as per UNEP-DTU methodology. In the first stage four agriculture sub-sectors have been identified as most economically important and vulnerable to climate change. Following multi-stakeholder consultations with experts and representatives of local and central government, a technology prioritization exercise highlighted the three most promising technologies for each sub-sector considered. The four sub-sectors considered are:

v. Aquaculture
vi. Livestock
vii. Horticulture
viii. Cereals

The prioritized technologies identified through the TNA process for the **aquaculture** sub-sector of Moldova are:

1) **Technology of complex capitalization of the trophic potential through interspecific polyculture.**
2) **An intervention to increase the water flow in the ponds used for growing fish in polyculture according to the continuous technology.**
3) **Fish protection system and ensuring food security in the conditions of climate change**

Likewise, priority adaptation technologies identified for the **livestock** sub-sector o are:

1) **Increase of areas under irrigation for the production of feed**
2) **Construction of platforms for the accumulation and storage of manure**

3) **Ensuring adequate conditions for animal welfare by optimizing the construction requirements of sheds and stables**

The prioritization exercise for the horticulture sector ranked the following technologies as the top three for Moldova:

1) **High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency**
2) **Modern irrigation systems: maximization of water and energy efficiency (e.g. renewable energy powered drip irrigation systems, etc.)**
3) **Hydroponics with recyclable solutions**

Similarly, concerning the **Cereals** sub-sector, the following technologies and practices have been prioritized:

1) **Conservation Agriculture System (crop rotations, No-till, cover crops, soil mulching)**
2) **Climate-smart rotations and using of predecessors capable to prevent problems**
3) **Climate-smart rotation in the frame of a network of shelter belts and ponds for increasing the humidity of the air**

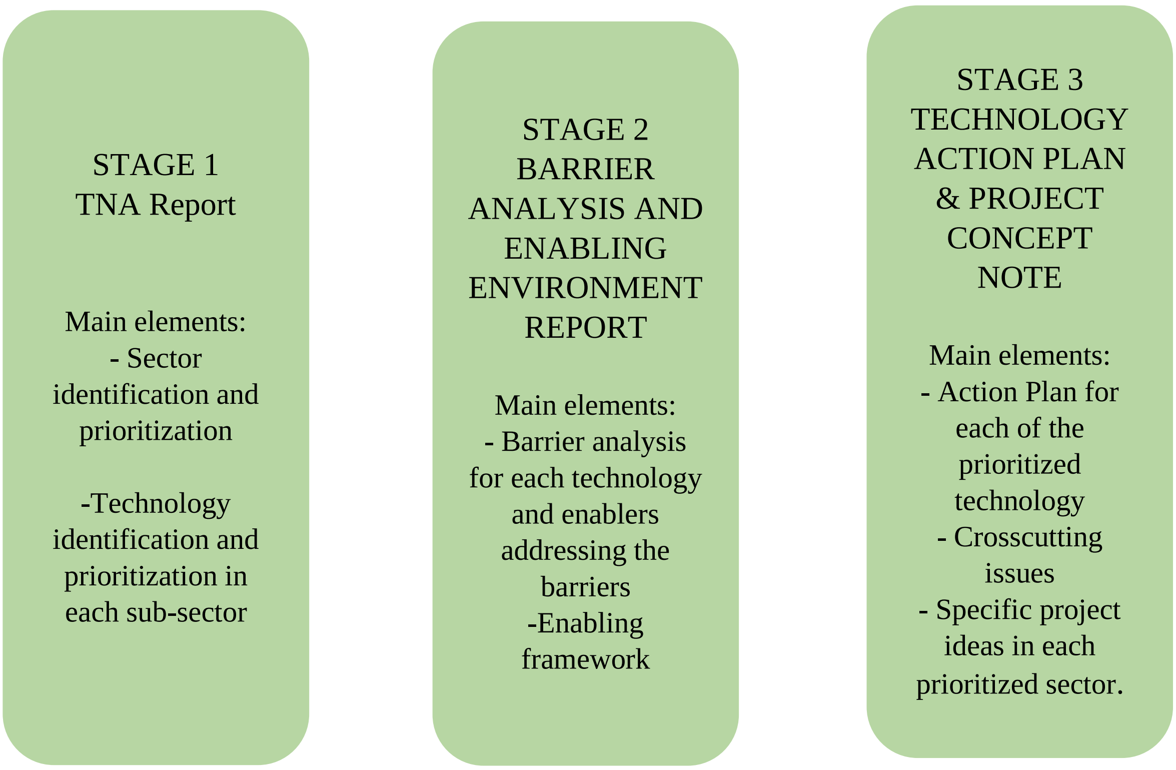


*Figure 1: The three stages of the TNA process and how it was implemented in Moldova*

Stage 1 and Stage 2 of the TNA process have been completed and reports detailing results of both processes are available. This report focuses instead on the action plans for the implementation of each prioritized technology. The report presents the starting point for the action plan development represented by the barriers identified during Stage 2 of this work and proceeds with analyzing each necessary action with its activities to remove specific barriers, quantifies costs and possible benefits and it lays down possible risks and associated contingencies.

## 1.2 General and common barriers for the implementation of prioritized technologies

The results of the Barrier Analysis highlighted general as well as technology-specific reasons holding farmers from adopting climate change adaptation technologies in Moldova. In most cases, main barriers are economic and financial ones particularly related to the initial capital expenditures necessary to procure technologies often characterized by relatively high up-front investments. Farmers have difficulties to cope with this critical challenge, as adoption of a sustainable technology requires a change in the equipment or upgrading existing tools and machineries. Also access to loans is difficult, especially for smallholders, and the high interest rates applied by commercial banks in the country are an important element of economic barriers. Measures addressing these economic and financial barriers consist of considering incentives to attract investments in climate change technologies and involving development banks that can apply lower interest rates, which would considerably increase the access of farmers to funding for climate-resilient technologies. Concerning policy and regulatory barriers, almost all technologies are affected by lack of specific sub-sector development policies, supportive instruments such as incentives, and where the latter are available, there is lack of sufficient regulatory enforcement and monitoring to ensure compliance. Human capacity is another common issue that hinders the uptake of virtually all proposed technologies. Lack of qualified workforce, low wages paid in the agriculture sector and the general decline of agricultural activities as a contributor to GDP make it unattractive for most qualified workers to apply themselves to any of the key sub-sectors analyzed. Linked to policy barriers and human capacity barriers, are a set of barriers belonging to the group of Institutional and Organizational barriers. A generic barrier of institutional capacity of the whole agriculture sector of Moldova is the weak understanding of the importance of climate change impacts and the consequent low consideration of climate change risks for the agriculture sector. A shortsighted conventional production approach prevails among farmers and agricultural institutions in the country and socio-cultural and behavioral barriers are relevant. Knowledge transfer to the farm community and to those working closely with farmers is essential to enable adaptive action. Extension services are poorly funded and their capacity to transfer knowledge is limited by their number and motivation. Academia and researchers working in the field of agriculture are also underfunded in Moldova and little room is given to their role as conveyors of knowledge to users. As a result of the low interconnection between research, academia, extension services and agricultural operators, farmers as well as rural entrepreneurs, there are profound technology transfer gaps in the country. Most smallholders practice agriculture on a secondary level of importance in their family budget, and although they make up a large share of total production quantity per sub-sector, they are mostly unaware of innovative actions and their justification as adaptation measures. As a result, there is lack of information and knowledge about the potential benefits of climate technologies, which are insufficiently promoted and explained to farmers. Technologies also have technical barriers to be overcome, these are clearly specific to each prioritized practice, but general remarks made during the stakeholder consultations highlighted the need for binding to local maintenance operators the procurement of the technologies and the initial support to farmers and operators.

## 1.3 Technology Action Plan methodology

Preparing a complete and balanced TAP is a step-by-step process that begins with the output of earlier TNA steps. It requires the participation and buy-in of key stakeholders, a clear process for moving forward, and methodical commitment by a TAP team (ideally a sectoral or technology-specific working group) to various quantitative and narrative chores.

According to the UNFCCC and UNEP-DTU's Guidance Report on the preparation of a Technology Action Plan[7], the first task to complete the TAP is to describe the scale and context for technology deployment and diffusion, referred to as the 'ambition'. Secondly, it is necessary to summarise the barriers to deployment and diffusion for each technology, as well as possible measures for addressing these. These first two aspects of a TAP should draw on the work completed in the previous steps of the TNA process (see Figure 1). For a TAP, the previously identified measures are turned into a list of Actions, which are then expanded into a set of specific activities, or the specific things to be done to realise an Action. Once the activities are defined, the relevant stakeholders, those who will be directly involved in the implementation of the TAP, should be identified. Here, it is also important to estimate a timeframe for each activity. Following the identification of stakeholders, the TAP should estimate the human and financial resources needed for each activity, including the type of financing required and potential sources of funding. The TAP should include a management plan for reporting, risk management, corrective measures, and contingency plans.

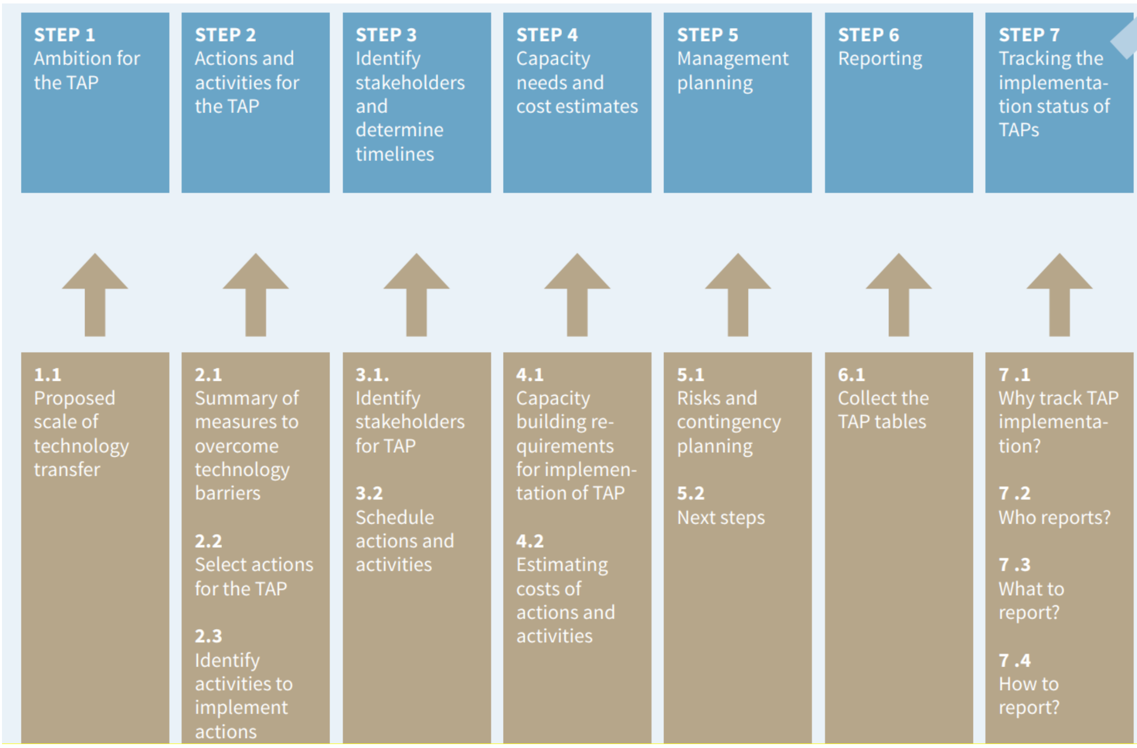


*Figure 2: Overview of the composition of a TAP*

The **Ambition** is the envisaged scale of implementation of the prioritised technology. The ambitions can be separated between the long-term vision for the technology, e.g., a vision of zero carbon electricity by 2050, or meeting a specific policy target for the sector, and the need to differentiate between short- and medium-term ambitions. In either case, and wherever possible and appropriate, TAPs should aim to establish or support efforts to rollout a given technology in a self-sustaining manner, e.g. by creating markets, ensuring replicability, securing a reliable funding source for operation and maintenance, etc. In the case of this TAP for the Moldovan agricultural sector, the ambition is defined for two levels, namely short-term and long-term. The short-term ambition is the level of uptake of a technology by year 2030 and is represented by the minimum scale that can demonstrate the technology at a representative level and that can set the basis for the creation of an enabling environment, market and value chain development. The long-term ambition is to

[7] tap-guidance-2020-4.pdf (unepccc.org)

scale-up and expand at the national level by 2050 the implementation of the technologies in the relevant sectors, and to contribute to specific national and sectoral policies including NAPs and NDCs.
Based on the assessment carried out during the TNA prioritization exercise and the BAEF analysis, a list of **Actions** and related **Activities** is produced for each technology to be implemented. Clearly, the Actions target specific identified measures to remove barriers for a specific technology and vary according to the scale, or ambition, of the TAP. Although all the identified measures can be considered important, as these were already prioritized during the BAEF stage of the TNA, it is recommended to select only the most important ones for the TAP and in this specific case, to discern among short-term implementation actions and long-term scale-up actions.
In the context of the TAP, **stakeholder mapping and identification**, as well as the contingent attribution of roles for activities' implementation to the aforementioned actors, is key to a successful planning and consequently to the effective deployment of the prioritized technologies. Each activity may involve multiple participants or interested stakeholders. Effective management requires that one institution (e.g. MAFI) and, preferably, a set of individuals within the institution have primary responsibility for implementing a given activity. It is important that those charged with driving forward the implementation feel sufficiently committed to the success of the TAP. Secondary responsibilities also can be shared for a specific activity, for instance when a financial component is involved in a technical activity (e.g. deployment of technology installations on farms), the primary technical unit or stakeholder should be accompanied by a secondary responsible stakeholders (e.g. Ministry of Finance, or a local bank, etc.) with responsibilities as donor relation focal point.
Determining **timelines** for implementation is another key methodological step in the definition of the TAP. At various levels of detail, the definition of timelines can take the shape of a broad estimate of the time required for the implementation of Actions and their Activities, or it can detail and correlate timelines with specific deliverables and components of the work, by means of a Gantt chart or similarly visual display aid. Activities can be sequential or implemented at the same time, and disaggregated into planning phase and actual implementation phase, to provide finer detail to the TAP timeline.
Determining **capacity building needs** is another key component of a TAP. Once Actions and Activities required to implement a certain technology have been laid out, the needs for capacity development to support the implementation of the technology will be evident to the TNA team. Capacity building is such an important step in the TAP that often it is a cross cutting action, with several activities built into each main action group. As part of this human capacity building it is important to also estimate, fund and provide hardware and software such as computers, project management programmes, estimating spread-sheets and budgeting templates. In addition, it is necessary to provide expert support services to ensure that the relevant skills are applied in the planning and implementation of specific Actions and Activities.
After Actions and Activities, timelines, capacity needs have been assessed, it is necessary to estimate **the costs and funding needs** of the specific Actions and Activities. There are two types of Actions and Activities costs estimates: 1) the estimates necessary to prepare a full programme for the diffusion of a prioritized technology (demonstration level); and 2) cost estimates leading to the actual full scale implementation. The first type relies more heavily on international and other forms of public funding (at least to an extent), and serve to demonstrate that a certain technology is economically sustainable at scale. As a consequence, the level of accuracy of type 1) estimates is going to be more accurate in this report than those of type 2), which would be better informed after the demonstration of technologies has been completed.

# CHAPTER – 2 THE AQUACULTURE SUB-SECTOR

## 2.1 Technology Action Plan for the Aquaculture sector

### 2.1.1 Sector overview

The Republic of Moldova is rich in retained water resources. Comparing the size of the country and the total area of water reservoirs and ponds, Moldova has the largest resources of artificial waterbodies among the countries of Central and Eastern Europe. The water reservoirs and ponds are owned by public local authorities, irrigation associations, the State and private owners. However, despite the large availability of waterbodies, aquaculture remains below its potential. The established aquaculture farms may face growing challenges to express their potential as expansion and even maintenance of the current levels is being hindered by impacts of climate change. These issues apply also to fishery, both commercial and recreational. The disappearance of sturgeons and other valuable species has been influenced by human factors as the conditions of breeding, feeding and growth of fishes have changed considerably. These consist mainly in the use of water resources for irrigation and the pollution of waterbodies with untreated wastewater of agricultural and industrial enterprises discharged pesticides, herbicides and other chemicals into the remaining waterbodies. But are the impacts of climate change that pose the greatest number of concerns for the sector. Increasing temperatures, especially in summer, have changed the composition of the fish fauna of Moldova, due to lower concentrations of dissolved oxygen into the water. Although this sub-sector does not have a monolithic relevance in terms of national GDP, the importance for local populations of farmers and for the overall biodiversity conservation of aquatic species in Moldova, led to the inclusion of this sub-sector among those receiving improved technological options to cope with the impacts of climate change.

### 2.2 Technology Action Plan for capitalization of the trophic potential through interspecific polyculture

### 2.2.1 Ambition

The ambition level for implementing this technology is proposed at long-term, full-scale level. A total of 37 ponds currently used for aquaculture will be developed into polyculture for a total of 6,770 ha. The ponds are distributed throughout the country, namely 14 in the Northern part of Moldova, with a cumulated area of 1,252 ha, 15 lakes in the Central part having a cumulated area of 3,015 ha, and the remaining 8 lakes are found in the South and have a total area of 2,510 ha. Currently, these lakes are stocked with juvenile - body weight 20 g – non better-defined phytophagous fish at a density of 1,200 – 1,500 pcs / ha and native European carp at a rate of 700 - 800 pcs / ha (e.g. Sarata Noua Lake) or, as in the case of Badragi Lake, with juveniles of two summers of phytophagous fish at a density of 300 -500 pcs / ha and carp at 800 pcs / ha. The productivity of these lakes is on average 550 kg of fish per ha with variations from north to south comprised in the 400 - 700 kg / ha range. Current harvest volumes total value of around 3,720 tons per year. The ambition of this TAP aims at modifying the species composition in these lakes in order to better exploit the trophic potential of the ponds increasing species count from 3 to 6 and harvest volumes from 3,720 t/year to 4,670 t/year. This goal will be achieved through the introduction of pikeperch - 120 pcs / ha, European wells - 100 pcs / ha, and European bream at a stocking rate of 170 pcs / ha. The increase in fish production at the second year of growth due to the introduction of additional species is expected to be between 100 and 160 kg/ha in total, and specifically 40 - 60 kg/ha from pikeperch, 50 - 60 kg/ha from European wells, and 10 - 30 kg/ha from breams. Total fish production in these 37 lakes can increase by almost 1,000 tons annually and reach 4,670 tons/year.

### 2.2.2 Actions and Activities selected for inclusion in the TAP

The creation of the enabling environment to the implementation of this technology encompasses the building of a governing structure that acknowledges the potential benefits of fish polyculture, governs its planning also by providing technical and financial support, especially for the construction of nurseries and the logistical structure that accompanies aquaculture entrepreneurs in obtaining and raising multi-species fish fry from those nurseries. The enablers for these changes are primarily policy-driven, as emerged from the analysis of the barriers (see BAEF report), but relevant emphasis is on capacity building to manage the polyculture and the production of multiple species broods and provide the existing workforce with the means to operate these resilient farms. Initial investments will require external support since a major barrier to the development of domestic self-sufficient supply of hatchlings and fry is the lack of investment capital of private aquaculture farms in Moldova. Subsequently, awareness raising on the potential of climate-resilient aquaculture is necessary to foster market access and demand for aquaculture products.

| Actions | Activities |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. |
| 2. Ensuring adequate breeding supply | 2.1 Aquaculture farmers association strengthening and representation enhancement |
| | 2.2 Creation of 5 breeding multispecies nurseries in the country |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national aquaculture sector |
| | 2.4 Development of sound sanitary control systems for hatchling stocks, grading, and sorting juveniles |
| | 2.5 Planning and implementation of nationwide distribution and supply chain for fish farms, including optimizing transport equipment for delivery of juveniles of multiple species and sizes |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector |
| | 3.2 Organization of trainings for nursery owners and fish fry producers on improved techniques and management of nurseries |
| | 3.3 Implementation of 6 pilot projects (2 in each region of Moldova) on appropriate water resources management models, and use of complex destination lakes in aquaculture activities |
| | 3.4 Establishment of champion farms and organization of Farmer Field Schools, Study Tours, and Field visits based on peer-to-peer knowledge sharing on management of polyculture in aquaculture |

| | |
|---|---|
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national aquaculture sector to retailers and consumers. |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring aquaculture farms sustainability performance |
| | 5.2. Monitoring campaign and analysis of introduced technology |

*Table 1. Overview of proposed Actions and Activities for the implementation of Polyculture and complex use of lakes and ponds*

#### 2.2.3 Stakeholders and Timeline for the implementation of TAP

In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are three key stakeholders involved in the implementation of this technology:

1. MAFI - Ministry of Agriculture and Food Industry
2. National Association of Fish Farmers of the Republic of Moldova (NAFF)
3. Center for Research of Aquatic Genetic Resources "ACVAGENRESURS" and National Institute for Zoology (NIZ).

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture. In this context however, the representation of fish farmers, through their National Association, is of paramount importance too as exchanges on the needs for the sound sector's development in a context of changing climate will be best voiced by those directly involved with fish farming activities in the country. The National Association will also provide liaison with farmers and entrepreneurs to be enrolled in the breeding and capacity building programs (Actions 2 and 3) together with the researchers from the Center for Research of Aquatic Genetic Resources and the National Institute for Zoology. Actions 4 (raising awareness and market opportunities creation) and 5 (Monitoring and Reporting) will see a predominant role of FAO and MAFI with support from other key stakeholders.

The timeline for the implementation of actions and activities discussed above is presented below.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | FAO; MAFI | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | FAO; MAFI; ACVAGENRESURS; NIZ; NAFF | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | FAO; MAFI; ACVAGENRESURS; NIZ | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | MAFI; FAO | 48 months |

| | | | |
|---|---|---|---|
| 2. Ensuring adequate breeding supply | 2.1 Aquaculture farmers association strengthening and representation enhancement | FAO; ACVAGENRESURS; NAFF | 12 months |
| | 2.2 Creation of 5 breeding multispecies nurseries in the country | MAFI; FAO; ACVAGENRESURS; NIZ; NAFF | 24 months |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national aquaculture sector | MAFI; FAO; ACVAGENRESURS; NIZ; NAFF | 48 months |
| | 2.4 Development of sound sanitary control systems for hatchling stocks, grading, and sorting juveniles | FAO; NIZ; NAFF | 12 months |
| | 2.5 Planning and implementation of nationwide distribution and supply chain for fish farms, including optimizing transport equipment for delivery of juveniles of multiple species and sizes | FAO; MAFI; ACVAGENRESURS; NAFF | 12 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | MAFI; FAO; | 36 months |
| | 3.2 Organization of trainings for nursery owners and fish fry producers on improved techniques and management of nurseries | FAO; ACVAGENRESURS; NIZ; NAFF | 12 months |
| | 3.3 Implementation of 6 pilot projects (2 in each region of Moldova) on appropriate water resources management models, and use of complex destination lakes in aquaculture activities | FAO; ACVAGENRESURS; NIZ; NAFF | 18 months |
| | 3.4 Establishment of champion farms and organization of Farmer Field Schools, Study Tours, and Field visits based on peer-to-peer knowledge sharing on management of polyculture in aquaculture | FAO; ACVAGENRESURS; MAFI; NAFF | 36 months |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | FAO; MAFI | 40 months |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national aquaculture sector to retailers and consumers. | MAFI; NIZ | 40 months |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | FAO; MAFI | 40 months |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring aquaculture farms sustainability performance | FAO; MAFI | 12 months |
| | 5.2. Monitoring campaign and analysis of introduced technology | FAO | 24 months |

*Table 2. Overview of Stakeholders and Timeline for the implementation of Polyculture in Moldovan aquaculture*

### 2.2.4 Financial Resources Estimation for Action and Activities

**The 60-month Technology Action Plan would require a total of 2,527,000 USD distributed among the necessary activities as illustrated in the table below.**

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | USD 30,000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10,000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48,000 |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | USD 240,000 |
| 2. Ensuring adequate breeding supply | 2.1 Aquaculture farmers association strengthening and representation enhancement | USD 72,000 |
| | 2.2 Creation of 5 breeding multispecies nurseries in the country | USD 325,000 |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national aquaculture sector | USD 360,000 |
| | 2.4 Development of sound sanitary control systems for hatchling stocks, grading, and sorting juveniles | USD 60,000 |
| | 2.5 Planning and implementation of nationwide distribution and supply chain for fish farms, including optimizing transport equipment for delivery of juveniles of multiple species and sizes | USD 122,000 |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | USD 180,000 |
| | 3.2 Organization of trainings for nursery owners and fish fry producers on improved techniques and management of nurseries | USD 48,000 |
| | 3.3 Implementation of 6 pilot projects (2 in each region of Moldova) on appropriate water resources management models, and use of complex destination lakes in aquaculture activities | USD 330,000 |
| | 3.4 Establishment of champion farms and organization of Farmer Field Schools, Study Tours, and Field visits based on peer-to-peer knowledge sharing on management of polyculture in aquaculture | USD 90,000 |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200,000 |

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| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national aquaculture sector to retailers and consumers. | USD 100,000 |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | USD 60,000 |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring aquaculture farms sustainability performance | USD 108,000 |
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 144,000 |

*Table 3. Financial Resources Estimation for implementing Polyculture in aquaculture sector of Moldova*

### 2.2.5 Risks and Contingency Planning

| Actions | Activities | Implementation Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | **No risk foreseen** |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. **Risk level: Low** |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. **Risk level: Medium** |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. **Risk level: Medium** |
| 2. Ensuring adequate breeding supply | 2.1 Aquaculture farmers association strengthening and representation enhancement | Reluctance to associate and share risks and benefits. **Risk level: Low** |
| | 2.2 Creation of 5 breeding multispecies nurseries in the country | Procurement difficulties, prices volatility, authorization delays. **Risk level: Medium-high** |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national aquaculture sector | Long-term results available only beyond project duration. **Risk level: Medium** |
| | 2.4 Development of sound sanitary control systems for hatchling stocks, grading, and sorting juveniles | Lack of private stakeholders acceptance. **Risk level: Low** |
| | 2.5 Planning and implementation of nationwide distribution and supply chain for fish farms, including optimizing transport equipment for delivery of juveniles of multiple species and sizes | Lack of demonstrated sustainability. **Risk level: Low** |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | Lack of commitment and participation. **Risk level: Low** |
| | 3.2 Organization of trainings for nursery owners and fish fry producers on improved techniques and management of nurseries | Lack of prepared and knowledgeable national trainers. **Risk level: Medium** |

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| | 3.3 Implementation of 6 pilot projects (2 in each region of Moldova) on appropriate water resources management models, and use of complex destination lakes in aquaculture activities | Possible difficulties in achieving full implementation due to extreme weather events, political conditions, etc. **Risk level: Medium** |
| | 3.4 Establishment of champion farms and organization of Farmer Field Schools, Study Tours, and Field visits based on peer-to-peer knowledge sharing on management of polyculture in aquaculture | Lack of participation of stakeholders. **Risk level: Low** |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | Lack of participation of stakeholders. **Risk level: Low** |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national aquaculture sector to retailers and consumers. | Lack of participation of stakeholders. **Risk level: Low** |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | Lack of capable local disseminators. **Risk level: Low** |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring aquaculture farms sustainability performance | Complexity of MRV systems and lack of practicality. **Risk level: Low** |
| | 5.2. Monitoring campaign and analysis of introduced technology | Lack of data and high data collection costs and time requirements: **Risk level: Low.** |

*Table 4. Risks for implementation of Technology 1 for aquaculture*

Most activities foreseen in this Technology Action Plan pose only very low risks. Changes in political priorities are considered medium-level risks and might affect the smooth development of policy amendments that support the aquaculture sector. As a response to this risk, the TAP should pose enhanced attention to the formation of a diverse multistakeholder working group, within the Ministry of Agriculture, that is participated by stable Ministry technical staff predominantly, so to mitigate the risk that possible political changes vanish the efforts to develop improved sectoral policies for aquaculture. Other activities for which risk level has been assessed as Medium-high is the development of 5 breeding nurseries (activity 2.2) which may be jeopardized by unpredictable material costs changes due to high price volatility, and unpredictable weather events that might cause delays in full pilot implementation (Activity 3.3). Contingency plans for these risks include the proposition of early procurement for goods and materials and securing of funds right from the start of the TAP implementation, whereas insurance plans have been factored in the total budget as part of the restoration of eventual losses in case of extreme weather events causing delays in implementation.

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GREEN CLIMATE FUND

| Actions | Activities | Stakeholders | Implementation Risks | Success criteria | Indicator | Timeline | Budget |
|---|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | FAO; MAFI | **No risk foreseen** | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing aquaculture | 6 months | USD 30,000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | FAO; MAFI; ACVAGENRESURS; NIZ; NAFF | Lack of participation of stakeholders. **Risk level: Low** | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months | USD 10,000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | FAO; MAFI; ACVAGENRESURS; NIZ | Change of country priorities and administrative structure. **Risk level: Medium** | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months | USD 48,000 |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | MAFI; FAO | Change of country priorities and administrative structure. **Risk level: Medium** | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining aquaculture | 48 months | USD 240,000 |
| 2. Ensuring adequate breeding supply | 2.1 Aquaculture farmers association strengthening and representation enhancement | FAO; ACVAGENRESURS; NAFF | Reluctance to associate and share risks and benefits. **Risk level: Low** | The coverage, composition and membership of aquaculture farmers association is enhanced | Aquaculture associations grows in members by at least 5 new associates | 12 months | USD 72,000 |
| | 2.2 Creation of 5 breeding multispecies nurseries in the country | MAFI; FAO; ACVAGENRESURS; NIZ; NAFF | Procurement difficulties, prices volatility, authorization delays. **Risk level: Medium-high** | The country has enough breeding supply to cover polyculture needs | 5 cutting-edge breeding nurseries have been modernized or created in Moldova | 24 months | USD 325,000 |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national aquaculture sector | MAFI; FAO; ACVAGENRESURS; NIZ; NAFF | Long-term results available only beyond project duration. **Risk level: Medium** | PhD laurates complete a formation period with tangible research outcomes | 4 PhD students complete their doctorate and produce at least 3 peer-reviewed publications which support enhanced breeding efforts in the country | 48 months | USD 360,000 |
| | 2.4 Development of sound sanitary control systems for hatchling stocks, grading, and sorting juveniles | FAO; NIZ; NAFF | Lack of private stakeholders acceptance. **Risk level: Low** | Grading, and sorting of juveniles is aligned to best-available international sanitary standards | 3 Sanitary standards are developed and tested in Moldovan aquaculture sector | 12 months | USD 60,000 |
| | 2.5 Planning and implementation of nationwide distribution and supply chain for fish farms, including optimizing transport equipment for delivery of juveniles of multiple species and sizes | FAO; MAFI; ACVAGENRESURS; NAFF | Lack of demonstrated sustainability. **Risk level: Low** | The country is equipped with a national distribution and supply chain for fish farm, associated research and testing of new equipment and techniques | 1 Nationwide distribution and supply chain for fish farms established and tested | 12 months | USD 122,000 |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | MAFI; FAO; | Lack of commitment and participation. **Risk level: Low** | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months | USD 180,000 |
| | 3.2 Organization of trainings for nursery owners and fish fry producers on improved techniques and management of nurseries | FAO; ACVAGENRESURS; NIZ; NAFF | Lack of prepared and knowledgeable national trainers. **Risk level: Medium** | Nursery owners are fully able to manage the introduced technologies and produce high-quality and guaranteed hatchlings | 5 trainings are organized to provide nursery owners with the capacity to manage improved | 12 months | USD 48,000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | technologies and practices for fry production | | |
| | 3.3 Implementation of 6 pilot projects (2 in each region of Moldova) on appropriate water resources management models, and use of complex destination lakes in aquaculture activities | FAO; ACVAGENRESURS; NIZ; NAFF | Possible difficulties in achieving full implementation due to extreme weather events, political conditions, etc. **Risk level: Medium** | Polyculture advantages in terms of adaptation to climate change have been demonstrated | 6 pilot projects have been developed to provide farmers with nationally-bred fish hatchlings, growing and yielding expected quantities | 18 months | USD 330,000 |
| | 3.4 Establishment of champion farms and organization of Farmer Field Schools, Study Tours, and Field visits based on peer-to-peer knowledge sharing on management of polyculture in aquaculture | FAO; ACVAGENRESURS; MAFI; NAFF | Lack of participation of stakeholders. **Risk level: Low** | Moldovan Fish farmers are familiarized and trained to deploy fish polyculture in their own ponds | 37 fish farmers are trained to deploy and manage polyculture in aquaculture | 36 months | USD 90,000 |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | FAO; MAFI | Lack of participation of stakeholders. **Risk level: Low** | Consumers, public institutions and academia are aware and recognize the risks and vulnerabilities to CC posing a burden of food security | 3 Conferences organized to present and discuss risks and vulnerabilities to CC posing a burden of food security | 40 months | USD 200,000 |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national aquaculture sector to retailers and consumers. | MAFI; NIZ | Lack of participation of stakeholders. **Risk level: Low** | Market actors are aware of national actions and efforts to produce climate-resilient domestic fish | At least 80% of tonnage of climate resilient products produced in the context of the project reach the market at competitive prices | 40 months | USD 100,000 |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | FAO; MAFI | Lack of capable local disseminators. **Risk level: Low** | Potential interested farmers are aware of the opportunities of polyculture and the supporting system created by the project | At least 10 potential new fish farms are informed about the opportunities of polyculture and sustainable aquaculture | 40 months | USD 60,000 |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring aquaculture farms sustainability performance | FAO; MAFI | Complexity of MRV systems and lack of practicality. **Risk level: Low** | The country is equipped with ad adapted MRV system to monitor aquaculture farms sustainability | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months | USD 108,000 |
| | 5.2. Monitoring campaign and analysis of introduced technology | FAO | Lack of data and high data collection costs and time requirements: **Risk level: Low.** | The sustainability impacts of polyculture fish farming in Moldova are published | At least 6 monitoring reports for fish farms using polyculture are produced and published | 24 months | USD 144,000 |

*Table 5. Overview of the TAP for Technology 1 for Aquaculture*

## 2.3 Technology Action Plan for increasing water flow in the ponds used for growing fish in polyculture

### 2.3.1 Ambition

The level of ambition for the deployment of this technology is proposed in the short term, at demonstration level, and in the long term, at full scale. At demonstration level, the increase in water flow will be applied in 30 ponds located in the 3 aquaculture areas of Moldova (10 ponds each in the northern, central and southern fish areas) Currently, in these ponds mostly cyprinids are grown (singer, novac, moose and carps) at the stocking density of 1,500-2,000 pcs/ha of one-year-old juveniles (80-120 kg/ha) and 1,000-1,200 pcs/ha of two-summer juveniles (250-320 kg/ha). The ambition of this TAP at demonstration level is to increase the volume of water flowing to the ponds via drainage and desilting works will increase the volume of water in ponds by approximately 20-25%. This will allow to regain the volume of water loss in recent years, as in the case of Nisporeni lake, where the water level decreased by 60 cm. This objective will be achieved by the removal of about 18,000-20,000 m$^3$ of silt, sand, overgrow vegetation and other debris, and through the development of dedicated capacity building program (6-8 million lei for each fish basin) to train staff to maintaining increased water flow in case study ponds. At full-scale implementation, this technology is going to interest a total of up to 2,400 aquaculture ponds with a total area of approximately 400,000 ha located in the north (35%), center (40%) and south (25%) of the country.

### 2.3.2 Actions and Activities selected for inclusion in the TAP

The removal of barriers to the implementation of techniques for increasing water flow in streams and aquaculture ponds requires firstly policymaking actions. The understanding of the responsibilities and requirements of land concessions over aquaculture water bodies is a key starting point to develop sound and agreed policies and consequently to implement them in the field. Once the gaps in regulation surrounding water basins ownership are defined, a sound planning of roles and responsibilities can be rolled out. As in the case of all technologies prioritized for aquaculture, capacity building of the workforce employed is another key aspect of intervention in this Technology Action Plan. Labor, equipment and management of operations to increase water flow will require adequate financial resources, especially upfront. This TAP, however, considers the generation of value from the application of this technology too. In fact, if the upfront capital investment in the form of working capital will be necessary to build up a National Water Flow Management Program, which institutes a management infrastructure to govern for a 10-year timeframe the cleaning of watersheds and the maintenance of their operations and functions, including the procurement of workforce to accomplish the actual work needed. The removal of sand, gravel and silts from the channels and the floodplains that interferes with aquaculture activities however, also generates a resource, which is to be appropriately marketed as a co-product of this intervention. Construction and cement industries in fact are hungry for materials such as sand and gravel and an action to link the removal of these materials with existing markets is envisaged. Initial investments will require external support since a major barrier to the development of this technology is the lack of capital of private aquaculture farms in Moldova, but the co-benefits of the sale of sand and gravel will mitigate these initial costs by an appreciable margin. Awareness raising on the potential of climate-resilient aquaculture and the role of sound watershed management is necessary to long term sustainability of the actions implemented and dedicated activities are foreseen in this TAP.

| Actions | Activities |
| --- | --- |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. |
| 2. National Water Flow Management Program for Aquaculture | 2.1 Survey and Mapping of water flow conditions of rivers and streams in Moldova |
| | 2.2 Creation of a National Water Flow Management agency |
| | 2.3 Deployment of desilting and drainage works on Moldovan obstructed watersheds |
| | 2.4 Circular economy for the Valorization of sand, gravel, and biomass procured |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector |
| | 3.2 Organization of trainings for ponds and lakes owners on improved techniques and management of water flow at streams, ponds and watershed levels |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media |
| | 4.2 Dissemination campaign among stakeholders and outreach |

*Table 6. Overview of proposed Actions and Activities for the implementation of increasing water flow in the ponds used for growing fish in polyculture*

### 2.2.3 Stakeholders and Timeline for the implementation of TAP

In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are three key stakeholders involved in the implementation of this technology:

1. MAFI - Ministry of Agriculture and Food Industry
2. MoE - Ministry of Environment
3. National Association of Fish Farmers of the Republic of Moldova (NAFF)
5. Association of Road Builders of Moldova (ARBM)

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture and the Ministry of Environment (MoE). In this context however, the representation of fish farmers, through their National Association, is of paramount importance too as exchanges on the needs for the sound sector's development in a context of changing climate will be best voiced by those directly involved with fish farming activities in the country. The National Association will also provide liaison with farmers and entrepreneurs to be enrolled in the capacity building programs (Actions 3) and will work hand-in-hand with the Association of Road Builders of Moldova for the deployment of desilting and drainage works of obstructed watersheds and the creation of a revolving fund to market the sand and gravel extracted (Activities 2.3 and 2.4). Actions 4 (raising awareness and market opportunities creation) will see a predominant role of FAO with support from other key stakeholders.

The timeline for the implementation of actions and activities discussed above is presented below.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | FAO; MAFI; MoE | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | FAO; MAFI; MoE; NAFF; ARBM | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | FAO; MAFI; MoE | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | MAFI; MoE; FAO | 48 months |
| 2. National Water Flow Management Program for Aquaculture | 2.1 Survey and Mapping of water flow conditions of rivers and streams in Moldova | FAO; MoE; NAFF | 30 months |
| | 2.2 Creation of a National Water Flow Management agency | MAFI; MoE; FAO; | 24 months |
| | 2.3 Deployment of desilting and drainage works on Moldovan obstructed watersheds | MAFI; MoE; FAO; NAFF; ARBM | 60 months |
| | 2.4 Circular economy for the Valorization of sand, gravel, and biomass procured | FAO; MoE; ARBM | 60 months |

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| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | FAO; MAFI; MoE | 36 months |
| | 3.2 Organization of trainings for ponds and lakes owners on improved techniques and management of water flow at streams, ponds and watershed levels | MAFI; FAO; NAFF | 48 months |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | FAO; NAFF | 40 months |
| | 4.2 Dissemination campaign among stakeholders and outreach | FAO; NAFF; ARBM | 40 months |

*Table 7. Overview of Stakeholders and Timeline for the implementation of increasing water flow in the ponds used for growing fish in polyculture*

### 2.2.4 Financial Resources Estimation for Action and Activities

The 72-month Technology Action Plan is expected to have costs but also, in part, revenues generated within the context of its activities. In particular, apart from Technical Assistance costs, the bulk of the working capital will be necessary for Action 2. National Water Flow Management Program for Aquaculture. In this action, activities like the creation of a National Water Flow Management Agency and the necessity for operational funds to secure its operation for at least 10 years will require significant financial resources. Moreover, based on the estimates carried out during the TNA process, the desilting operations necessary to remove sand and gravel accumulated in the supply channels will cost approximately USD 40,000 per waterway/channel. On average, it is estimated that each operation of desilting will remove about 20,000 tons of sand and gravel. In total then, to ensure that all 2,400 aquaculture lakes and ponds receive sufficient water supply a total expenditure of approximately USD 96 million (Activity 2.3). However, the resulting silt, sand and gravel dragged out of the waterways interested can and will be sold to the market for construction materials at a forecasted price of USD 11.75/ton. This will generate revenues for about USD 20 million, thus discounting the total budget for this TAP to a total of 80,931,000 USD distributed among the necessary activities as illustrated in the table below.

| Actions | Activities | Budget | |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD | 30,000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD | 10,000 |

| | | |
|---|---|---|
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48,000 |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | USD 240,000 |
| 2. National Water Flow Management Program for Aquaculture | 2.1 Survey and Mapping of water flow conditions of rivers and streams in Moldova | USD 1,740,000 |
| | 2.2 Creation of a National Water Flow Management agency | USD 1,180,000 |
| | 2.3 Deployment of desilting and drainage works on Moldovan obstructed watersheds | USD 96,000,000 |
| | 2.4 Circular economy for the Valorization of sand, gravel, and biomass procured | USD - (19,975,000) |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | USD 180,000 |
| | 3.2 Organization of trainings for ponds and lakes owners on improved techniques and management of water flow at streams, ponds and watershed levels | USD 1,200,000 |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200,000 |
| | 4.2 Dissemination campaign among stakeholders and outreach | USD 60,000 |

*Table 8. Financial Resources Estimation for increasing water flow in the ponds used for growing fish in polyculture*

### 2.2.5 Risks and Contingency Planning

| Actions | Activities | Risk |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. **Risk level: Low** |

| | | |
|---|---|---|
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. **Risk level: Medium** |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. **Risk level: Medium** |
| 2. National Water Flow Management Program for Aquaculture | 2.1 Survey and Mapping of water flow conditions of rivers and streams in Moldova | Difficulties in recruiting readily available qualified staff and logistical difficulties. **Risk level: Medium** |
| | 2.2 Creation of a National Water Flow Management agency | Procurement difficulties, prices volatility, authorization delays. **Risk level: Medium-high** |
| | 2.3 Deployment of desilting and drainage works on Moldovan obstructed watersheds | Technical difficulties and cost management. **Risk level: Medium** |
| | 2.4 Circular economy for the Valorization of sand, gravel, and biomass procured | Logistics and market limitations. **Risk level: Medium** |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | Lack of commitment and participation. **Risk level: Low** |
| | 3.2 Organization of trainings for ponds and lakes owners on improved techniques and management of water flow at streams, ponds and watershed levels | Lack of prepared and knowledgeable national trainers. **Risk level: Medium** |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | Lack of participation of stakeholders. **Risk level: Low** |
| | 4.2 Dissemination campaign among stakeholders and outreach | Lack of capable local disseminators. **Risk level: Low** |

*Table 9. Risks for implementation of increasing water flow in the ponds used for growing fish in polyculture*

Most activities foreseen in this Technology Action Plan pose mainly low risks with a few noteworthy exceptions. Changes in political priorities are considered medium-level risks and might affect the smooth development of policy amendments that support the aquaculture sector. As a response to this risk, the TAP poses increased attention to the formation of a diverse multistakeholder working group, within the Ministry of Agriculture, that is participated by permanent Ministry technical staff predominantly, so to mitigate the risk that possible political changes vanish the efforts to develop improved sectoral policies for aquaculture. Other activities for which risk level has been assessed as Medium-high is the creation of the National Water Flow Management Agency (activity 2.2) and the deployment of effecting desilting of the channels which may be jeopardized by unpredictable material costs changes due to high price volatility, and unpredictable weather events that might cause delays in full implementation (Activity 2.3 and 2.4). Contingency plans for these risks include the proposition of early procurement for goods and materials and securing of funds right from the start of the TAP implementation, whereas insurance plans have been factored in the total budget as part of the restoration of eventual losses in case of extreme weather events causing delays in implementation.

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD 30,000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing aquaculture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10,000 | Lack of participation of stakeholders.<br><br>**Risk level: Low** | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48,000 | Change of country priorities and administrative structure.<br><br>**Risk level: Medium** | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | USD 240,000 | Change of country priorities and administrative structure.<br><br>**Risk level: Medium** | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining aquaculture | 48 months |
| 2. National Water Flow Management Program for Aquaculture | 2.1 Survey and Mapping of water flow conditions of rivers and streams in Moldova | USD 1,740,000 | Difficulties in recruiting readily available qualified staff and logistical difficulties.<br><br>**Risk level: Medium** | National Survey and Mapping water flow database created and accessible | All 2,400 aquaculture lakes and ponds have been mapped, baseline and target water flow regimes of their watersheds defined | 30 months |
| | 2.2 Creation of a National Water Flow Management agency | USD 1,180,000 | Procurement difficulties, prices volatility, authorization delays.<br><br>**Risk level: Medium-high** | National Water Flow Managementr Agency established | 1 National Water Flow Management Agency is created and budgetary funds secured for operation for at least 10 years | 24 months |
| | 2.3 Deployment of desilting and drainage works on Moldovan obstructed watersheds | USD 96,000,000 | Technical difficulties and cost management. **Risk level: Medium-high** | Optimal waterflow is restored and resilence to extreme events is improved at the national level, contributing to mitigating flood impacts | Average water flow at the national level is increased by at least 25% compared to baseline | 60 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2.4 Circular economy for the Valorization of sand, gravel, and biomass procured | USD (19,975,000) | Logistics and market limitations.<br><br>**Risk level: Low** | Market placements and long term agreements with construction industry to re-use the silts, materials and biomass produced by the desilting works | Total volume of silts, sand and biomass removed and sold to construction, cement and energy companies equal to 1,700,000 tons | 60 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | USD 180,000 | Lack of commitment and participation.<br><br>**Risk level: Low** | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| | 3.2 Organization of trainings for ponds and lakes owners on improved techniques and management of water flow at streams, ponds and watershed levels | USD 1,200,000 | Lack of prepared and knowledgeable national trainers.<br><br>**Risk level: Low** | Moldovan Fish farmers are familiarized and trained to deploy measure to increase water flow in their ponds | 2,400 fish farmers are trained to deploy and manage water flow in aquaculture | 48 months |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200,000 | Lack of participation of stakeholders.<br><br>**Risk level: Low** | Consumers, public institutions and academia are aware and recognize the risks and vulnerabilities to CC posing a burden of food security | 3 Conferences organized to present and discuss risks and vulnerabilities to CC posing a burden of food security | 40 months |
| | 4.2 Dissemination campaign among stakeholders and outreach | USD 60,000 | Lack of capable local disseminators.<br><br>**Risk level: Low** | Potential interested farmers are aware of the opportunities of polyculture and the supporting system created by the project | At least 10 potential new fish farms are informed about the opportunities of polyculture and sustainable aquaculture | 40 months |

*Table 10. Overview of the TAP for increasing water flow in the ponds used for growing fish in polyculture*

## 2.4 Technology Action Plan for fish protection system and ensuring food security in the conditions of climate change

### 2.4.1 Ambition

The ambition of this technology at national level targets the 6,000 water bodies and the 1,000 active fish farms in Moldova. As a result of carrying out the inventory and determination of all land areas on which fish facilities are located - water bodies (ponds and lakes) used for fish production will be characterized and monitored.

### 2.4.2 Actions and Activities selected for inclusion in the TAP

The implementation of this technology requires the removal of some policy barriers and the organization of a structural system in the country to assess in near-real time water resources and aquaculture statuses for the monitoring and early intervention in focal areas. The development of the Fish Protection System to ensure safe and resilient food for Moldovan people will be the main Action of this TAP. Activities that compose this action look at assessing the baseline status with a nationwide survey of aquaculture status, fish health and sanitary risks of the sector, something the country has never carried out before.
Fisheries-biological substantiations are composed by a set of technical documentation and chemico-physical parameter monitoring equipment to collect and share near-real time data on water quality and impacts on fish health and productivity. These systems need to be managed by existing research institutions - properly trained - in collaboration with the Ministry of Agriculture to further expand their capabilities and products. Building human and institutional capacity to make best use of these systems will require a dedicated activity, as well as a specific monitoring of the impacts of FPBs will inform policymakers on the effectiveness of the TAP and its implementation.

| Actions | Activities |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on rights and commitments of regulatory acts on water use, development of corrective action plan in the regulatory framework. |
| | 2.1 Nationwide survey on aquaculture status, fish health and sanitary risks |
| 2.Fish Protection System development | 2.2 Elaboration of fisheries-biological substantiations (FPB) for water bodies in fisheries areas of Moldova |
| | 2.3 Support to national research institutions for research and development of technologies and practices to support the national aquaculture sector |

| | |
|---|---|
| 3. Capacity building | 3.1 Strengthening information measures for aquaculture practitioners and producers to solve resource saving tasks, project implementation, publication of recommendations |
| 4. Monitoring and Reporting | 4.1. Monitoring campaign and analysis of impacts of FPBs |

*Table 11. List of Actions and Activities for the implementation of Fish Protection Systems*

### 2.4.3 Stakeholders and Timeline for the implementation of TAP

In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are three key stakeholders involved in the implementation of this technology:

1. MAFI - Ministry of Agriculture and Food Industry
2. MoE - Ministry of Environment
3. National Association of Fish Farmers of the Republic of Moldova (NAFF)

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture and the Ministry of Environment (MoE). In this context, however, the representation of fish farmers, through their National Association, is of paramount importance too as exchanges on the needs for the sound sector's development in a context of changing climate will be best voiced by those directly involved with fish farming activities in the country. NAFF will also provide liaison with farmers and entrepreneurs to be enrolled in the Fish Protection System Development and capacity building programs (Actions 2 and 3). Action 4 (Monitoring and Reporting) will see a predominant role of FAO and MAFI. All actions will be deployed within a 48-month timeframe.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | MAFI; MoE; FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI; MoE; FAO; NAFF; ARBM | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | FAO; MAFI; ARBM | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of regulatory acts on water use, development of corrective action plan in the regulatory framework. | FAO; MAFI | 36 months |
| | 2.1 Nationwide survey on aquaculture status, fish health and sanitary risks | MAFI; MoE; FAO; NAFF; ARBM | 24 months |
| 2. Fish Protection System development | 2.2 Elaboration of fisheries-biological substantiations (FPB) for water bodies in fisheries areas of Moldova | NAFF; FAO; MAFI; MoE | 24 months |

| | | | |
|---|---|---|---|
| | 2.3 Support to national research institutions for research and development of technologies and practices to support the national aquaculture sector | FAO; NAFF | 48 months |
| 3. Capacity building | 3.1 Strengthening information measures for aquaculture practicioners and producers to solve resource saving tasks, project implementation, publication of recommendations | FAO; NAFF | 36 months |
| 4. Monitoring and Reporting | 4.1. Monitoring campaign and analysis of impacts of FPBs | FAO; MAFI | 12 months |

*Table 12. Overview of Stakeholders and Timeline for the implementation of Fish Protection Systems*

### 2.4.4 Financial Resources Estimation for Action and Activities

The 48-month Technology Action Plan would require a total of 2,934,000 USD distributed among the necessary activities as illustrated in the table below.

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | USD 30.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 |
| | 1.4 Amendment of normative acts on rights and commitments of regulatory acts on water use, development of corrective action plan in the regulatory framework. | USD 240.000 |
| | 2.1 Nationwide survey on aquaculture status, fish health and sanitary risks | USD 480.000 |
| 2. Fish Protection System development | 2.2 Elaboration of fisheries-biological substantiations (FPB) for water bodies in fisheries areas of Moldova | USD 1.010.000 |
| | 2.3 Support to national research institutions for research and development of technologies and practices to support the national aquaculture sector | USD 360.000 |
| 3. Capacity building | 3.1 Strengthening information measures for aquaculture practitioners and producers to solve resource saving tasks, project implementation, publication of recommendations | USD 612.000 |
| 4. Monitoring and Reporting | 4.1. Monitoring campaign and analysis of impacts of FPBs | USD 144.000 |

*Table 13. Financial Resources Estimation for a national Fish Protection System*

### 2.4.5 Risks and Contingency Planning

Most activities foreseen in this Technology Action Plan pose mainly low risks with a few noteworthy exceptions. Changes in political priorities are considered medium-level risks and might affect the smooth development of policy amendments that support the aquaculture sector. As a response to this risk, the TAP poses increased attention to the formation of a diverse multistakeholder working group, within the Ministry of Agriculture, that is participated by permanent Ministry technical staff predominantly, so to mitigate the risk that possible political changes vanish the efforts to develop improved sectoral policies for aquaculture. Other activities for which risk level has been assessed as Medium-high is the creation of the National Water Flow Management Agency (activity 2.2) and the deployment of effecting desilting of the channels which may be jeopardized by unpredictable material costs changes due to high price volatility, and unpredictable weather events that might cause delays in full implementation (Activity 2.3 and 2.4). Contingency plans for these risks include the proposition of early procurement for goods and materials and securing of funds right from the start of the TAP implementation, whereas insurance plans have been factored in the total budget as part of the restoration of eventual losses in case of extreme weather events causing delays in implementation.

| Actions | Activities | Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. **Risk level: Low** |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. **Risk level: Medium** |
| | 1.4 Amendment of normative acts on rights and commitments of regulatory acts on water use, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. **Risk level: Medium** |
| | 2.1 Nationwide survey on aquaculture status, fish health and sanitary risks | Low participation of respondents. **Risk level: Medium** |
| 2. Fish Protection System development | 2.2 Elaboration of fisheries-biological substantiations (FPB) for water bodies in fisheries areas of Moldova | No risks foreseen |
| | 2.3 Support to national research institutions for research and development of technologies and practices to support the national aquaculture sector | Long-term results available only beyond project duration. **Risk level: Low** |

| | | |
|---|---|---|
| 3. Capacity building | 3.1 Strengthening information measures for aquaculture practitioners and producers to solve resource saving tasks, project implementation, publication of recommendations | Lack of commitment and participation. **Risk level: Low** |
| 4. Monitoring and Reporting | 4.1. Monitoring campaign and analysis of impacts of FPBs | Data verification costs and time requirements: **Risk level: Low.** |

*Table 14. Risks associated with the implementation of the Fish Protection System*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing aquaculture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of regulatory acts on water use, development of corrective action plan in the regulatory framework. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 3 meetings of working group and Approved Review of amendments on laws pertaining aquaculture | 36 months |
| 2.Fish Protection System development | 2.1 Nationwide survey on aquaculture status, fish health and sanitary risks | USD 480.000 | Low participation of respondents. Risk level: Medium | A nationwide survey on aquaculture status, fish health and sanitary conditions produced | 1 Report summarizing the results of the survey and at least 50% of questionnaires returned and filled out | 24 months |
| | 2.2 Elaboration of fisheries-biological substantiations (FPB) for water bodies in fisheries areas of Moldova | USD 1.010.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium-high | The country has a complete overview of the overall health situation of its aquaculture sector | Fishery-biological substantiations (FPB) for the 6000 elaborated water bodies. Passport of the fish basin (water bodies) drawn up for 1000 fish farms | 24 months |
| | 2.3 Support to national research institutions for research and development of technologies and practices to support the national aquaculture sector | USD 360.000 | Long-term results available only beyond project duration. Risk level: Medium | PhD laurates complete a formation period with tangible research outcomes | 4 PhD students complete their doctorate and produce at least 3 peer-reviewed publications which support enhanced breeding efforts in the country | 48 months |
| 3. Capacity building | 3.1 Strengthening information measures for aquaculture practitioners and producers to solve resource saving tasks, project implementation, publication of recommendations | USD 612.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| 4. Monitoring and Reporting | 4.1. Monitoring campaign and analysis of impacts of FPBs | USD 144.000 | Data verification costs and time requirements: Risk level: Low. | The sustainability impacts of polyculture fish farming in Moldova are published | At least 6 monitoring reports for fish farms using polyculture are produced and published | 12 months |

*Table 15. Overview of the TAP for Fish Protection Systems*

# CHAPTER – 3 THE LIVESTOCK SUB-SECTOR

## 3.1 Technology Action Plan and Project Ideas for the Livestock sector

### 3.1.1 Sector overview

Between 1995 and 2015, cattle livestock decreased by 75 percent, pig production by 50 percent, and sheep and goats by 50 percent. The fall in livestock numbers was the consequence of inefficient restructuring of large animal and poultry farms, and also the consequence of a lack of investment funds. During the last years, this trend slowed down. Livestock production in Moldova is very sensitive to climate changes, mainly through a lack or shortage of fodder. Moldova is importing approximately 60 percent of its consumption of dairy and beef products, with only 40 percent coming from domestic production. Pork is the most extensively produced type of meat. In particular, pork is one of the most popular meat types for Moldovan customer, since it is much more affordable than beef. Moldova's pork production was 54 thousand tons in 2009 and increased by 65 percent in 2019, reaching 83 thousand tons in live weight. A study on the literature available on impacts of climate change on livestock sector was carried out by National Consultants in the context of the TNA and the results indicate that the sub-sector will be affected negatively by the warming climate and water scarcity. The general results of the study were that, relative to the baseline, the production of beef cattle and chickens will decline with rising temperatures in the future – thus following the negative path observed until 2015 - but that the probability of affecting dairy cattle, goats, and sheep will increase. Income per animal is also expected to decline across all livestock types, but most dramatic changes are already being observed for beef cattle, goats, and chickens. A model-based study mixed with literature trends shown a fall in income due to lower bodyweight gains for all livestock types with temperature increase of 2.5°C compared to last century's values. Rising temperatures, in general, lead to a response to reduce the predicted number of beef cattle and chickens on each farm, but increase the number of the other livestock types, especially free grazing animals. Drought and water stresses however, are responsible for a decreases in pasture's availability and quality, especially protein. This is why actions to adapt to these changes are essential also for the livestock sector.

The TNA prioritization phase looked at these climate stressors individually and derived a set of 13 technologies and practices, that have been preliminarily targeted to compose the Long List of Technologies. The pivotal aspect of this selection is the need to address the perceived decreased availability of feed produced domestically as a consequence of long-term changes in the precipitation patterns. Especially in the central and northern part of Moldova, grazing is becoming less attractive for livestock farmers as the quality and availability of this feed is decreasing due to shifts in precipitation patterns year-round. Increasing areas under irrigation for feed production, especially maize silage, would represent a crucial improvement on the side of feed availability, however not one that comes without tradeoffs and barriers. Switching feed production towards crops that are less susceptible to dry conditions, such as sorghum instead of maize, might be a valuable alternative. Though, it is felt that Moldova in general lacks a certain level of capacity of livestock farmers to optimize the nutrition regime of their animals and maximise the efficiency of these systems. Extreme temperatures also cause damages to the productivity of livestock in Moldova, and key technologies to streamline shed designs and construction techniques have been preliminarily targeted. For free grazing livestock, the effects of climate change are obvious through the limited availability of water resources in the landscape, which due to extreme events such as increased frequency of droughts, are becoming a limiting factor for livestock production with this form of management. Preliminary targeted technologies also included actions directly aimed at addressing these issues. The full set of technologies preliminarily targeted by the TNA process is available in the table below.

## 3.2 Technology Action Plan for increasing areas under irrigation for the production of feed

### 3.2.1 Ambition

The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At demonstration level, technologies to increase areas under irrigation to produce feed will be implemented in 13 farms of an average surface of 50 ha each which currently produce forage and feed. The farms are in the northern part of Moldova. Currently, these farms produce maize silage with yields of about 30-40 tons/ha, but during drought years yields are reduced by up to 50%, down to 15-20 t/ha. However, the use of proper irrigation systems on maize can sustain yields of 25-35 tons/ha even in drought years. The ambition of this TAP at demonstration level is to sustain yields during drought periods. Irrigation infrastructures include water harvesting and banking operations, where areas are devoted to water storage, they are recharged during precipitation events, participate in protecting from flood risks and are capable of releasing the water when drought occurs. The cumulated volume of water banking should reach around 4,000,000 $m^3$, enough to deliver some 6,000 $m^3$ per ha per year. In addition to water banking works, the sustained yield goal will be achieved thanks to the introduction of improved feed production techniques (better varieties, crop rotations, etc.) for each farm, and the development of 4 programs to train personnel and maintain the increased productivity in the case study farms.
At full scale level implementation, this technology is targeted to interest a total of 100 farms in Moldova, for a total surface of 15,000 ha, and an estimated volume of irrigation water of approximately 90 million $m^3$ sufficient to ensure the production of some 675,000 tons of feed. These comprise established feed and forage farms in the southern and northern part of Moldova. Currently, these farms produce alfalfa with an average productivity of 5 tons of product per ha and maize silage is about 30-40 tons / Ha, and a decreasing yield trend is observed compared to 10-15 years ago, when yields were comparatively higher at 8-10 t/ha for alfalfa. The ambition of this TAP at national level is to increase yields from the current average of 8 t/ha for alfalfa to 15 t/ha, and maintain maize silage yields at about 40 tons/ha also during drought years. This goal will be achieved through the introduction of irrigation, fertilizers application, crop rotations, etc. and the development of 4 programs to train personnel and maintain the increased productivity in the Moldovan farms.

### 3.2.2 Actions and Activities selected for inclusion in the TAP

The implementation of this technology requires the removal of some policy barriers and the organization of a Sustainable Irrigation Program for feed production in Moldova. The development of the program will ensure safe and resilient feed for Moldovan livestock farmers and will be the main Action of this TAP. Activities that compose this action look at assessing the baseline status with a nationwide survey of irrigation needs and conditions of established forage farms. This activity will be conducive to planning water banking works and related irrigation systems and networks interesting the 100 feed producing farms in Moldova to date. The planning will require assessing geological conditions of the sites, designing individual water banking schemes for each farm and the related irrigation network. Following this activity, the deployment of such systems can be enabled and will require naturalistic and civil engineering work in all farms enrolled in the program. Along the lines of the planning of water supply in drought years to existing and established feed crops, an activity dedicated to researching and testing best practices for input-efficient feed types diversification in the country is also necessary to complete the resilience of the sector to the impacts of climate change. In fact, this activity will offer important benefits including increased economic stability of feed producing farms as a result of the diversification of the offer of feed to the market. Livestock farms will maintain income levels despite the impacts of climate change in drought years thanks to increased feed availability.

In order to deploy the aforementioned activities, capacity building at both institutional and farmers level is necessary. In addition, to detect inefficiencies and correct management approaches a monitoring and reporting action and related activities has also been foreseen.

| Actions | Activities |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. |
| 2. Sustainable Irrigation Program for feed production | 2.1 Survey and Mapping of irrigation needs and conditions of established forage farms in Moldova |
| | 2.2 Designing of water banking systems and sustainable irrigation systems |
| | 2.3 Water banking and related irrigation systems construction |
| | 2.4 Best practices for input-efficient feed types diversification |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector |
| | 3.2 Organization of trainings for farm owners on improved techniques and management of water banking systems for sustainable irrigation in drought years |
| 4. Monitoring and reporting | 4.1. Selection and adaptation of MRV systems for monitoring feed farms sustainability performance |

| | |
|---|---|
| | 4.2. Monitoring campaign and analysis of introduced technology |

*Table 16. Overview of proposed Actions and Activities for increasing areas under irrigation for the production of feed*

### 3.2.3 Stakeholders and Timeline for the implementation of TAP

In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are three key stakeholders involved in the implementation of this technology:

1. MAFI - Ministry of Agriculture and Food Industry (MAFI) and Ministry of Environment (MoEF)
2. Association of Livestock producers

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture to define the necessary policy amendments to align livestock regulations and targets with the changing priorities imposed by the impacts of climate change. In this context however, the representation of farmers, through their National Associations, is of paramount importance too as exchanges on the needs for the sound sector's development with those directly involved with feed production and livestock activities in general is key to completeness and policymaking inclusiveness. Livestock farmers and their associations will be predominantly engaged with the Sustainable Irrigation Program for feed production development and capacity building programs (Actions 2 and 3). Action 4 (Monitoring and Reporting) will see a predominant role of FAO and MAFI. All actions will be deployed within a 54-month timeframe.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, MoEF, Associations of sector, FAO | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | FAO, MAFI | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | MAFI | 40 months |
| 2. Sustainable Irrigation Program for feed production | 2.1 Survey and Mapping of irrigation needs and conditions of established forage farms in Moldova | MAFI, Associations of sector, FAO | 6 months |
| | 2.2 Designing of water banking systems and sustainable irrigation systems | MAFI, Associations of sector, FAO | 12 months |

| | | | |
|---|---|---|---|
| | 2.3 Water banking and related irrigation systems construction | MAFI, Associations of sector, FAO | 36 months |
| | 2.4 Best practices for input-efficient feed types diversification | MAFI, Associations of sector, FAO | 24 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | MAFI, FAO | 36 months |
| | 3.2 Organization of trainings for farm owners on improved techniques and management of water banking systems for sustainable irrigation in drought years | Associations of sector, FAO | 12 months |
| 4. Monitoring and reporting | 4.1. Selection and adaptation of MRV systems for monitoring feed farms sustainability performance | MAFI, FAO | 12 months |
| | 4.2. Monitoring campaign and analysis of introduced technology | FAO | 24 months |

*Table 17. Overview of Stakeholders and Timeline for increasing areas under irrigation for the production of feed*

### 3.2.4 Financial Resources Estimation for Action and Activities

The 54-month Technology Action Plan would require a total of 14,896,000 USD distributed among the necessary activities as illustrated in the table below.

| Actions | Activities | Budget | |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD | 30.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD | 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD | 48.000 |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD | 92.000 |

| | | | |
|---|---|---|---|
| 2. Sustainable Irrigation Program for feed production | 2.1 Survey and Mapping of irrigation needs and conditions of established forage farms in Moldova | USD | 90.000 |
| | 2.2 Designing of water banking systems and sustainable irrigation systems | USD | 244.000 |
| | 2.3 Water banking and related irrigation systems construction | USD | 13.000.000 |
| | 2.4 Best practices for input-efficient feed types diversification | USD | 900.000 |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD | 180.000 |
| | 3.2 Organization of trainings for farm owners on improved techniques and management of water banking systems for sustainable irrigation in drought years | USD | 50.000 |
| 4. Monitoring and reporting | 4.1. Selection and adaptation of MRV systems for monitoring feed farms sustainability performance | USD | 108.000 |
| | 4.2. Monitoring campaign and analysis of introduced technology | USD | 144.000 |

*Table 18. Financial Resources Estimation for increasing areas under irrigation for the production of feed*

Action 2. (Sustainable Irrigation Program for feed production), particularly with Activities 2.3 (Water banking system construction) and 2.4 (input-efficient feed types diversification) are the areas of main budget expenditure in this Technology Action Plan. These activities are characterized by hard actions to take place in 100 farms across the country and will have an expected lifetime of at least 30 years, and provided that successful maintenance occurs, their lifetime can be extended indefinitely, as a stable adaptation measure. Moreover, these activities can be extended to other subsectors of agriculture and different agrifood systems by learning lessons and sharing the accumulated knowledge. The cost estimates for the construction of a single water banking system are generic and average, whereas in real-world scenarios these might vary by a certain margin. This is why in this TAP, a conservative estimate of USD 40,000 per water banking system (1 per farm) is proposed for a total of USD 4,000,000. In addition, modern irrigation systems can have a cost of up to USD 600 per ha (15,000 h required for a total investment of USD 9,000,000), making the total cost of implementing this technology USD 13,000,000. Deploying alternative feed crops in at least 10% of the existing farms will result in costs of about USD 1,000,000. Technical Assistance and other costs amount to USD 896,000 for the development of all other activities of this TAP, including policy development and capacity building.

### 3.2.5 Risks and Contingency Planning

As in the case of aquaculture, also for livestock the majority of activities foreseen in this Technology Action Plan pose mainly low risks with only a few exceptions, for which however, risk level is considered medium at most, and no high-risk activities are envisaged. Changes in political priorities are considered medium-level risks and might affect the smooth development of policy amendments that support the livestock sector as well as all other sectors of the economy. As a response to this risk, the TAP poses increased attention to the formation of a diverse multistakeholder working group, within the Ministry of Agriculture, that is participated by permanent Ministry technical staff predominantly, so to mitigate the risk that possible political changes vanish the efforts to develop improved sectoral policies for aquaculture. Other activities for which risk level has been assessed as Medium-high is the creation of the Sustainable Irrigation Program for feed production (Action 2.) and the deployment of water banking systems and above all equipping with efficient irrigation networks the 15,000 ha currently used to produce livestock feed in Moldova may be subject to costs fluctuations, and unpredictable weather events that might cause delays in full implementation (Activity 2.3 and 2.4). As in similar cases across this TAP, contingency plans for these risks include the proposition of early procurement for goods and materials and securing of funds right from the start of the TAP implementation, whereas insurance plans have been factored in the total budget as part of the restoration of eventual losses in case of extreme weather events causing delays in implementation.

| Actions | Activities | Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Medium |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. Risk level: Medium |
| 2. Sustainable Irrigation Program for feed production | 2.1 Survey and Mapping of irrigation needs and conditions of established forage farms in Moldova | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium |
| | 2.2 Designing of water banking systems and sustainable irrigation systems | Difficult planning and adequate geological conditions and difficulties in obtaining authorizations. Risk level: low |

| | | |
|---|---|---|
| | 2.3 Water banking and related irrigation systems construction | Technical difficulties and cost management. Risk level: Medium |
| | 2.4 Best practices for input-efficient feed types diversification | Technical difficulties and cost management. Risk level: Medium |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | Lack of commitment and participation. Risk level: Low |
| | 3.2 Organization of trainings for farm owners on improved techniques and management of water banking systems for sustainable irrigation in drought years | Lack of prepared and knowledgeable national trainers. Risk level: Medium |
| 4. Monitoring and reporting | 4.1. Selection and adaptation of MRV systems for monitoring feed farms sustainability performance | Complexity of MRV systems and lack of practicality. Risk level: Low |
| | 4.2. Monitoring campaign and analysis of introduced technology | Lack of data and high data collection costs and time requirements: Risk level: Low. |

*Table 19. Risks for the implementation of measures to increase areas under irrigation for the production of feed*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing livestock | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 40 months |
| 2. Sustainable Irrigation Program for feed production | 2.1 Survey and Mapping of irrigation needs and conditions of established forage farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 36months |
| | 2.2 Designing of water banking systems and sustainable irrigation systems | USD 144.000 | Difficult planning and adequate geological conditions. Risk level: low | National Water Banking plan for adapting livestock feed production to climate change | 1 National Water Banking plan for feed production is produced | 24 months |
| | 2.3 Water banking and related irrigation systems construction | USD 13.000.000 | Technical difficulties and cost management. Risk level: Medium | Optimal water balance between flood and drought years is established and resilience to extreme events is improved at the national level, contributing to mitigating CC impacts | Optimal water requirements for feed production are met also in drought years | 36 months |
| | 2.4 Best practices for input-efficient feed types diversification | USD 1.000.000 | Technical difficulties and cost management. Risk level: Medium | New and more input-efficient feed types are introduced, tested and commercialized | At least 25 farms diversified their feed production types with water-efficient varieties | 24 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD 180.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| | 3.2 Organization of trainings for farm owners on improved techniques and management of water banking systems for sustainable irrigation in drought years | USD 50.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan feed producers are familiarized and trained to manage water banking and diversify feed types | 100 farmers are trained to deploy and manage water banking and irrigation systems, in addition to increased diversification of feed types | 12 months |
| 4. Monitoring and reporting | 4.1. Selection and adaptation of MRV systems for monitoring feed farms sustainability performance | USD 108.000 | Complexity of MRV systems and lack of practicality. Risk level: Low | The country is equipped with ad adapted MRV system to monitor aquaculture farms sustainability | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 4.2. Monitoring campaign and analysis of introduced technology | USD 144.000 | Lack of data and high data collection costs and time requirements: Risk level: Low. | The sustainability impacts of water banking for feed production in Moldova are published | At least 25 monitoring reports for feed farms using water banking and irrigation are produced and published | 24 months |

*Table 20. Overview of the TAP for increasing areas under irrigation for the production of feed*

## 3.3 Technology Action Plan for the construction of platforms for the accumulation and storage of manure and organic fertilizers production

### 3.3.1 Ambition

The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At the demonstration level, the construction of platforms for the accumulation of manure and the production of organic fertilizers will be implemented in 5 farms. The farms are in the northern part of Moldova. Currently, each of these dairy farms produces about 140 tons of milk per year and a decreasing production trend is observed compared to 2008 average values, because of lack of quality organic fertilizers for the feed production industry. The ambition of this TAP at demonstration level is to produce 5,500 tons of organic fertilizers in the form of composted, mature manure. This goal will be achieved through the construction of special platforms for each farm, and the development of 2 programs to train personnel and maintain the increased productivity in the case study farms.
At full scale level implementation, this technology is targeted to interest a total of 100 farms. These comprise established livestock farms in the northern, central, and southern part of Moldova, distributed for a 45% percent in the North, 34% percent in the Center and 21% in the South of the country. Currently, each of these dairy farms produces about 650 tons of milk per year and a decreasing production trend is observed compared to 2008 average values, because of lack of quality organic fertilizers for the feed production industry. The ambition of this TAP at the national level is to produce 941 000 tons of organic fertilizers per year after implementation. This goal will be achieved through the construction of construction of manure maturation and composting structures (e.g. pits) for each farm for a total of 100 platforms, and the development of training campaigns to maintain manure composting production in the farms.

### 3.3.2 Actions and Activities selected for inclusion in the TAP

Properly designed and operated manure management systems prevent manure from overflowing or discharging from a facility, and allow for timely nutrient application for vegetative growth. Whether the manure is stored in a lagoon, earthen structure, tank or deep pit, similar principles exist to maintaining a sound manure storage structure. Frequent evaluation of the system and preventative maintenance reduce the risk of costly structural and/or environmental issues down the road. This TAP is designed around the maximization of the efficiency of manure storage and maturation processes and the construction of efficient platforms for these operations. An important component of the TAP involves the planning and execution of the logistics for organic fertilizer applications in the soils used to produce feed for the livestock sector. Capacity building of farmers enrolled in this program is crucial to train them on the sound management of manure for organic fertilizers production.

| Actions | Activities |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding the produce and use of animal manure as organic fertilizers |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |

| | |
|---|---|
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. |
| 2. Planning and construction of organic fertilizer production platforms | 2.1 Survey and mapping of farms in Moldova that require the provision of platforms for keeping manure |
| | 2.2 Designing of manure management structures and platforms |
| | 2.3 Manure management and organic fertilizer production systems construction |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector |
| | 3.2 Organization of trainings for farmers on management of organic fertilizer production platforms and alternative methods of producing and using organic fertilizers |

*Table 21. Overview of Actions and Activities for the construction of platforms for the accumulation and storage of manure and organic fertilizers production*

### 3.3.3 Stakeholders and Timeline for the implementation of TAP

In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are two more key stakeholders involved in the implementation of this technology:

1. MAFI - Ministry of Agriculture and Food Industry
2. Association of Livestock producers

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture to define the necessary policy amendments to align livestock regulations and targets with the changing priorities imposed by the impacts of climate change. In this context however, the representation of farmers, through their National Associations, is of paramount importance too as exchanges on the needs for the sound sector's development with those directly involved with feed production and livestock activities in general is key to completeness and policymaking inclusiveness. Livestock farmers and their associations will be predominantly engaged with the Sustainable Irrigation Program for feed production development and capacity building programs (Actions 2 and 3). Action 4 (Monitoring and Reporting) will see a predominant role of FAO and MAFI. All actions will be deployed within a 54-month timeframe.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding the produce and use of animal manure as organic fertilizers | FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, Associations of sector, FAO | 12 months |

| | | | |
|---|---|---|---|
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | FAO, MAFI | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | MAFI | 12 months |
| 2. Planning and construction of organic fertilizer production platforms | 2.1 Survey and Mapping of organic fertilizers needs and conditions of established forage farms in Moldova | MAFI, Associations of sector, FAO | 6 months |
| | 2.2 Designing of manure management structures and platforms | FAO, MAFI, Association of sector | 12 months |
| | 2.3 Manure management and organic fertilizer production systems construction | FAO, MAFI, Association of sector | 24 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | MAFI, FAO | 12 months |
| | 3.2 Organization of trainings for farmers on management of organic fertilizer production platforms | FAO, Association of sector | 12 months |

*Table 22. Overview of Stakeholders and Timeline for the construction of platforms for the accumulation and storage of manure and organic fertilizers production*

### 3.3.4 Financial Resources Estimation for Action and Activities

The TAP will have an approximate cost of USD 2,124,000 to provide 100 farms in Moldova with organic fertilizer infrastructure. The bulk of the expenditure will be with the construction of the platforms (USD 1,500,000 Activity 2.3). This was estimated starting from information in the literature. The storage pits are going to be built in concrete and will have an approximate surface of 100 $m^2$ each. Unitary costs are about USD 150/$m^2$ for these structures, thus some USD 15,000 per farm. Enrolling 100 farms in the TAP would entail an investment cost of about USD 1,500,000 while the remaining budget will be represented by operational expenditures and technical assistance funds (USD 624,000).

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding the produce and use of animal manure as organic fertilizers | USD 30.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |

| | | | |
|---|---|---|---|
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD | 48.000 |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD | 92.000 |
| 2. Planning and construction of organic fertilizer production platforms | 2.1 Survey and Mapping of organic fertilizers needs and conditions of established forage farms in Moldova | USD | 90.000 |
| | 2.2 Designing of manure management structures and platforms | USD | 144.000 |
| | 2.3 Manure management and organic fertilizer production systems construction | USD | 1.500.000 |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD | 60.000 |
| | 3.2 Organization of trainings for farmers on management of organic fertilizer production platforms | USD | 150.000 |

*Table 23. Financial Resources Estimation for the construction of platforms for the accumulation and storage of manure and organic fertilizers production*

### 3.3.5 Risks and Contingency Planning

All activities foreseen in this Technology Action Plan pose low risks and no high risk activities are envisaged. Changes in political priorities are considered also low risks in this case because the entire project duration (42 months) does not expose its outcomes to the risk of changes in political arrangements that could take place on a longer time horizon (e.g. 48 months). Slight delays might occur in the implementation of Action 2. due to adverse weather but that should be contained within the 24-month duration of the dedicated Activity (Activity 2.3). As in similar cases across this TAP, contingency plans for these risks include the proposition of early procurement for goods and materials and securing of funds right from the start of the TAP implementation, whereas insurance plans have been factored in the total budget as part of the restoration of eventual losses in case of extreme weather events causing delays in implementation.

| Actions | Activities | Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies the produce and use of animal manure as organic fertilizers | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |

| | | |
|---|---|---|
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Low |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. Risk level: Low |
| 2. Planning and construction of organic fertilizer production platforms | 2.1 Survey and Mapping of organic fertilizers needs and conditions of established forage farms in Moldova | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium |
| | 2.2 Designing of manure management structures and platforms | Difficult planning and adequate geological conditions and authorization delays. Risk level: low |
| | 2.3 Manure management and organic fertilizer production systems construction | Technical difficulties and cost management. Risk level: Medium |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | Lack of commitment and participation. Risk level: Low |
| | 3.2 Organization of trainings for farmers on management of organic fertilizer production platforms | Lack of prepared and knowledgeable national trainers. Risk level: Medium |

*Table 24. Risks associated with the implementation of measure to build for the accumulation and storage of manure and organic fertilizers production*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies the produce and use of animal manure as organic fertilizers | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing livestock | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |
| 2. Planning and construction of organic fertilizer production platforms | 2.1 Survey and Mapping of organic fertilizers needs and conditions of established forage farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 6 months |
| | 2.2 Designing of manure management structures and platforms | USD 144.000 | Difficult planning and adequate geological conditions. Risk level: low | National Plan for manure management for organic fertilizer production and guidelines | 1 Organic fertilizer production platform plan developed | 12 months |
| | 2.3 Manure management and organic fertilizer production systems construction | USD 1.500.000 | Technical difficulties and cost management. Risk level: Medium | Manure is managed and organic fertilizers are produced | 941,000 tons of manure are turned into organic fertilizers every year | 36 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD 60.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 12 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.2 Organization of trainings for farmers on management of organic fertilizer production platforms | USD 150.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan farmers are familiarized and trained to produce organic fertilizers from manure | 100 farmers trained to manage platoforms for the production of organic fertilizers | 12 months |

*Table 25. Overview of the TAP for the construction of platforms for the accumulation and storage of manure and organic fertilizers production*

## 3.4 Technology Action Plan for improved animal sheds construction

### 3.4.1 Ambition

This TAP involves two activities. The first is the planning and provision of guidance to build or retrofit animal shelters to ensure their welfare in the context of climate change. The guidelines and engineering drawings will be procured for the following livestock classes and farms:
For dairy cattle - 20, 40, 60, 80 and 100 animals.
For fattening pigs – 100, 300, 500, 700 and 1000 animals.
For laying birds – 20 000 and 50 000 heads.
For broiler chickens – 25 000, 50 000, 75 000 and 100 000 heads.
Subsequently, these guidelines will be employed to retrofit existing farms. The level of ambition for the deployment of this technology is proposed in the short term, at demonstration level, and in the long term, at full scale level. At demonstration level, the construction of improved shelters (modernization of microclimate systems) for animals will be implemented in 4 poultry farms in total of which 2 layers (2 halls) and 2 broilers (6 halls) farms. Farms are located in the northern, central and southern parts of Moldova. Currently, these farms produce around 8,000 tons of poultry meat and 12 million eggs annually and there is a downward trend in production during the warm period of the year due to increased heat and cold stress. The implementation of this technology will require building 8 cooling systems to equip the 8 halls with climate control units and dedicated management software and perform a full thermal insulation of the halls. In addition to poultry farms, 2 cattle farms (one for 40 dairy cattle and one for 100 dairy cattle) will also be included in the demonstration phase. A dedicated procurement contract with a local design company will be issued. The estimated cost of each demonstration case study will be comprised between USD 45,000 and 100,000.
At full-scale implementation level, the construction of improved animal shelters will be implemented in 100 farms nationwide (poultry farms, and pig and cattle farms). Farms are distributed equally in the northern, central, and southern parts of Moldova. Currently, these farms produce various animal products (eggs, milk, meat) and there is a tendency to decrease production during warm periods of the year because of increased heat and stress suffered by the animals.

### 3.4.2 Actions and Activities selected for inclusion in the TAP

This TAP targets the creation of a national set of guidelines and their implementation in existing livestock farms to ensure animal welfare despite the impacts of climate change. Actions to implement mandating policies to enhance the requirements for animal welfare are envisaged. Also training of institutions and policymakers to develop such policies is included in the Technology Action Plan. Two key objectives of this TAP are the production of a set of national guidelines for animal welfare, including supporting documentation on how to built new animal shelters, and the retrofitting of existing halls and stables to ensure that existing farmers apply the principles of the guidelines. These two activities will form the bulk of Action 2., the Improved Animal Welfare Program for Moldova. Also farmers, in addition to policymakers will benefit from a dedicated capacity development program to ensure long-term sustainability of the interventions on the ground.

| Actions | Activities |
|---|---|

| | |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of in the field of animal farm constructions and the creation of animal welfare conditions |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. |
| 2. Improved Animal Welfare Program | 2.1 Survey and Mapping of existing livestock halls, shelters, stables and other animal husbandry structures in the country |
| | 2.2 Designing of improved thermally insulated and climate control equipped halls for all livestock farm types in Moldova |
| | 2.3 Retrofitting of existing livestock farms with thermally optimized systems and automated systems for maintaining the microclimate |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector |
| | 3.2 Organization of trainings for farmers on the practices to ensure animal welfare in the context of the changing climate |

*Table 26. Overview of Actions and Activities for improved animal sheds construction*

### 3.4.3 Stakeholders and Timeline for the implementation of TAP

For this TAP, key stakeholders include the associations of producers and the Ministry of Agriculture (MAFI). FAO, will have a key role as implementing partner. In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are two key stakeholders involved in the implementation of this technology:

1. MAFI - Ministry of Agriculture and Food Industry
2. Association of Livestock producers

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture to define the necessary policy amendments to align livestock regulations and targets with the changing priorities imposed by the impacts of climate change. In this context however, the representation of farmers, through their National Associations, is of paramount importance too as exchanges on the needs for the sound sector's development with those directly involved with feed production and livestock activities in general is key to completeness and policymaking inclusiveness. Livestock farmers and their associations will be predominantly engaged with the Improved Animal Welfare Program and capacity building programs (Actions 2 and 3).

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing in the field of animal farm constructions and the creation of animal welfare conditions | FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, Associations of sector, FAO | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | FAO, MAFI | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | MAFI | 12 months |
| 2. Improved Animal Welfare Program | 2.1 Survey and Mapping of existing livestock halls, shelters, stables and other animal husbandry structures in the country | MAFI, Associations of sector, FAO | 6 months |
| | 2.2 Designing of improved thermally insulated and climate control equipped halls for all livestock farm types in Moldova | FAO, MAFI, Association of sector | 12 months |
| | 2.3 Retrofitting of existing livestock farms with thermally optimized systems and automated systems for maintaining the microclimate | FAO, MAFI, Association of sector, farmers | 36 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | MAFI, FAO | 12 months |
| | 3.2 Organization of trainings for farmers on the practices to ensure animal welfare in the context of the changing climate | FAO, Association of sector, National Agency for Food Safety | 12 months |

*Table 27. Overview of Stakeholders and Timeline for improved animal sheds construction*

### 3.4.4 Financial Resources Estimation for Action and Activities

The TAP will have an approximate cost of USD 7,010,000 to provide all farm classes in the country with operational guidelines on how to ensure animal welfare in the context of climate change, develop a supportive policy framework, support policymakers and farmers with the capacity to deliberate such policies and attain certain regulations respectively, and above all to retrofit some 100 farms in Moldova with climate control systems and thermal insulation of their animal sheds. The bulk of the expenditure will be with the retrofitting of existing farms (USD 60,000 per farm, Activity 2.3) for a total budget forecast of USD 6,000,000. This was estimated starting from information in the literature retrieved by the National Consultant. The remaining budget will be represented by operational expenditures and technical assistance funds (USD 1,010,000).

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies developmen t | 1.1 Stocktaking of existing policies in the field of animal farm constructions and the creation of animal welfare conditions s | USD 30.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 |
| 2. Improved Animal Welfare Program | 2.1 Survey and Mapping of existing livestock halls, shelters, stables and other animal husbandry structures in the country | USD 120.000 |
| | 2.2 Designing of improved thermally insulated and climate control equipped halls for all livestock farm types in Moldova | USD 500.000 |
| | 2.3 Retrofitting of existing livestock farms with thermally optimized systems and automated systems for maintaining the microclimate | USD 6.000.000 |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD 60.000 |
| | 3.2 Organization of trainings for farmers on the practices to ensure animal welfare in the context of the changing climate | USD 150.000 |

*Table 28. Financial Resources Estimation for implementing improved animal sheds*

### 3.4.5 Risks and Contingency Planning

All risks for this TAP are considered low.

| Actions | Activities | Risk |
|---|---|---|
| 1. Enabling policies developmen t | 1.1 Stocktaking of existing policies in the field of animal farm constructions and the creation of animal welfare conditions | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |

| | | |
|---|---|---|
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Low |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. Risk level: Low |
| 2. Improved Animal Welfare Program | 2.1 Survey and Mapping of existing livestock halls, shelters, stables and other animal husbandry structures in the country | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Low |
| | 2.2 Designing of improved thermally insulated and climate control equipped halls for all livestock farm types in Moldova | Capacity of national design firms limited. Risk level: low |
| | 2.3 Retrofitting of existing livestock farms with thermally optimized systems and automated systems for maintaining the microclimate | Technical difficulties and cost management. Risk level: low |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | Lack of commitment and participation. Risk level: Low |
| | 3.2 Organization of trainings for farmers on the practices to ensure animal welfare in the context of the changing climate | Lack of prepared and knowledgeable national trainers. Risk level: Low |

*Table 29. Risks associated with the implementation of improved animal sheds*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding in the field of animal farm constructions and the creation of animal welfare conditions | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing livestock | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Low | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Low | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |
| 2. Improved Animal Welfare Program | 2.1 Survey and Mapping of existing livestock halls, shelters, stables and other animal husbandry structures in the country | USD 120.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Low | National Survey and Mapping of feed production database created and accessible | All 100 current farms were mapped, the equipment with microclimate maintenance systems and thermal insulation were defined | 6 months |
| | 2.2 Designing of improved thermally insulated and climate control equipped halls for all livestock farm types in Moldova | USD 500.000 | Capacity of national design firms limited. Risk level: low | National Guidelines on correct construction of animal sheds to ensure welfare in the context of CC | Technical projects for the improvement of halls through thermal insulation and equipped with climate control for all types of livestock farms was produced | 12 months |
| | 2.3 Retrofitting of existing livestock farms with thermally optimized systems and automated systems for maintaining the microclimate | USD 6.000.000 | Technical difficulties and cost management. Risk level: low | Existing livestock halls are retrofitted to ensure animal welfare | 100 existing poultry, pig and cattle shelters of various sizes are retrofitted with modern climate control and insulation systems | 36 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD 60.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 12 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.2 Organization of trainings for farmers on the practices to ensure animal welfare in the context of the changing climate | USD 150.000 | Lack of prepared and knowledgeable national trainers. Risk level: Low | Moldovan farmers are familiarized and trained to ensure animal welfare | 300 farmers trained on animal welfare principles are requirements | 12 months |

*Table 30. Overview of the TAP for improved animal sheds construction*

# CHAPTER – 4 THE HORTICULTURE SUB-SECTOR

## 4.1 Technology Action Plan and Project Ideas for the Horticulture sector

### 4.1.1 Sector overview

Moldova has all natural conditions necessary for intensive development of horticulture. From old times, this branch has been and is likely to remain one of the main pillars of the national agriculture, because it is a source of wealth, leading to efficiency of the entire agricultural sector of the country. Fruit-growing represents one of the main strategic branches of the national economy, accounting for around 40 percent of the agricultural production value. Moldova is a net exporter of fruits, and from 2003 a net importer of vegetables. With vegetables, however, being a net importer is due to the off-season import of products that are grown seasonally (May - November) in Moldova. The local production and marketing season could be extended to provide more competition to imports over a greater time period, provided that the right technologies are implemented. The market structure for fruits and vegetables in Moldova includes the following distribution channels: approximately one hundred open air markets, four wholesale markets, one hundred supermarkets, and a myriad of small kiosks. Vegetable production remains one of the main branches of the horticultural sector in the Republic of Moldova, aimed to ensure the population with fresh vegetables and the canning industry with raw material. Relatively favourable climatic conditions of the country, traditions and experience allows the cultivation of over 60 species of vegetable crops, obtaining high yields and good profit for most vegetable crops. This is confirmed by vegetable development indices registered in the period of 80 – 90s of the last century, when the annual gross harvest of vegetables constituted 1,200 – 1,300 thousand tons, including 700 thousand tons processed by canneries and more than 250 thousand tons exported fresh. However, over the years the vegetable production has dropped considerably. According to statistical data, it declined to 307 thousand tons in 2019. The average annual area of planted open field vegetables is 63 thousand hectares, while the protected area (greenhouses) for growing vegetables has a surface area of 170 hectares, much declined since the former Soviet times, when a much larger market and energy supply conditions supported a supply base 10 times the current one. Vegetable production, greenhouse and open field are scattered throughout the country, based on water accessibility and soil quality. The total annual production of vegetables is about 307 thousand tons excluding potatoes, which alone account for another 177 thousand tons. The main vegetable crops produced in open fields are tomatoes (38 thousand tons), cabbage (18 thousand tons), onions (50 thousand tons), peppers (14 thousand tons), cucumbers (45 thousand tons), pumpkins (33 thousand tons), and other vegetables (144 thousand tons), with averages fluctuating by 10 percent year by year. In greenhouses, total production approximates 2 thousand tons of vegetables. Climate change is expected, among other things, to reduce crop yields across the three agro-ecozones by 10–30% by 2050 (relative to 2013 yields), considering no adaptation measure and given the current water challenges (World Bank, 2019). However, higher temperatures could shift grape cultivation towards the country's northern border and may improve grape quality, by increasing sugar content, which could significantly boost wine quality. Apples however, are more likely to be impacted mainly negatively by these climate change-induced effects. Although the share of national arable land cultivated with tomatoes and apples is low (0.3% and 2.9% respectively) these crops have high added value and relatively competitive productivity but late frosts and hails events have been causing growing concerns for a sustainable future of the sub-sector. The main climate stressors responsible for the impacts mentioned above are again, as in the case of aquaculture and livestock sector, a combination of increased temperatures, changes in the precipitation pattern and extreme events including droughts in summer, but also late frost and hail storms in spring, when horticultural products in Moldova have an important phenological stage. Key technologies prioritized for this sector ranged widely from advanced climate-control systems in greenhouse farming settings, to pollinator's management techniques, as climate change is impacting biodiversity and with it the fertilization capacity of flowering horticultural plants. The intensity of sun irradiation and increasing temperatures call for actions to adapt cropping systems to these changes, through the use of technologies like agri-photovoltaics and agroforestry solutions.

### 4.2 Technology Action Plan for high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency

#### 4.2.1 Ambition

The construction of high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency will be implemented in 25 farms. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce tomatoes, cucumber, cabbage, bell peppers, eggplants and until the 1990s they produced about 40 t/ha for tomato, 50 t/ha for cucumbers, 55 t/ha of cabbage, bell peppers yield some 25 t/ha, eggplants 40 t/ha. Current yields are decreasing as a consequence of increased climate-induced stresses, such as extreme temperature variations, heatwaves and late frost events. The ambition of this TAP at demonstration level is to deploy 25 high-tech greenhouses for tomatoes, cucumber, cabbage, broccoli, cauliflower, strawberry, raspberry, grape, asparagus. This goal will be achieved through the construction of greenhouse shells made of galvanized metal and equipped with best-in-class double glass and PCM walls for maximum climate control. In addition, high-tech greenhouses are equipped with shade cloth, anti-insect nets, irrigation and fertilization system, ventilation system, complete climate control systems, renewable energy powered, equipped with biomass burners for $CO_2$ supply in greenhouses, computerized control system of all systems, artificial intelligence, Internet of Things and home automation controls, for greenhouses with an area of approximately 1,000 $m^2$ for each farm, and the development of programmes to train personnel to operate and maintain the high-tech greenhouses in the case study farms.

#### 4.2.2 Actions and Activities selected for inclusion in the TAP

Well-designed and operated high-tech greenhouses are spreading in several countries in the EU and in the United States as they are capable of providing year round production of vegetables with unparalleled efficiency and total resilience to the impacts of climate change. Planning attentively where to locate these structures is however a key determinant of success. Several limitations currently exist in Moldova for authorizing the building of these structures on agricultural land, and these procedures are often complex, costly and time consuming. Policymaking is necessary to remove these barriers and a dedicated action (Action 1.) is foreseen to this end. An important component of the TAP involves the planning and execution of the procurement of high-tech greenhouse (glasshouses and PCM-RA structures) and their ancillary equipment, including renewable energy sources like agrivoltaics and biomass burners to produce heat and renewable CO2 for injection into the greenhouses. Currently, greenhouse employed in Moldova are for the most part (95%) based on galvanized metal and plastic film cover. Activity 2.3 will substitute up to 25 plastic film greenhouses and recycle agricultural plastics used for greenhouse covers and crop mulching. Capacity building of farmers enrolled in this program is crucial to train them on the sound management of the high-tech greenhouses built and to maximise their output for a resilient horticultural sector in Moldova. The Capacity Building Action (Action 3.) will train greenhouse operators in hardware and software management, problem solving and long-term maintenance of the greenhouses and their systems. Capacity building will also be provided to extension agents and future entrepreneurs as well as scientists through the provision of PhD courses for 10 students (at least 50% of them females) to develop the capacity of high-tech greenhouse managers of tomorrow through classes, study tours and study abroad exchange programs with the main

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European and American Universities working in this field. Lastly, Action 4. will develop solid market opportunities for the uptake of domestic horticulture products through a full value chain approach, to inform and include retailers and consumers as key players for the success of this TAP.

| Actions | Activities |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova |
| | 2.2 Designing of high-tech greenhouse systems and agrovoltaics systems |
| | 2.3 Procurement and construction of high-tech greenhouses |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program |
| | 3.2 Training of farmers on use and maintenance of high-tech greenhouses |
| 4. Market access | 4.1. Market mapping analysis |
| | 4.2. Market access development |

*Table 31. Overview of Actions and Activities for the implementation of high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency*

#### 4.2.3 Stakeholders and Timeline for the implementation of TAP

FAO, will have a key role as implementing partner. In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are four key stakeholders involved in the implementation of this technology, key stakeholders include the associations of producers and the Ministry of Agriculture and Food Industry (MAFI):

1. Ministry of Agriculture and Food Industry (MAFI)
2. Association Moldova Fruct (AMF)
3. Association of Producers and Exporters of Table Grapes (APETG)
4. Technical University of Moldova (TUM)
5. The Chamber of Commerce and Industry of the Republic of Moldova (CCI RM)

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture to define the necessary policy amendments to align horticulture regulations and targets with the changing priorities imposed by the impacts of climate change. In this context however, the representation of farmers, through their National Associations, is of paramount importance too as exchanges on the needs for the sound sector's development with those directly involved with vegetables production and horticulture activities in general is key to completeness and policymaking inclusiveness. Horticulture farmers and their associations will be predominantly engaged with the Deployment of High-Tech Greenhouses and capacity building programs (Actions 2 and 3), together with TUM for the selection of excellence students and PhD candidates. Market access actions will see the contribution of the Chamber of Commerce and Industry of the Republic of Moldova (CCI RM) to convey key food market actors and support the establishment of partnerships and supply contracts.

The TAP will have an overall duration of 48 months and the table below shows the expected duration of each activity.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | MAFI, FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, TUM, AMF, APETG, CCI RM | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | MAFI, FAO | 6 months |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | MAFI | 12 months |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | AMF, APETG MAFI | 3 months |

| | | | |
|---|---|---|---|
| | 2.2 Designing of high-tech greenhouse systems and agrovoltaics systems | FAO, TUM | 12 months |
| | 2.3 Procurement and construction of high-tech greenhouses | FAO, MAFI, AMF, APETG, | 24 months |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | FAO, TUM | 48 months |
| | 3.2 Training of farmers on use and maintenance of high-tech greenhouses | FAO, MAFI, TUM | 12 months |
| 4. Market access | 4.1. Market mapping analysis | CCI RM, AMF, APETG, | 12 months |
| | 4.2. Market access development | CCI RM, MAFI, FAO | 48 months |

*Table 32. Overview of Stakeholders and Timeline for the implementation of high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency*

#### 4.2.4 Financial Resources Estimation for Action and Activities

The TAP will have an approximate cost of USD 11,516,000 to build a modern and climate resilient protected agriculture sector in the country with operational guidelines and trained staff to ensure stable, efficient, sustainable, and economically viable vegetable supply in the context of climate change. This work will include the development of a supportive policy framework, through desk work and in-person workshops, support policymakers and farmers with the capacity to deliberate such policies and attain certain regulations respectively, and above all to retrofit some 25 farms in Moldova with high-tech greenhouses equipped with efficient climate control systems and renewable energy systems. The bulk of the expenditure will be with the deployment of 25 high-tech greenhouses and retrofitting of polluting plastic film greenhouses (USD 360,000 per farm, Activity 2.3) for a total budget forecast of USD 9,000,000. This was estimated starting from information in the literature retrieved by the National Consultant and the Technology Factsheets of the prioritized technology. Capacity building to ensure long-term sustainability of operations of protected agriculture in Moldova will also require substantial resources to support the studies of 10 PhD students (at least 50% of them females) and their international exchanges to deliver the next generation of technicians and experts to Moldova (Activity 3.1) for an estimated budget of USD 1,730,000.

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | USD 30.000 |

| | | |
|---|---|---|
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | USD 90.000 |
| | 2.2 Designing of high-tech greenhouse systems and agrovoltaics systems | USD 144.000 |
| | 2.3 Procurement and construction of high-tech greenhouses | USD 9.000.000 |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | USD 1.730.000 |
| | 3.2 Training of farmers on use and maintenance of high-tech greenhouses | USD 150.000 |
| 4. Market access | 4.1. Market mapping analysis | USD 108.000 |
| | 4.2. Market access development | USD 294.000 |

*Table 33. Financial Resources Estimation for high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency*

#### 4.2.5 Risks and Contingency Planning

Most activities foreseen in this TAP show low risks to their implementation, with some noteworthy exceptions being Action 1. due to possible political instability and lack of recognition of the importance of the horticulture sector, and Activity 3.2 due to possible lack of nationally available experts for training local staff. In the case of Action 1. countermeasures include the development of accurate amendments to key policy sections rather than changes to encompass broad policy statutes. This is expected to lower even further the magnitude of this risk. Costs volatility and authorization procedures should be kept in check by early procurement and parallel policy work when developing activities under Action 2. Last but not least, the support of international Organizations like FAO is key to develop a sound Capacity Building program that is not impeded by lack of nationally available experts and connections but that thrives from the extended network of experts and outreach that FAO can deliver in this context to connect TUM with world-class research centers and top universities in Europe and the United States.

| Actions | Activities | Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Medium |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. Risk level: Medium |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium |
| | 2.2 Designing of high-tech greenhouse systems and agrovoltaics systems | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. |
| | 2.3 Procurement and construction of high-tech greenhouses | Technical difficulties and cost management. Risk level: Medium |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | No risk foreseen |
| | 3.2 Training of farmers on use and maintenance of high-tech greenhouses | Lack of prepared and knowledgeable national trainers. Risk level: Medium |
| 4. Market access | 4.1. Market mapping analysis | Prices volatility of imported products might jeopardize the results of the study. Risk level: low. |

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|---|---|---|
| | 4.2. Market access development | Lack of GD qualified and interested actors: Risk level: Low. |

*Table 34. Risks associated with the implementation of high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing horticulture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 3 months |
| | 2.2 Designing of high-tech greenhouse systems and agrovoltaics systems | USD 144.000 | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. | Availability of high-tech greenhouses and agrivoltaics system designs and construction plans | Guidelines on high-tech greenhouses and agrivoltaics system designs and construction adapted to Moldovan context | 12 months |
| | 2.3 Procurement and construction of high-tech greenhouses | USD 9.000.000 | Technical difficulties and cost management. Risk level: Medium | High-tech glasshouses with PCM-RA walls and complete climate control systems, including off-grid renewable energy sources | 25 high-tech greenhouses are built and functioning, together with agrivoltaics systems to supply renewable energy off-grid | 24 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | USD 1.730.000 | No risk foreseen | PhD courses and study tours to world-class greenhouse producers of vegetables in EU and in the US are organized to share knowledge and train scientists from Moldova | 10 PhD students completed specialized education courses, attending exchanges and study tours, and are employed as extension agents for knowledge transfer in Moldova | 48 months |
| | 3.2 Training of farmers on use and maintenance of high-tech greenhouses | USD 150.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan vegetable producers are familiarized and trained to manage production in high-tech greenhouses | 100 farmers are trained to manage full production cycles in high-tech greenhouses | 12 months |
| 4. Market access | 4.1. Market mapping analysis | USD 108.000 | Prices volatility of imported products might jeopardize the results of the study. Risk level: low. | Development of a detailed horticultural products market mapping study | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 4.2. Market access development | USD 294.000 | Lack of GD qualified and interested actors: Risk level: Low. | Market access for sustainable horticulture products from high-tech greenhouses is enhanced | At least 10 retailers in Moldova established long-term direct-purchase supply contracts with producers | 48 months |

*Table 35. Overview of the TAP for high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency*

## 4.3 Technology Action Plan for modern irrigation systems

### 4.3.1 Ambition

The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full scale level. At demonstration level, modern irrigation systems will be implemented in 4 horticulture farms. The farms are located in the northern, central and southern part of Moldova. Currently, these farms have yields o about 50 t/ha for tomatoes, aubergine – 50 t/ha, potatoes – 15 t/ha, apples – 25 t/ha, strawberries – 10 t/ha, raspberries – 15 t/ha, table grapes – 20 t/ha and a decreasing production trend is observed compared to 20-25 years ago, as a consequence of increased climate-induced stresses. The ambition of this TAP at demonstration level is to deploy 4 modern irrigation systems for tomato, eggplant, cucumber, cabbage, strawberry, blackberry, apple, cherry, grape covering some 200 hectares. This goal will be achieved through the construction of water catchment systems, water storage basin, water filtration system, distribution system, fertilization system, drippers, renewable energy systems, for 50 ha for each farm, and the development of 10 programmes to train personnel to operate and maintain the modern irrigation systems in the case study farms.
At full scale level the construction of modern irrigation systems will be implemented in 30 horticulture farms. The farms are located in the northern, central and southern part of Moldova, with a predominance in the the central and southern part of the country. The construction of 30 small irrigation systems connected to the existing Central Irrigation Systems will encompass the creation of rainwater catchment systems and storage basins to be used for irrigation lined with geotextile and protective polypropylene lining with a storage capacity of up to 25,000 $m^3$ each and adduction pipelines to the beneficiaries' lands.

### 4.3.2 Actions and Activities selected for inclusion in the TAP

The results of the BAEF report highlighted the measures to enable the deployment of modern irrigation systems in Moldova. Barriers are mainly financial, and among the non-financial barriers, technical aspects are the predominant hurdle to implementation, followed by capacity-related issues and finally institutional inefficiencies, especially with regard to water management for irrigation specifically in horticultural areas of the country. In Moldova, there is lack of technical knowledge on the design of modern irrigation systems and particularly on the rainwater harvesting and water banking solutions that accompany modern sustainable irrigation systems worldwide, in a context of adaptation to climate change. The construction of these structures, reservoirs and the renewable energy sources to power the irrigation system is another key activity that requires both financial and technical support. This TAP considers the measures to address the aforementioned barriers under Action 1.
The capacity of local stakeholders to manage these improved systems to store and release water for irrigation requires development, in the form of two activities targeting two separated groups: district or water consortium managers on one hand, and direct users, on the other hand. The two sets of skills to be developed are broadly different, the former being on the management of water storage and release, water levels and weather conditions forecasting and response, the latter being on the management of water distribution systems on-farm, sprinklers and piping infrastructure, to avoid clogging and ensure maximum efficiency. Water management consortia do not exist in many areas of Moldova where horticulture is practiced and where there is the growing need for the establishment of adaptation actions to cope with the impacts of climate change. The creation of these Consortia will be part of a dedicated activity under Action 3 of this TAP.

| Actions | Activities |
|---|---|
| 1. Deployment of Modern Irrigation Systems for increased resilience of horticulture sector | 1.1 Survey and Mapping of horticulture farms in Moldova |
| | 1.2 Designing of modern irrigation systems and RE pumping stations |
| | 1.3 Construction of modern irrigation systems |
| 2. Capacity building | 2.1 Study tours, student exchanges, extension agents development program |
| | 2.2 Training of farmers on use and maintenance of modern irrigation systems |
| 3. Institutional and Associations Development | 3.1. Strengthening existing and future Associations of Producers |
| | 3.2. Support to the creation of Water Management Consortia |

*Table 36. Overview of Actions and Activities for the implementation of modern irrigation systems*

### 4.3.3 Stakeholders and Timeline for the implementation of TAP

For this TAP, key stakeholders include the associations of producers and the Ministry of Agriculture and Food Industry (MAFI). FAO, will have a key role as implementing partner. Key national stakeholders involved in the implementation of this technology include:

1. MAFI - Ministry of Agriculture and Food Industry
2. Association Moldova Fruct (AMF)
3. Association of Producers and Exporters of Table Grapes (APETG)
4. The Federation of Farmers from Moldova (FFM)
5. Technical University of Moldova (TUM)
6. Moldova Waters Agency (MWA)

Horticulture farmers and their associations will be predominantly engaged with the Deployment of the irrigation systems (Action 1.) and the development of the capacity to manage on-farm irrigation systems together with the TUM. Institutional capacity and the support to existing and new associations and authorities to manage irrigation systems will see a pivotal role of MAFI.

The TAP will have an overall duration of 48 months and the table below shows the expected duration of each activity.

| Actions | Activities | Timeline |
|---|---|---|
| 1. Deployment of Modern Irrigation Systems for increased resilience of horticulture sector | 1.1 Survey and Mapping of horticulture farms in Moldova | 3 months |
| | 1.2 Designing of modern irrigation systems and RE pumping stations | 12 months |
| | 1.3 Construction of modern irrigation systems | 24 months |
| 2. Capacity building | 2.1 Study tours, student exchanges, extension agents development program | 6 months |
| | 2.2 Training of farmers on use and maintenance of modern irrigation systems | 12 months |
| 3. Institutional and Associations Development | 3.1. Strengthening existing and future Associations of Producers | 12 months |
| | 3.2. Support to the creation of Water Management Consortia | 24 months |

*Table 37. Overview of Stakeholders and Timeline for the implementation of modern irrigation systems*

#### 4.3.4 Financial Resources Estimation for Action and Activities

The TAP will have an approximate cost of USD 11,851,000 to build a modern irrigation systems in 30 farms (100 ha each, for a total of 3,000 ha nationwide) across the central and southern part of the country. This work will lead to restoring yields and sustain them during drought years, and will foresee expenditure for the construction of water storage structures (reservoirs) and solar pumping stations. This activity will require the vast majority of the funds estimated for the TAP, at USD 10,500,000. Production will be restored to year 2000 levels, at some 25% higher than current. The long-term sustainability of this TAP is invariably linked to the creation of Water Management Consortia (WMC) that will ensure that the technologies deployed are maintained efficiently for at least 25 years. This activity will require a budget of USD 486,000 but will generate increased revenues that in turn are going to provide funds for funding WMC beyond the 48-month TAP implementation period.

| Actions | Activities | Budget |
|---|---|---|
| 1. Deployment of Modern Irrigation Systems for increased resilience of horticulture sector | 1.1 Survey and Mapping of horticulture farms in Moldova | USD 132.000 |
| | 1.2 Designing of modern irrigation systems and RE pumping stations | USD 312.000 |
| | 1.3 Construction of modern irrigation systems | USD 10.500.000 |
| 2. Capacity building | 2.1 Study tours, student exchanges, extension agents development program | USD 25.000 |
| | 2.2 Training of farmers on use and maintenance of modern irrigation systems | USD 120.000 |
| 3. Institutional and Associations Development | 3.1. Strengthening existing and future Associations of Producers | USD 276.000 |
| | 3.2. Support to the creation of Water Management Consortia | USD 486.000 |

*Table 38. Financial Resources Estimation for modern irrigation systems*

#### 4.3.5 Risks and Contingency Planning

Most activities foreseen in this TAP show low risks to their implementation, with some noteworthy exceptions being Action 1., Activity 1.3 (Construction of modern irrigation systems) due to price volatility, cost management, and technical difficulties. Costs volatility and authorization procedures should be kept in check by early procurement and parallel policy work when developing activities under Action 1 but risk level is assessed as Medium. The support of international Organizations like FAO is key to develop a sound Capacity Building program that is not impeded by lack of nationally available experts and connections but that thrives from the extended network of experts and outreach that FAO can deliver in this context to connect TUM with world-class experts and deliver effective training to Moldovan farmers and irrigation consortia managers.

| Actions | Activities | Risks |
|---|---|---|
| 1. Deployment of Modern Irrigation Systems for increased resilience of horticulture sector | 1.1 Survey and Mapping of horticulture farms in Moldova | Delays in recruiting readily available qualified staff and logistical difficulties. Risk level: Low |
| | 1.2 Designing of modern irrigation systems and RE pumping stations | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. |
| | 1.3 Construction of modern irrigation systems | Technical difficulties and cost management. Risk level: Medium |
| 2. Capacity building | 2.1 Study tours, student exchanges, extension agents development program | No risk foreseen |
| | 2.2 Training of farmers on use and maintenance of modern irrigation systems | Lack of prepared and knowledgeable national trainers. Risk level: Low |
| 3. Institutional and Associations Development | 3.1. Strengthening existing and future Associations of Producers | Low participation of horticulture producers. Risk level: Low. |
| | 3.2. Support to the creation of Water Management Consortia | Low participation of horticulture producers. Risk level: Low. |

*Table 39. Risks associated with the implementation of modern irrigation systems*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Deployment of Modern Irrigation Systems for increased resilience of horticulture sector | 1.1 Survey and Mapping of horticulture farms in Moldova | USD 132.000 | Delays in recruiting readily available qualified staff and logistical difficulties. Risk level: Low | National Survey and Mapping of feed production database created and accessible | All horticulture farms have been mapped, baseline and target irrigation regimes defined | 3 months |
| | 1.2 Designing of modern irrigation systems and RE pumping stations | USD 312.000 | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. | Availability of modern irrigation system designs and construction plans | Guidelines on modern irrigation system designs and construction adapted to Moldovan context | 12 months |
| | 1.3 Construction of modern irrigation systems | USD 10.500.000 | Technical difficulties and cost management. Risk level: Medium | Modern irrigation systems are deployed | 30 modern irrigation systems including water reservoirs of 25,000 m3 each and drip irrigation infrastructure covering 3,000 ha of horticultural land in Moldova are deployed and fully functional | 24 months |
| 2. Capacity building | 2.1 Study tours, student exchanges, extension agents development program | USD 25.000 | No risk foreseen | 2 study tours to water management champion institutions are organized to share knowledge and train trainers from Moldova | 2 Scientists are trained to become trainers in modern irrigation systems management and maintenance | 6 months |
| | 2.2 Training of farmers on use and maintenance of modern irrigation systems | USD 120.000 | Lack of prepared and knowledgeable national trainers. Risk level: Low | Moldovan vegetable producers are familiarized and trained to manage modern irrigation systems | 30 farmers are trained to manage vegetable production using modern irrigation systems | 12 months |
| 3. Institutional and Associations Development | 3.1. Strengthening existing and future Associations of Producers | USD 276.000 | Low participation of horticulture producers. Risk level: Low. | Associations of Producers of horticulture products are strengthened | 1 Association of Producers is strengthened in terms of technical staff and authority on water management issues in the context of CCA | 12 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3.2. Support to the creation of Water Management Consortia | USD 486.000 | Low participation of horticulture producers. Risk level: Low. | Water Management Consortia are formed and staffed | At least 2 Water Management Consortia are formed in the Center and South of the Country | 24 months |

*Table 40. Overview of the TAP for modern irrigation systems*

## 4.4 Technology Action Plan for hydroponics with recyclable solutions

### 4.4.1 Ambition

The construction of 50 hydroponic greenhouses, located in disadvantaged regions of the country, especially in the localities in the south of the country, with an average area of 1000 $m^2$ each. Greenhouse features: glass 960×R250 – USD 85,000, height 4.50m, roof ventilation system – USD 15,000, “sandwich” type walls and triple layer insulated roof – USD 65,000, suspended culture troughs – USD 10,000 , micro-sprinkler system – USD 34,000, cold room for storage – USD 23,000, processing area, water storage tank and fertigation – USD 20,000, pumping station and fertilizer mixing with frequency variators – USD 36,000, heating equipment on three levels – USD 13,000. The investment value per 1 $m^2$ is – USD 280. The estimated total value is USD 13,850,000. An estimated production of 1250 tons of tomatoes or 300 tons of cucumbers in two production cycles or 100 tons of strawberries, salads, spinach, greens, etc. This technology is suitable for growing fruits and vegetables in two or more production cycles per year.

### 4.4.2 Actions and Activities selected for inclusion in the TAP

Hydroponics is a soilless farming method that can contribute to meeting the global food demand, improving food sustainability as well as ensuring food availability in a novel high efficiency yet low maintenance way. Especially for leafy vegetables (Lettuce, Chicory, Anise, badian, fennel, coriander, etc) yields of the controlled environment are significantly higher than in open-air setups, in particular during adverse and extreme climate conditions. Moreover, hydroponics for leafy vegetables allows multiple continuous growing cycles in a year compared to one or two for most vegetables grown as summer crops in Moldova.
As in the case of high-tech greenhouses, since hydroponics are mostly built inside greenhouses, several limitations currently exist in Moldova for authorizing the building of these structures on agricultural land, and these procedures are often complex, costly and authorization can be time consuming. Policymaking is necessary to remove these barriers and a dedicated action (Action 1.) is foreseen to this end. An important component of the TAP involves the planning and execution of the procurement of hydroponic systems and their ancillary equipment, including hydroponics racks, pumps, lighting, water circulation and nutrient dosage systems, biomass burners to produce heat and renewable $CO2$ for injection into the greenhouses. Currently, only one commercial operator in Moldova uses hydroponics systems to market horticultural products. Activity 2.3 will build up to 50 new hydroponic systems is southern, most economically depressed locations of Moldova. Capacity building of farmers enrolled in this program is crucial to train them on the sound management of the hydroponic systems built and to maximise their output for a resilient horticultural sector in Moldova. The Capacity Building Action (Action 3.) will train hydroponic operators in hardware and software management, problem solving and long-term maintenance of the equipment and structures. Capacity building will also be provided to extension agents and future entrepreneurs as well as scientists through the provision of PhD courses for 3 students (at least 50% of them females) to develop the capacity of hydroponic systems managers of tomorrow through classes, study tours and study abroad exchange programs with the main European and American Universities working in this field. Lastly, Action 4. will develop solid market opportunities for the uptake of domestic horticulture products through a full value chain approach, to inform and include retailers and consumers as key players for the success of this TAP.

| Actions | Activities |
| --- | --- |

| | |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova |
| | 2.2 Designing of hydroponics systems |
| | 2.3 Procurement and construction of hydroponic systems in Moldova |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program |
| | 3.2 Training of farmers on use and maintenance of hydroponic systems |
| 4. Market access | 4.1. Market mapping analysis |
| | 4.2. Market access development |

*Table 41. Overview of Actions and Activities for the implementation of hydroponics with recyclable solutions*

#### 4.4.3 Stakeholders and Timeline for the implementation of TAP

FAO, will have a key role as implementing partner. In addition to FAO, that will coordinate activities in the field and provide necessary technical assistance, there are four key stakeholders involved in the implementation of this technology, key stakeholders include the associations of producers and the Ministry of Agriculture and Food Industry (MAFI):

1. Ministry of Agriculture and Food Industry (MAFI)

2. Association Moldova Fruct (AMF)
3. Association of Producers and Exporters of Table Grapes (APETG)
4. The Federation of Farmers from Moldova
5. Technical University of Moldova (TUM)
6. The Chamber of Commerce and Industry of the Republic of Moldova (CCI RM)

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture to define the necessary policy amendments to align horticulture regulations and targets with the changing priorities imposed by the impacts of climate change. In this context however, the representation of farmers, through their National Associations, is of paramount importance too as exchanges on the needs for the sound sector's development with those directly involved with vegetables production and horticulture activities in general is key to completeness and policymaking inclusiveness. Horticulture farmers and their associations will be predominantly engaged with the Deployment of hydroponics systems and capacity building programs (Actions 2 and 3), together with TUM for the selection of excellence students and PhD candidates. Market access actions will see the contribution of the Chamber of Commerce and Industry of the Republic of Moldova (CCI RM) to convey key food market actors and support the establishment of partnerships and supply contracts.

The TAP will have an overall duration of 48 months and the table below shows the expected duration of each activity.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | MAFI, FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, TUM, AMF, APETG, FFM, CCI RM | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | MAFI, FAO | 6 months |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | MAFI | 12 months |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | AMF, APETG, FFM, MAFI | 3 months |
| | 2.2 Designing of hydroponics systems | FAO, TUM | 12 months |
| | 2.3 Procurement and construction of hydroponic systems in Moldova | FAO, MAFI, AMF, APETG, FFM | 24 months |

| | | | |
|---|---|---|---|
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | FAO, TUM | 48 months |
| | 3.2 Training of farmers on use and maintenance of hydroponic systems | FAO, MAFI, TUM | 12 months |
| 4. Market access | 4.1. Market mapping analysis | CCI RM, AMF, APETG, FFM | 12 months |
| | 4.2. Market access development | CCI RM, MAFI, FAO | 48 months |

*Table 42. Overview of Stakeholders and Timeline for the implementation of hydroponics with recyclable solutions*

#### 4.4.4 Financial Resources Estimation for Action and Activities

The TAP will have an approximate cost of USD 16,410,000 to build a sizeable hydroponic vegetable production sector in the country with operational guidelines and trained staff to ensure stable, efficient, sustainable, and economically viable supply in the context of climate change. This work will include the development of a supportive policy framework, through desk work and in-person workshops, support policymakers and farmers with the capacity to deliberate such policies and attain certain regulations respectively, and above all the construction from the ground up of 50 hydroponic farms in Moldova. The bulk of the expenditure will be with the deployment of 50 hydroponic greenhouses (USD 300,000 per farm, Activity 2.3) for a total budget forecast of USD 15,000,000. This was estimated starting from information in the literature retrieved by the National Consultant and the Technology Factsheets of the prioritized technology. Capacity building to ensure long-term sustainability of operations of protected agriculture in Moldova will also require substantial resources to support the studies of 3 PhD students (at least 2 of them females) and their international exchanges to deliver the next generation of technicians and experts to Moldova (Activity 3.1) for an estimated budget of USD 519,000.

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | USD 30.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 |

| | | |
|---|---|---|
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | USD 90.000 |
| | 2.2 Designing of hydroponics systems | USD 144.000 |
| | 2.3 Procurement and construction of hydroponic systems in Moldova | USD 15.000.000 |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | USD 519.000 |
| | 3.2 Training of farmers on use and maintenance of hydroponic systems | USD 75.000 |
| 4. Market access | 4.1. Market mapping analysis | USD 108.000 |
| | 4.2. Market access development | USD 294.000 |

*Table 43. Financial Resources Estimation for hydroponics with recyclable solutions*

### 4.4.5 Risks and Contingency Planning

Most activities foreseen in this TAP show low risks to their implementation, with some noteworthy exceptions being Action 1. due to possible political instability and lack of recognition of the importance of the horticulture sector, and Activity 3.2 due to possible lack of nationally available experts for training local staff. In the case of Action 1. countermeasures include the development of accurate amendments to key policy sections rather than changes to encompass broad policy statutes. This is expected to lower even further the magnitude of this risk. Costs volatility and authorization procedures should be kept in check by early procurement and parallel policy work when developing activities under Action 2. Last but not least, the support of international Organizations like FAO is key to develop a sound Capacity Building program that is not impeded by lack of nationally available experts and connections but that thrives from the extended network of experts and outreach that FAO can deliver in this context to connect TUM with world-class research centers and top universities in Europe and the United States.

| Actions | Activities | Risks |
|---|---|---|

| | | |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Medium |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | Change of country priorities and administrative structure. Risk level: Medium |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium |
| | 2.2 Designing of hydroponics systems | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. |
| | 2.3 Procurement and construction of hydroponic systems in Moldova | Technical difficulties and cost management. Risk level: Medium |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | No risk foreseen |
| | 3.2 Training of farmers on use and maintenance of hydroponic systems | Lack of prepared and knowledgeable national trainers. Risk level: Medium |
| 4. Market access | 4.1. Market mapping analysis | Prices volatility of imported products might jeopardize the results of the study. Risk level: low. |
| | 4.2. Market access development | Lack of GD qualified and interested actors: Risk level: Low. |

*Table 44. Risks associated with the implementation of hydroponics with recyclable solutions*

Food and Agriculture Organization of the United Nations

GREEN CLIMATE FUND

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing horticulture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 3 months |
| | 2.2 Designing of hydroponics systems | USD 144.000 | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. | Availability of hydroponics systems designs and construction plans | Guidelines on hydroponics systems designs and construction adapted to Moldovan context | 12 months |
| | 2.3 Procurement and construction of hydroponic systems in Moldova | USD 15.000.000 | Technical difficulties and cost management. Risk level: Medium | Complete hydroponics systems are built | 50 hydroponics systems are built and functioning | 24 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | USD 519.000 | No risk foreseen | PhD courses and study tours to world-class greenhouse producers of vegetables in EU and in the US are organized to share knowledge and train scientists from Moldova | 3 PhD students (2 females) completed specialized education courses, attending exchanges and study tours, and are employed as extension agents for knowledge transfer in Moldova | 48 months |
| | 3.2 Training of farmers on use and maintenance of hydroponic systems | USD 75.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan vegetable producers are familiarized and trained to manage production in hydroponics systems | 50 farmers are trained to manage full production cycles in hydroponics systems | 12 months |
| 4. Market access | 4.1. Market mapping analysis | USD 108.000 | Prices volatility of imported products might jeopardize the results of the study. Risk level: low. | Development of a detailed horticultural products market mapping study | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 4.2. Market access development | USD 294.000 | Lack of GD qualified and interested actors: Risk level: Low. | Market access for sustainable horticulture products from high-tech greenhouses is enhanced | At least 10 retailers in Moldova established long-term direct-purchase supply contracts with producers | 48 months |

*Table 45. Overview of the TAP for hydroponics with recyclable solutions*

# CHAPTER – 5 THE CEREALS SUB-SECTOR

## 5.1 Technology Action Plan and Project Ideas for the Cereals sector

### 5.1.1 Sector overview

Wheat, barley and maize, are key food crops produced in Moldova. The assessment carried out estimated that these crops cover the majority of the agricultural land in the country and make up the majority of the production of agricultural commodities (source FAOSTAT, 2022). Wheat and Maize are the two most common crops in Moldova by surface area, with about 17 and 22% of total harvested agricultural land respectively, cumulatively making up to one third of all arable land in the country. That being said, their productivity levels are rather low, especially if compared to neighboring Ukraine. Soil quality in Moldova is decaying, and the cultivation of these annual crops through tillage and erosion deplete the organic carbon content of the soils. This fact is not a direct consequence of climate change, as farming practices adopted since the Soviet Union's times without a systemic approach to farm management, including the landscape organization of the territory, led to the drastic reduction of soil organic matter and with it, of soil functions, as a consequence of excessive use of inputs and tillage. Excluding forage crops from the structure of sowing areas, especially of perennial herbaceous crops from the crop rotations after 1990, together with the disintegration of animal and crop husbandries, also have contributed to the depletion of soil fertility.

Harvesting of the winter cereal crops, mainly wheat, is finalized in the month of August, while harvesting of spring crops, mainly maize, is concluded by late November. A severe drought affected crop yields in the 2021/22 season. In addition, very high fertilizer and fuel prices constrained farmers' access to agricultural inputs, with a reduction of fertilizer application rates and a negative impact on yields. As a result the 2022 aggregate cereal output is estimated at about 1.8 million tons, 46 percent below the five-year average level and the lowest volume on record for the country. Wheat output is set at 872 000 tons, over 20 percent below average, and production of maize is estimated at 761 000 tons, 60 percent below the average level.

Planting of the 2023 winter cereal crops took place in October 2022. Near-average rainfall amounts in August and September 2022 partially restored moisture reserves in the arable layer of the soil, but severe moisture deficits persisted, as of October, in the lower soil layers, with likely adverse effects on the start of the 2022/23 cropping season.

The changing climate is exacerbating the negative situation by reducing the opportunities of soils to restore their productive potential. Cereals, especially wheat, are growingly being cultivated in poorly planned rotations, the logic being the product market price of the season rather than the long-term preservation of the productive potential of the land. As a result of these factors, necessary actions are needed for the cereals sector to be more resilient to long-term impacts of mismanagement and climate determinants. Climate-smart agriculture, especially the careful interpretation of correct rotations for the specific conditions of the soil coupled with minimal tillage and soil structure destructive actions (e.g. tillage) have been prominently proposed by the TNA Team. Continuous cover crops and perennial forage in intercropping schemes or in extended rotations were two additional key practices considered to have a high potential to adapt this sub-sector to the changing climate. Reduced fertility of cereal crop's flowers is another consequence of increased temperature observed in Moldova and extreme climatic events, which in addition also weaken growing plants and expose them to more aggressive pathogens. Measures to control soil erosion (e.g. shelterbelts) are another impellent need to adapt Moldova cereals production to the impacts of climate change.

## 5.2 Technology Action Plan for Conservation Agriculture

### 5.2.1 Ambition

The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full scale level. At demonstration level, Conservation Agriculture will be implemented in 20 farms of an average surface of 58,000 ha. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce 58,000 ha with a productivity of 3,4 t/ha of winter wheat and a decreasing yield trend is observed compared to 3 years ago, when yields were comparatively higher at 3,6 t/ha on average. The ambition of this TAP at demonstration level is to increase yields from the current average of 3,0 t/ha to 3.6 t/ha.

At full scale level implementation, this technology is targeted to interest a total of 340,000 ha and an estimated volume of approximately 1,565,000 tons of cereals. These comprise established cereal farms in the northern, central and southern part of Moldova, distributed for a 70% in the North, 15% in the Center and 15% in the South of the country. Currently, these farms produce winter wheat with a yield of approximately 3,0 t/ha, sunflower at 1,5 t/ha and maize at a yield of 3.5 t/ha showing a marked decrease in yields compared to year 2020, when yields were comparatively higher at - 3,5 t/ha for winter wheat; 2,0 t/ha for sunflower and 4.5 t/ha of maize on average. The ambition of this TAP at national level is to establish the conditions that sustain optimal yields even in the face of adverse climatic conditions to 2020 levels.

### 5.2.2 Actions and Activities selected for inclusion in the TAP

As indicated in the Barrier Analysis and Enabling Framework report, the implementation of Conservation Agriculture (CA) faces difficulties at many levels, and actions tackle them are proposed in this TAP, based on the full scale of intervention. Existing policies will be reviewed and discussed in order to find opportunities to favor virtuous farmers in adapting to climate change. This will entail also to develop amendments to supportive policies that currently subsidize conventional agriculture to incorporate externalities as a limiting factor in obtaining subsidies and divert those subsidies to farmers who employ CA techniques. Action 1, on policy development, is a necessary step to enable the deployment of CA equipment and technologies on a large scale in Moldova, through Action 2 (National Conservation Agriculture Programme). This Action is composed of four Activities, leading to the creation of the supporting structures that enable effective deployment of CA in Moldova, from the strengthening of existing and the creation of further CA farmer associations, to the support to the development of national breeds and varieties better adapted to CA growing technologies like direct sowing. This work will be carried out with the support of the State Agrarian University of Moldova and international wheat breeding and research centers of excellence. Activity 2.4 will consist in the creation of an credit infrastructure to lend specifically to farmers engaged in CA for the purchase of machinery for no-till. The capacity to manage CA will be developed in the dedicated Action (Action 3. – Capacity Building) which also includes an Activity on Soil Stewardship, to embrace all cereals farmers in Moldova and reach out to other categories of farmers as well, on the importance of managing properly soil resources, reduce quality loss, and deliver to future generations healthy and productive soils that are in optimal conditions, despite the impacts of CC. Along with building the capacity of farmers, an awareness program is also proposed to reach additional stakeholders, key value chain ones, as well as consumers and common citizens. Action 4, in fact, will touch upon policymakers, product retailers and consumers. The TAP will need to be monitored over time to enable changes and adjustments along the way. A dedicated MRV system will be developed in collaboration with the Ministry of Agriculture (MAFI) to ensure alignment with policy directives and the continuous improvement of the cereals sector.

| Actions | Activities |
| --- | --- |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. |
| 2. National Conservation Agriculture Programme | 2.1 Cereal farmers associations strengthening and representation enhancement |
| | 2.2 Creation and upgrading of 5 wheat breeding facilities in the country |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national cereals sector |
| | 2.4 Credit support to acquisition of direct seeding drillers for Conservation Agriculture |
| 3. Capacity building on CA and soil stewardship | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the cereals sector |
| | 3.2 Organization of trainings for cereals farmers on improved techniques and management for wheat production in CA |
| | 3.3 Nationwide campaign on soil stewardship for long-term ownership of land and responsible management of natural resources |
| 4. Promoting knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national cereals sector to retailers and consumers. |

| | |
|---|---|
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring cereals farms sustainability performance |
| | 5.2. Monitoring campaign and analysis of introduced technology |

*Table 46. Overview of Actions and Activities for the implementation of Conservation Agriculture*

### 5.2.3 Stakeholders and Timeline for the implementation of TAP

Conservation agriculture is already practiced in certain areas of Moldova, and a growing community of practice exists. However, key stakeholders involved in applying Conservation Agriculture should include a broad set of institutions especially for the provision of support to farmers in the various cereal production areas of the country. Mainly Universities and Research institutions should have this role. In addition, key stakeholders to the large scale implementation of this technology are the line Ministries (MAFI and MoEF). Associations of producers and farmers are crucial actors in this TAP but to complete the activities proposed National as well as International Development Banks are required to provide the financial support and mechanism to enable loan disbursement and repayment in the context of the project. The complete list of key stakeholders to be involved in the context of this Technology Action Plan includes the following actors:

1. Technical University of Moldova, (former State Agricultural University)
2. Research Institute of Pedology and Agrochemistry “N.Dimo"
3. Research Institute of Crop Production (corn production) "Porumbeni"
4. Selectia Research Institute of Field Crops (Balti)
5. College of Excellence In Taul,Donduseni district,Republic of Moldova
6. State University of Moldova
7. Academy of Sciences of Moldova
8. Ministry of Agriculture and Food Industries (MAFI)
9. Ministry of Environment and Forestry (MoEF)
10. Association of cereal producers of Moldova
11. National and International Development Banks (DB)

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture to define the necessary policy amendments to align regulations and targets with the changing priorities imposed by the impacts of climate change and support CA efforts of farmers. In this context the representation of farmers, through their National Associations, is of paramount importance as exchanges on the needs for the sound sector’s development with those directly involved cereals production activities in general is key to completeness and policymaking inclusiveness. Cereal farmers and their associations will be predominantly engaged with the implementation of CA equipment and technologies, in addition to capacity building programs (Actions 2 and 3). Especially for the deployment of equipment for CA, the structure proposed requires the disbursement of discounted loans to farmers by accredited national and/or international development banks, depending upon the outcomes of Action 1. and the direction that policy instruments decide for enabling this change. The Academia and Research Institutions of the country will have a pivotal role in Capacity Building activities (Action 3), as well as in promoting awareness among farmers and agricultural entrepreneurs on the needs to implement CA in every farm in Moldova.

The complete, nationwide conversion of the main agricultural activity of the country will require at least 10 years for its completion. This TAP will have therefore an overall duration of 120 months and the table below shows the expected duration of each activity. As for all other TAPs in this report, a dedicated Gantt chart with relative duration of each activity is proposed in a dedicated Annex file.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | MAFI, FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, Research Centers, Academia, Association of Producers, FAO | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | MAFI, FAO | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | MAFI | 12 months |
| 2. National Conservation Agriculture Programme | 2.1 Cereal farmers associations strengthening and representation enhancement | Association of Producers, FAO | 12 months |
| | 2.2 Creation and upgrading of 5 wheat breeding facilities in the country | MAFI, Research Centers, Academia, FAO | 24 months |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national cereals sector | MAFI, MoEF, FAO | 48 months |
| | 2.4 Credit support to acquisition of direct seeding drillers for Conservation Agriculture | MAFI, MoEF, FAO, DB | 120 months |
| 3. Capacity building on CA and soil stewardship | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the cereals sector | FAO, Association of Producers | 36 months |
| | 3.2 Organization of trainings for cereals farmers on improved techniques and management for wheat production in CA | MAFI, Research Centers, Academia, | 120 months |

| | | | |
|---|---|---|---|
| | 3.3 Nationwide campaign on soil stewardship for long-term ownership of land and responsible management of natural resources | MAFI, Research Centers, Academia, FAO | 48 months |
| 4. Promoting knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | FAO, Research Centers, Academia, Associations of Producers | 40 months |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national cereals sector to retailers and consumers. | MAFI, Research Centers, Academia, Associations of Producers | 40 months |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | Research Centers, Academia, Associations of Producers | 40 months |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring cereals farms sustainability performance | MAFI, MoEF, FAO | 12 months |
| | 5.2. Monitoring campaign and analysis of introduced technology | MAFI, MoEF | 24 months |

*Table 47. Overview of Stakeholders and Timeline for the implementation of Conservation Agriculture*

### 5.2.4 Financial Resources Estimation for Action and Activities

The financial resources necessary for the implementation of this TAP are subdivided into grants and loans. Technical assistance and other activities will require support in the form of grants to enable large scale implementation of CA machinery and practices, while the bulk of expenditures of the TAP (activity 2.4) will see a predominant component of discounted loans to be issued by national and international development banks. This activity represents the 90% (USD 56.8 million) of the overall cost of this TAP (USD 60,039,000), but the very nature of an investment in CA equipment (e.g. direct drilling seeders) underlines the generation of increased value from the switching to a conservative cultivation regime, thus leading to sustained yields and income overtime. The cost of the equipment has been estimated starting from literature research on existing best-available technologies for CA. A direct driller has a capital cost of USD 200,000 and is capable of covering 120 ha/day. Considering a sowing window of 10 days, one of these machines can sow a total of 1,200 ha/season at USD 167/ha. To equip the 340,000 ha of farmland employed every year for the production of cereals, the TAP foresees that about 285 direct drillers will be necessary, for an estimated cost of USD 56.8 million. Farmers enrolled in the program then will have a mix of financial products to be developed and disbursed by accredited financial entities involved (e.g. EBRD) tailored to the expected ability to repay for the investment within a duration of 10 years maximum. Building the infrastructure to align the Republic of Moldova with the rest of countries in Europe with domestic breeding capacity to ameliorate the performance of cereals produced under Conservation Agriculture regimes is another important step to achieve food security through seeds and genetic resources' self-sufficiency (Activities 2.2 and 2.3). For these activities, a cumulated budget of USD 1.3 million is foreseen.

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 240.000 |
| 2. National Conservation Agriculture Programme | 2.1 Cereal farmers associations strengthening and representation enhancement | USD 72.000 |
| | 2.2 Creation and upgrading of 5 wheat breeding facilities in the country | USD 875.000 |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national cereals sector | USD 432.000 |
| | 2.4 Credit support to acquisition of direct seeding drillers for Conservation Agriculture | USD 56.780.000 |
| 3. Capacity building on CA and soil stewardship | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the cereals sector | USD 180.000 |
| | 3.2 Organization of trainings for cereals farmers on improved techniques and management for wheat production in CA | USD 600.000 |
| | 3.3 Nationwide campaign on soil stewardship for long-term ownership of land and responsible management of natural resources | USD 130.000 |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200.000 |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national cereals sector to retailers and consumers. | USD 100.000 |

| | | |
|---|---|---|
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | USD 60.000 |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring cereals farms sustainability performance | USD 108.000 |
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 144.000 |

*Table 48. Financial Resources Estimation for Conservation Agriculture*

### 5.2.5 Risks and Contingency Planning

The main risks are linked to the extensive deployment of financial products and services, and the related implementation of CA technologies and practices over a period of 10 years. Price volatility of final products such as wheat and maize, might steer the overall economics of the TAP in either direction, thus making it difficult to predict the actual payback period of the investments, something that in turn will translate into higher investment risks and therefore higher interest rates. This is why International Development Banks, like for instance the European Bank for Reconstruction and Development (EBRD), are considered preferred partners for the implementation of the TAP as they can offer stable financial products to abate inflation and price volatility risks, while still providing competitive discount rates for the borrowers. The duration of the project poses risks on other activities as well, but these are considered lower than financial risks and likely counterbalanced by the interim results of the TAP.

| Actions | Activities | Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Medium |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | Change of country priorities and administrative structure. Risk level: Medium |
| 2. National Conservation Agriculture Programme | 2.1 Cereal farmers associations strengthening and representation enhancement | Reluctance to associate and share risks and benefits. Risk level: Low |
| | 2.2 Creation and upgrading of 5 wheat breeding facilities in the country | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium |

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|---|---|---|
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national cereals sector | Long-term results available only beyond project duration. Risk level: Medium |
| | 2.4 Credit support to acquisition of direct seeding drillers for Conservation Agriculture | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium |
| 3. Capacity building on CA and soil stewardship | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the cereals sector | Lack of commitment and participation. Risk level: Low |
| | 3.2 Organization of trainings for cereals farmers on improved techniques and management for wheat production in CA | Lack of prepared and knowledgeable national trainers. Risk level: Medium |
| | 3.3 Nationwide campaign on soil stewardship for long-term ownership of land and responsible management of natural resources | Low attendance of remote farmers and smallholders Risk level: Medium |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | Lack of participation of stakeholders. Risk level: Low |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national cereals sector to retailers and consumers. | Lack of participation of stakeholders. Risk level: Low |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | Lack of capable local disseminators. Risk level: Low |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring cereals farms sustainability performance | Complexity of MRV systems and lack of practicality. Risk level: Low |
| | 5.2. Monitoring campaign and analysis of introduced technology | Lack of data and high data collection costs and time requirements: Risk level: Low. |

*Table 49. Risks associated with the implementation of Conservation Agriculture*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing agriculture and the cereals sector | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining the cereals sector. | 48 months |
| 2. National Conservation Agriculture Programme | 2.1 Cereal farmers associations strengthening and representation enhancement | USD 72.000 | Reluctance to associate and share risks and benefits. Risk level: Low | The coverage, composition and membership of farmers association is enhanced | Cereal producer associations grow in members by at least 50 new associates | 12 months |
| | 2.2 Creation and upgrading of 5 wheat breeding facilities in the country | USD 875.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | The country has enough breeding supply to cover polyculture needs | 5 cutting-edge breeding nurseries have been modernized or created in Moldova | 24 months |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national cereals sector | USD 432.000 | Long-term results available only beyond project duration. Risk level: Medium | PhD laurates complete a formation period with tangible research outcomes | 4 PhD students complete their doctorate and produce at least 3 peer-reviewed publications which support enhanced breeding efforts in the country | 48 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2.4 Credit support to acquisition of direct seeding drillers for Conservation Agriculture | USD 56.780.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | A supportive mechanism based on an efficient mix of loans, equity and grants is provided to sustain the retrofitting of wheat farm equipment with direct sowing and CA-ready machinery | 3 Credit support instruments and delivery structures (North, center and south) are created and operational in Moldovan to support full conversion to CA of the cereals sector | 120 months |
| 3. Capacity building on CA and soil stewardship | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the cereals sector | USD 180.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| | 3.2 Organization of trainings for cereals farmers on improved techniques and management for wheat production in CA | USD 600.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Cereal farmers are fully able to manage the introduced technologies in a CA regime | Average yields of enrolled farms are restored at at least 3.5 t/ha for wheat | 120 months |
| | 3.3 Nationwide campaign on soil stewardship for long-term ownership of land and responsible management of natural resources | USD 130.000 | Low attendance of remote farmers and smallholders Risk level: Medium | Farmers understand their role in protecting soils for the benefit of current and future generations and are empowered to monitor and actively protect their soils. | 24 workshops have been carried out nationwide and attended by at least wheat 1,000 farmers in total | 48 months |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200.000 | Lack of participation of stakeholders. Risk level: Low | Consumers, public institutions and academia are aware and recognize the risks and vulnerabilities to CC posing a burden of food security | 3 Conferences organized to present and discuss risks and vulnerabilities to CC posing a burden of food security | 40 months |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national cereals sector to retailers and consumers. | USD 100.000 | Lack of participation of stakeholders. Risk level: Low | Market actors are aware of national actions and efforts to produce climate-resilient cereals sector | At least 80% of tonnage of climate resilient products produced in the context of the project reach the market at competitive prices | 40 months |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | USD 60.000 | Lack of capable local disseminators. Risk level: Low | Potential interested farmers are aware of the opportunities of polyculture and the supporting system created by the project | At least 10 potential new fish farms are informed about the opportunities of polyculture and sustainable aquaculture | 40 months |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring cereals farms sustainability performance | USD 108.000 | Complexity of MRV systems and lack of practicality. Risk level: Low | The country is equipped with ad adapted MRV system to monitor wheat farms sustainability | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 144.000 | Lack of data and high data collection costs and time requirements: Risk level: Low. | The sustainability impacts of CA in Moldova are published | 2 yearly monitoring reports for cereals farms enrolled to date applying CA principles and techniques | 24 months |

*Table 50. Overview of the TAP for Conservation Agriculture*

## 5.3 Technology Action Plan for climate-smart rotations and organic fertilizer production.

### 5.3.1 Ambition

The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At demonstration level, climate-smart rotations and organic fertilizer production will be implemented in 2 farms of a cumulated surface of 500 ha. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce winter wheat, corn for grain, and sunflower with a productivity of 3,0 t/ha, 3,5 t/ha and 1,5 t/ha respectively. A decreasing yield trend is observed compared to 2020 (- 0,5 t/ha for wheat, maize and sunflower). The ambition of this TAP at demonstration level is to increase yields to 3,5 t/ha for winter wheat; to 4,0 t/ha for maize and to 2 t/ha for sunflower within the first 2 years of implementation. To do so, the use of synthetic nitrogen fertilizer will be decreased to 90 kg/ha and 2.5 tons of organic fertilizer like cattle manure (or equivalent) will be added to the soils. This will require to dispose of some 1,250 tons of organic fertilizer per year.
At full scale level implementation, this technology is targeted to interest a total of 200 farms annually, for a total surface of 50,000 ha. These comprise established cereal farms in the northern, central and southern part of Moldova, distributed for a 70,0 percent in the North, 15,0 percent in the Center and 15,0 in the South of the country. Currently, these farms produce winter wheat, corn for grain, and sunflower with a productivity of 3,0 t/ha, 3,5 t/ha and 1,5 t/ha respectively. A decreasing yield trend is observed compared to 2020 (- 0,5 t/ha for wheat, maize and sunflower). The ambition of this TAP at full-scale level is to increase yields to 3,5 t/ha for winter wheat; to 4,0 t/ha for maize and to 2 t/ha for sunflower within the first 2 years of implementation and sustain such productivity long-term. This three-year TAP will deliver an additional 25,000 t/year of wheat, corn and sunflower, while preserving the producing capacity of the land. To do so, the use of synthetic nitrogen fertilizer will be decreased to 90 kg/ha and 2.5 tons of organic fertilizer like cattle manure (or equivalent) will be added to the soils. This will entail disposing of some 125,000 tons of manure per year.

### 5.3.2 Actions and Activities selected for inclusion in the TAP

Policies require updating of legislative documents for horizontal and vertical cooperation of farms. In addition, a system that incentivizes cooperation of cereal farms and livestock farms is necessary to set the basis for a balanced supply of organic fertilizers. These policy acts could also include incentives for farmers adopting consolidation measures as well as transition to more sustainable farming systems (Action 1.). Purchasing and delivering 2.5 tons of manure to a field has a cost of about USD 200/ha and in the context of the TAP a financial mechanism to support early adopters will be put in place, but long-term adoption requires supportive policies that enable competitive prices. In addition to costs, the effectiveness of the proposed measures encompasses a consistent provision of organic fertilizers to be employed in cereal farming (125,000 tons/year) for which adequate agreement frameworks and planning is necessary at national level. This will be the main topic of Action 2. The other major enabler for working with climate-smart rotations and organic fertilizers is predominantly the provision of training to develop the capacity of farmers to manage these technologies and practices properly (Action 3.). The TAP foresees extended trainings and knowledge exchanges around this theme and beyond, as it was evident from the analysis of barriers to the implementation of climate-smart rotations and organic fertilizer use that in general the country is lacking an ingrained knowledge of the potential of sustainable agricultural practices that are context-specific and adapted to the Moldovan conditions. To this end, the TAP foresees a multicentric and interdisciplinary national research program that will fund up to 10 research projects per year over three years. This will allow participants to exchange knowledge from different institutions and disciplines for the advancement of the scientific base for sustainable agrifood systems in Moldova.

| Actions | Activities |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. |
| 2. Implementation of Climate Smart Rotations and Organic Fertilizer Use | 2.1 Organic fertilizer production and delivery infrastructure development |
| | 2.2 Climate-smart rotations implementation |
| 3. Capacity building on Climate-Smart Rotations and Organic Fertilizer Use | 3.1 Organization of trainings for cereals farmers on Climate-smart rotations and wheat predecessors selection |
| | 3.2 Training and education doctoral degree on Climate-smart agriculture |
| | 3.3. National interdisciplinary research program for achieving a more resilient and sustainable food system in Moldova |

*Table 51. Overview of Actions and Activities for the implementation of climate-smart rotations and organic fertilizer production*

### 5.3.3 Stakeholders and Timeline for the implementation of TAP

As in the case of Conservation Agriculture, also for the implementation of Climate-Smart rotations and organic fertilizer use, key stakeholders involve line ministries, research centers and academia, financial institutions, cereal producers and farmers, and crucially, also the livestock sector, in a cooperative context that leads to the efficient use and distribution of resources available in agriculture.

The complete list of key stakeholders to be involved in the context of this Technology Action Plan includes the following actors:

1. Technical University of Moldova, (former State Agricultural University)
2. Research Institute of Pedology and Agrochemistry “N.Dimo"
3. Research Institute of Crop Production (corn production) "Porumbeni"
4. Selectia Research Institute of Field Crops (Balti)
5. College of Excellence In Taul,Donduseni district,Republic of Moldova
6. State University of Moldova
7. Academy of Sciences of Moldova
8. Ministry of Agriculture and Food Industries (MAFI)
9. Ministry of Environment and Forestry (MoEF)
10. Association of cereal producers of Moldova
11. National and International Development Banks (DB)
12. Association of Livestock Producers and Regional Livestock Associations.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | MAFI, FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, Research Centers, Academia, Association of Producers, FAO | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | MAFI, FAO | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | MAFI | 12 months |
| 2. Implementation of Climate Smart Rotations and Organic Fertilizer Use | 2.1 Organic fertilizer production and delivery infrastructure development | MAFI, Research Centers, Academia, Association of Producers, FAO, DB | 36 months |
| | 2.2 Climate-smart rotations implementation | MAFI, Research Centers, Academia, Association of Producers, FAO, DB | 36 months |
| 3. Capacity building on Climate-Smart | 3.1 Organization of trainings for cereals farmers on Climate-smart rotations and wheat predecessors selection | Research Centers, Academia, Association of Producers, FAO | 36 months |

| | | | |
|---|---|---|---|
| Rotations and Organic Fertilizer Use | 3.2 Training and education doctoral degree on Climate-smart agriculture | Research Centers, Academia, Association of Producers, FAO | 36 months |
| | 3.3. National interdisciplinary research program for achieving a more resilient and sustainable food system in Moldova | MAFI, Research Centers, Academia, FAO | 36 months |

*Table 52. Overview of Stakeholders and Timeline for the implementation of climate-smart rotations and organic fertilizer production*

Policymaking actions (Action 1.) will see a pivotal role of the Ministry of Agriculture to define the necessary policy amendments to align regulations and targets with the changing priorities imposed by the impacts of climate change and support farmers efforts in implementing climate-smart rotations and organic fertilizers. In this context the representation of farmers, through their National Associations, is of paramount importance as exchanges on the needs for the sound sector's development with those directly involved cereal production activities as well as livestock is key to completeness and policymaking inclusiveness. Cereal farmers and their associations will be predominantly engaged with the implementation of Climate-smart rotations equipment and technologies, in addition to capacity building programs (Actions 2 and 3). Through Activity 2.1 "Organic fertilizer production and delivery infrastructure development", the TAP will convey all key stakeholders to plan out the logistics for the supply of organic fertilizers and the delivery to cereal farms, in addition to providing financial resources to cover this work. The supply of organic fertilizers and the deployment of equipment and practices for correct rotations, will require the disbursement of subsidies or loans to farmers by accredited national and/or international development banks, depending upon the outcomes of Action 1, for the purchase of equipment and organic fertilizers. The Academia and Research Institutions of the country will have a pivotal role in Capacity Building activities (Action 3), both as providers of knowledge and trainings to farmers as well as recipients of funds for the creation of a national interdisciplinary research program that allows the country to adapt and advance in the research and development of practices and technologies for sustainable agrifood systems in Moldova.
The timeline for the completion of this TAP is estimated in up to 36 months. As for all other TAPs in this report, a dedicated Gantt chart with relative duration of each activity is proposed in a dedicated Annex file.

### 5.3.4 Financial Resources Estimation for Action and Activities

The total volume of financial resources necessary for the implementation of this TAP was estimated to be USD 40,262,000. Like all other investment activities in this report expected to generate increased income, an ad-hoc financial mechanism has to be developed together with key financial institutions (e.g. National Commercial banks or International Development Banks) to provide the most efficient mix of financial instruments including subsidies, grants and discounted loans. In fact, the goal of this TAP is to achieve increased and long-term sustained yields of all crops included in the rotations starting from year 3 of implementation, thus enabling increased income despite the impacts of climate change. That is a key enabler for financial models that encompass a short term grace period of at least 2 years, followed by a repayment period of up to 5 years. The financial resources that will be disbursed through such instrument consist of USD 36,000,000 (Activity 2.1 + Activity 2.2) and therefore constitute about 90% of the total volume of financial resources estimated for the implementation of this TAP. Another relevant spending item is connected to Activity 3.3 (National interdisciplinary research program for achieving a more resilient and sustainable food system in Moldova), where a budget of USD 3,360,000 in the form of grants is foreseen to develop up to 30 interdisciplinary research projects. Potentially, co-funding from private sector entities might add or match these funds, as research activities will be targeted to providing private sector actors with the necessary innovations to enable more efficient food production systems in Moldova.

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 96.000 |
| 2. Implementation of Climate Smart Rotations and Organic Fertilizer Use | 2.1 Organic fertilizer production and delivery infrastructure development | USD 30.000.000 |
| | 2.2 Climate-smart rotations implementation | USD 6.000.000 |
| 3. Capacity building on Climate-Smart Rotations and Organic Fertilizer Use | 3.1 Organization of trainings for cereals farmers on Climate-smart rotations and wheat predecessors selection | USD 400.000 |
| | 3.2 Training and education doctoral degree on Climate-smart agriculture | USD 288.000 |
| | 3.3. National interdisciplinary research program for achieving a more resilient and sustainable food system in Moldova | USD 3.360.000 |

*Table 53. Financial Resources Estimation for climate-smart rotations and organic fertilizer production*

### 5.3.5 Risks and Contingency Planning

There are a few risks considered of Medium level in this TAP. The main risks are linked to the development and subsequent deployment of financial products and services, and the related implementation of Climate-Smart rotations technologies and practices. Adverse climatic conditions might undermine the success of rotation programs and consequently product availability and their sales. Price changes of intermediate products like manure and other organic fertilizers will likely take place during the project as a consequence of demand and supply interactions. This risk however will be managed by a solid financial structure and supply agreements for the duration of the project.

| Actions | Activities | Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Medium |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | Change of country priorities and administrative structure. Risk level: Medium |
| 2. Implementation of Climate Smart Rotations and Organic Fertilizer Use | 2.1 Organic fertilizer production and delivery infrastructure development | Lack of sufficient supply of quality manure, price volatility. Risk level: low. |
| | 2.2 Climate-smart rotations implementation | Procurement difficulties, prices volatility, extreme climatic events. Risk level: Medium |
| 3. Capacity building on Climate-Smart Rotations and Organic Fertilizer Use | 3.1 Organization of trainings for cereals farmers on Climate-smart rotations and wheat predecessors selection | Lack of prepared and knowledgeable national trainers. Risk level: Medium |
| | 3.2 Training and education doctoral degree on Climate-smart agriculture | Difficulties in completing the PhD courses on time. Risk level: Medium |
| | 3.3. National interdisciplinary research program for achieving a more resilient and sustainable food system in Moldova | Logistical difficulties to obtain authorizations, and timely organization and coordination among universities. Risk level: low. |

*Table 54. Risks associated with the implementation of climate-smart rotations and organic fertilizer production*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing agriculture and the cereals sector | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 96.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining the cereals sector. | 12 months |
| 2. Implementation of Climate Smart Rotations and Organic Fertilizer Use | 2.1 Organic fertilizer production and delivery infrastructure development | USD 30.000.000 | Lack of sufficient supply of quality manure | Enough organic fertilizer is produced and delivered to cereal farms, purchased through agreements between livestock and cereals farms supported by adequate financial mechanism (e.g. microloans) | 125,000 tons of manure per year are collected and delivered to cereals farms | 36 months |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2.2 Climate-smart rotations implementation | USD 6.000.000 | Procurement difficulties, prices volatility, climatic events. Risk level: Medium | A supportive mechanism based on an efficient mix of loans, equity and grants is provided to sustain the retrofitting of wheat farm equipment with materials and equipment for Climate-smart rotations | 200 farms are equipped to implement Climate-smart rotations | 36 months |
| 3. Capacity building on Climate-Smart Rotations and Organic Fertilizer Use | 3.1 Organization of trainings for cereals farmers on Climate-smart rotations and wheat predecessors selection | USD 400.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Cereal farmers are fully able to manage Climatae-smart rotations | At least 200 farmers demonstrated capacity to manage Climate-smart rotations | 36 months |
| | 3.2 Training and education doctoral degree on Climate-smart agriculture | USD 288.000 | Difficulties in completing the PhD courses on time. Risk level: Medium | Doctorate students are trained expressively on Climate-smart agriculture | At least 4 PhD candidates (50% females) complete their doctorate degree | 36 months |
| | 3.3. National interdisciplinary research program for achieving a more resilient and sustainable food system in Moldova | USD 3.360.000 | Logistical difficulties to obtain authorizations, and timely organization and coordination among Universities. Risk level: low. | The country has a National research program on sustainable food systems | 10 research projects on sustainable food systems are funded every year | 36 months |

*Table 55. Overview of the TAP for climate-smart rotations and organic fertilizer production*

## 5.4 Technology Action Plan for network of shelterbelts and ponds to reduce erosion and increase air humidity

### 5.4.1 Ambition

Soil erosion impacts Moldova severely. It is estimated that about 1.4 million ha of land are subject to erosion and a 0.86% growth rate is observed annually. Wind erosion makes up a share of this total, but virtually every high-tillage field where annual crops are produced contributes to soil erosion. It is estimated that as much as 30 t of soils are eroded every year per ha. Considering that wheat production takes place on some 340,000 ha, every year Moldova loses the equivalent of 10 million tons of soil due to erosion. Shelterbelts networks are a necessary contributor to limiting such trend, although not capable alone of annihilating the transport of soil away from its original position. Based on national statistics, at least 50% of cereals field (approx. 170,000 ha) are at high risk of erosion and require immediate action. For every hectare of land, about 250 meters of doubled row shelterbelts are necessary to stop wind erosion. Species selection is key to maximise performance and so is planning and accurate plant spacing. For this TAP it is proposed to use two rows of walker poplar (growth rate of about 1 m per year) plus one row of evergreens. The walker poplar (Populus x Walker) is the only woody species with horizontal branches at ground level. This allows it to stop ground winds very effectively for the entire duration of its life, up to 50 years. At full scale implementation, this technique will interest about 170,000 ha of cereals land in Moldova, with a linear development of shelterbelts of about 42,500 km. The planting and management of two-rows shelterbelts has an approximate cost of USD 409 per ha or USD 1,636 per km (250 meters belt for each ha of land to protect).

### 5.4.2 Actions and Activities selected for inclusion in the TAP

Implementing shelterbelts and ponds networks will require major policy work to create and update legislative documents that govern the functions of private and public land in Moldova. In addition, a system that incentivizes cooperation between public entities and private farms is required to adapt the management of agricultural landscapes to cope with increased erosion and other impacts of climate change. These policy acts could also include incentives for farmers adopting consolidation measures as well as transition to more sustainable farming systems (Action 1.). Action 2. is the main area of technical work for this TAP. It is composed of four activities, that collectively will enable the deployment of networks of shelterbelts and ponds for the respective mitigation of erosion and increasing air humidity. The first step of this action will be the attentive mapping of effective areas of the country that are posed at highest risk of erosion. The outcome of this activity will inform the following steps of the completion of Action 2. Once the demand and location of shelterbelts and ponds areas is identified, the necessary supply of materials (especially tree seedlings) will be developed under a dedicated activity (Activity 2.2). The TAP foresees the building or upgrading of up to 5 tree nurseries for the production of the necessary amount of trees to fulfil national needs (about 4.5 million plants/year). Activities 2.3 and 2.4 consist in the deployment of the networks of ponds and shelterbelts, respectively. Along the course of this program, there will be the need to monitor the effectiveness in terms of soil erosion control by developing an MRV system and building up a database of information on soil quality and particles transport (Action 3.).

| Actions | Activities |
|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova |
| | 1.2. Multistakeholder dialogue, discussions and workshops |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. |
| 2. National Shelterbelts program | 2.1 Mapping of erosion risk areas, prioritization and planning of execution |
| | 2.2 Creation and upgrading of 5 tree nursery facilities in the country |
| | 2.3 Development of network of ponds in Moldovan cereals sector |
| | 2.4 Development of network of shelterbelts in Moldovan cereals sector |
| 3. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring soil erosion at the landscape level |
| | 5.2. Monitoring campaign and analysis of introduced technology |

*Table 56. Overview of Actions and Activities for the implementation of a network of shelterbelts and ponds to reduce erosion and increase air humidity*

### 5.4.3 Stakeholders and Timeline for the implementation of TAP

For the implementation of networks of shelterbelts and ponds, key stakeholders involve line ministries, research centers and academia, cereal producers and farmers as well as tree breeding experts and nurseries.

| Actions | Activities | Stakeholders | Timeline |
|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | MAFI, FAO | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | MAFI, Research Centers, Academia, Association of Producers, FAO | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | MAFI, FAO | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | MAFI | 48 months |
| 2. National Shelterbelts program | 2.1 Mapping of erosion risk areas, prioritization and planning of execution | MAFI, Associations of Farmers, FAO | 30 months |
| | 2.2 Creation and upgrading of 5 tree nursery facilities in the country | MAFI, FAO, Tree breeders | 24 months |
| | 2.3 Development of network of ponds in Moldovan cereals sector | MAFI, Associations of Farmers, FAO | 120 months |
| | 2.4 Development of network of shelterbelts in Moldovan cereals sector | MAFI, Associations of Farmers, Tree Breeders, FAO | 120 months |
| 3. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring soil erosion at the landscape level | MAFI, FAO | 12 months |
| | 5.2. Monitoring campaign and analysis of introduced technology | MAFI | 84 months |

*Table 57. Overview of Stakeholders and Timeline for the implementation of a network of shelterbelts and ponds to reduce erosion and increase air humidity*

The overall duration of this TAP is at least 12 years, as the extent of coverage requires a relevant timeframe for the implementation of shelterbelts over the large surfaces necessary in the case of Moldova.

### 5.4.4 Financial Resources Estimation for Action and Activities

This TAP has an estimated budget of USD 96,210,000. The bulk of the expenditure is under Action 2. for the implementation of shelterbelts and ponds. The construction of ponds (1 every 70 ha) is estimated at USD 10,000, the cost of shelterbelts is estimated at USD 409 per ha (250 meters double row of Walker poplars), for a total of USD 69,530,000. The construction of breeding facilities and nurseries will amount to an estimated USD 875,000, though these are potentially going to be funded by private sector entities and might be reimbursed to the project. The major reliance on grants for the execution of this TAP will require external financial support as economic benefits can only pay off over the entire lifetime of the shelterbelts (approx. 50 years) and these investments cannot be expected from farmers and private sector entities. The benefits of this technology are multiple and relevant for the entire society of Moldova. The implementation of this technology will have relevant benefits on economic, social and environmental sustainability of the sector. In dry years, the soil is more prone to suspension by the wind resulting in erosion and sandblasting of crops by suspended soil particles. This may lower yields and protein content, and cause delayed maturity, or even mortality. Shelterbelts trap suspended dust and soil particles and help to reduce the physical damage to crops by soil erosion. Long term effects of shelterbelts are therefore the lower transport of soil particles and increased soil availability, including the availability of soil organic matter and carbon, and the reduced impact on existing crops, thus leading to sustained productive capacity of the land. A network of shelterbelt coupled with a network of ponds to increase the humidity of the air can magnify the aforementioned benefits to the point of interacting also with temperatures and overal plant vigor in any agrifood system. Incorporating shelterbelts into management regimes has the potential to improve the ecological health of agricultural landscapes. One of the major environmental benefits is the provision of ecological goods and services to producers as well as to society. These include carbon sequestration, maintenance of biodiversity both above- and belowground, and protection of soil and water resources. In addition, potential for increased property values and improved recreational opportunities (i.e., hunting, bird watching, and hiking) are also credited to shelterbelts in and around yard sites or where people live. Providing habitat for pollinators is considered a benefit recognized by farmers that could be promoted to increase shelterbelt adoption. Shelterbelts also provide an increased level of underground biodiversity, water infiltration, and soil moisture retention compared with the monoculture that surrounds them; this is due to the extensive rooting zones and aboveground biomass of the perennial plants associated with shelterbelts. These benefits should be attentively documented to sufficiently justify the request for external financial support in the form of grants. A long-term policy instrument that poses incentives and disincentives on sustainable vs unsustainable soil management practices respectively, will be monitored by Action 3.

| Actions | Activities | Budget |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 |

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| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 240.000 |
| 2. National Shelterbelts program | 2.1 Mapping of erosion risk areas, prioritization and planning of execution | USD 550.000 |
| | 2.2 Creation and upgrading of 5 tree nursery facilities in the country | USD 875.000 |
| | 2.3 Development of network of ponds in Moldovan cereals sector | USD 24.285.714 |
| | 2.4 Development of network of shelterbelts in Moldovan cereals sector | USD 69.530.000 |
| 3. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring soil erosion at the landscape level | USD 108.000 |
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 504.000 |

*Table 58. Financial Resources Estimation for a network of shelterbelts and ponds to reduce erosion and increase air humidity*

### 5.4.5 Risks and Contingency Planning

The main risk associated with the implementation of this TAP are linked to the overall duration of the proposed actions and the difficulties in effectively planning and contemplating all potential time-sensitive variables, including price changes and volatility, climatic impacts, political changes etc.

| Actions | Activities | Risks |
|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | No risk foreseen |
| | 1.2. Multistakeholder dialogue, discussions and workshops | Lack of participation of stakeholders. Risk level: Low |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | Change of country priorities and administrative structure. Risk level: Medium |

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| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | Change of country priorities and administrative structure. Risk level: Medium |
| 2. National Shelterbelts program | 2.1 Mapping of erosion risk areas, prioritization and planning of execution | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium |
| | 2.2 Creation and upgrading of 5 tree nursery facilities in the country | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium |
| | 2.3 Development of network of ponds in Moldovan cereals sector | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium |
| | 2.4 Development of network of shelterbelts in Moldovan cereals sector | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium |
| 3. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring soil erosion at the landscape level | Complexity of MRV systems and lack of practicality. Risk level: Low |
| | 5.2. Monitoring campaign and analysis of introduced technology | Lack of data and high data collection costs and time requirements: Risk level: Low. |

*Table 59. Risks associated with the implementation of a network of shelterbelts and ponds to reduce erosion and increase air humidity*

| Actions | Activities | Budget | Risks | Success Criteria | Indicators of completion | Timeline |
|---|---|---|---|---|---|---|
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing agriculture and the cereals sector | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining the cereals sector. | 48 months |
| 2. National Shelterbelts program | 2.1 Mapping of erosion risk areas, prioritization and planning of execution | USD 550.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping soil erosion database created and accessible | All 340,000 ha of annual crop lands have been mapped, baseline and target erosion volumes defined | 30 months |
| | 2.2 Creation and upgrading of 5 tree nursery facilities in the country | USD 875.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | The country has enough breeding supply to cover shelterbelt trees supply | 5 cutting-edge breeding nurseries have been modernized or created in Moldova | 24 months |
| | 2.3 Development of network of ponds in Moldovan cereals sector | USD 24.285.714 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | Network of ponds for increased air humidity is constituted in Moldova | 2,400 ponds are build over 170,000 ha of land to increase the humidity of the air | 120 months |

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| | 2.4 Development of network of shelterbelts in Moldovan cereals sector | USD 69.530.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | Network of shelterbelts for soil erosion control is constituted in Moldova | 42,500 km of two-rows shelterbelts are built and managed to reduce soil erosion | 120 months |
| 3. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring soil erosion at the landscape level | USD 108.000 | Complexity of MRV systems and lack of practicality. Risk level: Low | The country is equipped with ad adapted MRV system to monitor soil erosion levels | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 504.000 | Lack of data and high data collection costs and time requirements: Risk level: Low. | The sustainability impacts of shelterbelts on erosion control in Moldova are monitored and published | 1 yearly monitoring report for cereals farms enrolled to date applying soil erosion control techniques | 84 months |

*Table 60. Overview of the TAP for a network of shelterbelts and ponds to reduce erosion and increase air humidity*

# ANNEX I: Gantt Chart and Complete TAP overview for Aquaculture Sector

| | | | | | | |
|---|---|---|---|---|---|---|
| **Sector** | Agriculture | | | | | |
| **Subsector** | Aquaculture | | | | | |
| **Technology** | Fish farming in polyculture | | | | | |
| **Ambition** | The ambition level for implementing this technology is proposed at long-term, full-scale level. A total of 37 ponds currently used for aquaculture will be developed into polyculture for a total of 6,770 ha. The ponds are distributed throughout the country, namely 14 in the Northern part of Moldova, with a cumulated area of 1,252 ha, 15 lakes in the Central part having a cumulated area of 3,015 ha, and the remaining 8 lakes are found in the South and have a total area of 2,510 ha. Currently, these lakes are stocked with juvenile - body weight 20 g – non better-defined phytophagous fish at a density of 1,200 – 1,500 pcs / ha and native European carp at a rate of 700 - 800 pcs / ha (e.g. Sarata Noua Lake) or, as in the case of Badragi Lake, with juveniles of two summers of phytophagous fish at a density of 300 -500 pcs / ha and carp at 800 pcs / ha. The productivity of these lakes is on average 550 kg of fish per ha with variations from north to south comprised in the 400 -700 kg / ha range. Current harvest volumes total value of around 3,720 tons per year. The ambition of this TAP aims at modifying the species composition in these lakes in order to better exploit the trophic potential of the ponds increasing species count from 3 to 6 and harvest volumes from 3,720 t/year to 4,670 t/year. This goal will be achieved through the introduction of pikeperch - 120 pcs / ha, European wells - 100 pcs / ha, and European bream at a stocking rate of 170 pcs / ha. The increase in fish production at the second year of growth due to the introduction of additional species is expected to be between 100 and 160 kg/ha in total, and specifically 40 - 60 kg/ha from pikeperch, 50 - 60 kg/ha from European wells, and 10 - 30 kg/ha from breams. Total fish production in these 37 lakes can increase by almost 1,000 tons annually and reach 4,670 tons/year. | | | | | |
| **Benefits** | The implementation of this technology will have relevant benefits on economic, social and to a lesser extent, environmental sustainability of the sector. Market benefit will be realized through increased productivity and production efficiency, which in turn will translate into lower purchase price per unit of product. Social benefits will be particularly relevant. Firstly, the resilience of the aquaculture sector in Moldova will ignite a cascading effect along the value chain as actors become more resilient to climate change too. One aquaculture farm in four is owned by women, and they will obtain increased independence and empowerment as a consequence of a more fluorish economic activity. The TAP presents a number of actions developed to support increased food security by providing more diverse, abundant, affordable and sustainable animal protein in the diet of Moldovan people. In addition, imported fishery and seafood resources are of low quality in Moldova, whereas high quality national production is necessary. These socio-economic benefits are expected to have a relevant impact on the society of Moldova. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing aquaculture | 6 months |

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| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining aquaculture | 48 months |
| | 2.1 Aquaculture farmers association strengthening and representation enhancement | USD 72.000 | Reluctance to associate and share risks and benefits. Risk level: Low | The coverage, composition and membership of aquaculture farmers association is enhanced | Aquaculture associations grows in members by at least 5 new associates | 12 months |
| | 2.2 Creation of 5 breeding multispecies nurseries in the country | USD 325.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium-high | The country has enough breeding supply to cover polyculture needs | 5 cutting-edge breeding nurseries have been modernized or created in Moldova | 24 months |
| 2. Ensuring adequate breeding supply | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national aquaculture sector | USD 360.000 | Long-term results available only beyond project duration. Risk level: Medium | PhD laurates complete a formation period with tangible research outcomes | 4 PhD students complete their doctorate and produce at least 3 peer-reviewed publications which support enhanced breeding efforts in the country | 48 months |
| | 2.4 Development of sound sanitary control systems for hatchling stocks, grading, and sorting juveniles | USD 60.000 | Lack of private stakeholders acceptance. Risk level: Low | Grading, prophylactic processing with harmless preparations and sorting of juveniles is aligned to best-available international sanitary standards | 3 Sanitary standards are developed and tested in Moldovan aquaculture sector | 12 months |

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| | 2.5 Planning and implementation of nationwide distribution and supply chain for fish farms, including optimizing transport equipment for delivery of juveniles of multiple species and sizes | USD 122.000 | Lack of demonstrated sustainability. Risk level: Low | The country is equipped with a national distribution and supply chain for fish farm, associated research and testing of new equipment and techniques | 1 Nationwide distribution and supply chain for fish farms established and tested | 12 months |
| | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | USD 180.000 | | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| | 3.2 Organization of trainings for nursery owners and fish fry producers on improved techniques and management of nurseries | USD 48.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Nursery owners are fully able to manage the introduced technologies and produce high-quality and guaranteed hatchlings | 5 trainings are organized to provide nursery owners with the capacity to manage improved technologies and practices for fry production | 12 months |
| 3. Capacity building | 3.3 Implementation of 6 pilot projects (2 in each region of Moldova) on appropriate water resources management models, and use of complex destination lakes in aquaculture activities | USD 330.000 | Possible difficulties in achieving full implementation due to extreme weather events, political conditions, etc. Risk level: Medium | Polyculture advantages in terms of adaptation to climate change have been demonstrated | 6 pilot projects have been developed to provide farmers with nationally-bred fish hatchlings, growing and yielding expected quantities | 18 months |
| | 3.4 Establishment of champion farms and organization of Farmer Field Schools, Study Tours, and Field visits based on peer-to-peer knowledge sharing on management of polyculture in aquaculture | USD 90.000 | Lack of participation of stakeholders. Risk level: Low | Moldovan Fish farmers are familiarized and trained to deploy fish polyculture in their own ponds | 37 fish farmers are trained to deploy and manage polyculture in aquaculture | 36 months |

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| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200.000 | Lack of participation of stakeholders. Risk level: Low | Consumers, public institutions and academia are aware and recognize the risks and vulnerabilities to CC posing a burden of food security | 3 Conferences organized to present and discuss risks and vulnerabilities to CC posing a burden of food security | 40 months |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national aquaculture sector to retailers and consumers. | USD 100.000 | Lack of participation of stakeholders. Risk level: Low | Market actors are aware of national actions and efforts to produce climate-resilient domestic fish | At least 80% of tonnage of climate resilient products produced in the context of the project reach the market at competitive prices | 40 months |
| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | USD 60.000 | Lack of capable local disseminators. Risk level: Low | Potential interested farmers are aware of the opportunities of polyculture and the supporting system created by the project | At least 10 potential new fish farms are informed about the opportunities of polyculture and sustainable aquaculture | 40 months |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring aquaculture farms sustainability performance | USD 108.000 | Complexity of MRV systems and lack of practicality. Risk level: Low | The country is equipped with ad adapted MRV system to monitor aquaculture farms sustainability | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 144.000 | Lack of data and high data collection costs and time requirements: Risk level: Low. | The sustainability impacts of polyculture fish farming in Moldova are published | At least 6 monitoring reports for fish farms using polyculture are produced and published | 24 months |

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| **Sector** | Agriculture | | | | | |
| **Subsector** | Aquaculture | | | | | |
| **Technology** | An intervention to increase the water flow in ponds used for fish farming in polyculture according to continuous technology | | | | | |
| **Ambition** | The level of ambition for the deployment of this technology is proposed in the short term, at demonstration level, and in the long term, at full scale. At demonstration level, the increase in water flow will be applied in 30 ponds located in the 3 aquaculture areas of Moldova (10 ponds each in the northern, central and southern fish areas) Currently, in these ponds mostly cyprinids are grown (singer, novac, moose and carps) at the stocking density of 1,500-2,000 pcs/ha of one-year-old juveniles (80-120 kg/ha) and 1,000-1,200 pcs/ha of two-summer juveniles (250-320 kg/ha). The ambition of this TAP at demonstration level is to increase the volume of water flowing to the ponds via drainage and desilting works will increase the volume of water in ponds by approximately 20-25%. This will allow to regain the volume of water loss in recent years, as in the case of Nisporeni lake, where the water level decreased by 60 cm. This objective will be achieved by the removal of about 18,000-20,000 m3 of silt, sand, overgrow vegetation and other debris, and through the development of dedicated capacity building program (6-8 million lei for each fish basin) to train staff to maintaining increased water flow in case study ponds. At full-scale implementation, this technology is going to interest a total of up to 2,400 aquaculture ponds with a total area of approximately 400,000 ha located in the north (35%), center (40%) and south (25%) of the country. | | | | | |
| **Benefits** | Immediate benefits will include the increased resilience of the aquaculture sector to the impacts of climate change because ponds and lakes will be able to withstand extreme precipitation events, limiting the likelihood of floods. Moreover, increased water flows will enable increased volumes of water for farming and thus increased production, with clear social and food security benefits. The production of sand and gravel will also impact positively the economy of the country, eager to source construction materials sustainably. In fact, also environmental impacts will be positive as a regulated and sustainable extraction of sand and gravel will displace illegal and unregulated operations of extraction and excavation in areas where instead an environmental damage is caused by these activities. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing aquaculture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |

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| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of water basin users, development of corrective action plan in the regulatory framework. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining aquaculture | 48 months |
| 2. National Water Flow Management Program for Aquaculture | 2.1 Survey and Mapping of water flow conditions of rivers and streams in Moldova | USD 1.740.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping water flow database created and accessible | All 2,400 aquaculture lakes and ponds have been mapped, baseline and target water flow regimes of their watersheds defined | 30 months |
| | 2.2 Creation of a National Water Flow Management agency | USD 1.180.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium-high | National Water Flow Managementr Agency established | 1 National Water Flow Management Agency is created and budgetary funds secured for operation for at least 10 years | 24 months |
| | 2.3 Deployment of desilting and drainage works on Moldovan obstructed watersheds | USD 96.000.000 | Technical difficulties and cost management. Risk level: Medium | Optimal waterflow is restored and resilence to extreme events is improved at the national level, contributing to mitigating flood impacts | Average water flow at the national level is increased by at least 25% compared to baseline | 60 months |
| | 2.4 Circular economy for the Valorization of sand, gravel, and biomass procured | USD (19.975.000) | Logistics and market limitations. Risk level: Low | Market placements and long term agreements with construction industry to re-use the silts, materials and biomass produced by the desilting works | Total volume of silts, sand and biomass removed and sold to construction, cement and energy companies equal to 1,700,000 tons | 60 months |

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| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the aquaculture sector | USD 180.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| | 3.2 Organization of trainings for ponds and lakes owners on improved techniques and management of water flow at streams, ponds and watershed levels | USD 1.200.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan Fish farmers are familiarized and trained to deploy measure to increase water flow in their ponds | 2,400 fish farmers are trained to deploy and manage water flow in aquaculture | 48 months |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200.000 | Lack of participation of stakeholders. Risk level: Low | Consumers, public institutions and academia are aware and recognize the risks and vulnerabilities to CC posing a burden of food security | 3 Conferences organized to present and discuss risks and vulnerabilities to CC posing a burden of food security | 40 months |
| | 4.2 Dissemination campaign among stakeholders and outreach | USD 60.000 | Lack of capable local disseminators. Risk level: Low | Potential interested farmers are aware of the opportunities of polyculture and the supporting system created by the project | At least 10 potential new fish farms are informed about the opportunities of polyculture and sustainable aquaculture | 40 months |

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| **Sector** | Agriculture | | | | | |
| **Subsector** | Aquaculture | | | | | |
| **Technology** | Fish Protection Systems | | | | | |
| **Ambition** | The ambition of this technology at national level targets the 6,000 water bodies and the 1,000 active fish farms in Moldova. As a result of carrying out the inventory and determination of all land areas on which fish facilities are located - water bodies (ponds and lakes) used for fish production will be characterized and monitored. | | | | | |
| **Benefits** | Immediate benefits will include the increased resilience of the aquaculture sector to the impacts of climate change because ponds and lakes will be able to withstand extreme precipitation events, limiting the likelihood of floods. Moreover, increased water flows will enable increased volumes of water for farming and thus increased production, with clear social and food security benefits. The production of sand and gravel will also impact positively the economy of the country, eager to source construction materials sustainably. In fact, also environmental impacts will be positive as a regulated and sustainable extraction of sand and gravel will displace illegal and unregulated operations of extraction and excavation in areas where instead an environmental damage is caused by these activities. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding aquaculture in Moldova | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing aquaculture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |

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| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and commitments of regulatory acts on water use, development of corrective action plan in the regulatory framework. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 3 meetings of working group and Approved Review of amendments on laws pertaining aquaculture | 36 months |
| | 2.1 Nationwide survey on aquaculture status, fish health and sanitary risks | USD 480.000 | Low participation of respondents. Risk level: Medium | A nationwide survey on aquaculture status, fish health and sanitary conditions produced | 1 Report summarizing the results of the survey and at least 50% of questionnaries returned and filled out | 24 months |
| 2.Fish Protection System development | 2.2 Elaboration of fisheries-biological substantiations (FPB) for water bodies in fisheries areas of Moldova | USD 1.010.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium-high | The country has a complete overview of the overall health situation of its aquaculture sector | Fishery-biological substantiations (FPB) for the 6000 elaborated water bodies. Passport of the fish basin (water bodies) drawn up for 1000 fish farms | 24 months |
| | 2.3 Support to national research institutions for research and development of technologies and practices to support the national aquaculture sector | USD 360.000 | Long-term results available only beyond project duration. Risk level: Medium | PhD laurates complete a formation period with tangible research outcomes | 4 PhD students complete their doctorate and produce at least 3 peer-reviewed publications which support enhanced breeding efforts in the country | 48 months |
| 3. Capacity building | 3.1 Strengthening information measures for aquaculture practicioners and producers to solve resource saving tasks, project implementation, publication of recommendations | USD 612.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| 4. Monitoring and Reporting | 4.1. Monitoring campaign and analysis of impacts of FPBs | USD 144.000 | Data verification costs and time | The sustainability impacts of polyculture | At least 6 monitoring reports for fish farms using | 12 months |

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| | | | requirements: Risk level: Low. | fish farming in Moldova are published | polyculture are produced and published | |
| | | USD 2.934.000 | | | | |

## ANNEX II: Gantt Chart and Complete TAP overview for Livestock Sector

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| **Sector** | Agriculture |
| **Subsector** | Livestock |
| **Technology** | Increasing areas under irrigation for the production of feed |
| **Ambition** | The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At demonstration level, technologies to increase areas under irrigation to produce feed will be implemented in 13 farms of an average surface of 50 ha each which currently produce forage and feed. The farms are in the northern part of Moldova. Currently, these farms produce maize silage with yields of about 30-40 tons/ha, but during drought years yields are reduced by up to 50%, down to 15-20 t/ha. However, the use of proper irrigation systems on maize can sustain yields of 25-35 tons/ha even in drought years. The ambition of this TAP at demonstration level is to sustain yields during drought periods. Irrigation infrastructures include water harvesting and banking operations, where areas are devoted to water storage, they are recharged during precipitation events, participate in protecting from flood risks and are capable of releasing the water when drought occurs. The cumulated volume of water banking should reach around 4,000,000 m3, enough to deliver some 6,000 m3 per ha per year. In addition to water banking works, the sustained yield goal will be achieved thanks to the introduction of improved feed production techniques (better varieties, crop rotations, etc.) for each farm, and the development of 4 programs to train personnel and maintain the increased productivity in the case study farms.<br>At full scale level implementation, this technology is targeted to interest a total of 100 farms in Moldova, for a total surface of 15,000 ha, and an estimated volume of irrigation water of approximately 90 million m3 sufficient to ensure the production of some 675,000 tons of feed. These comprise established feed and forage farms in the southern and northern part of Moldova. Currently, these farms produce alfalfa with an average productivity of 5 tons of product per ha and maize silage is about 30-40 tons / Ha, and a decreasing yield trend is observed compared to 10-15 years ago, when yields were comparatively higher at 8-10 t/ha for alfalfa. The ambition of this TAP at national level is to increase yields from the current average of 8 t/ha for alfalfa to 15 t/ha, and maintain maize silage yields at about 40 tons/ha also during drought years. This goal will be achieved through the introduction of irrigation, fertilizers application, crop rotations, etc. and the development of 4 programs to train personnel and maintain the increased productivity in the Moldovan farms. |

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| **Benefits** | Economic benefits: maintaining feed and forage yields also during drought years and in a context of changing precipitation patterns will ensure sustained income for farmers engaged in feed production. In addition, increasing the diversity of feed types produced with the addition of water-efficient feed varieties will increase economic resilience of feed producing farms by diversifying the offer of feed to the market. Livestock farms will maintain income levels despite the impacts of climate change in drought years thanks to increased feed availability. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing livestock | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 40 months |

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| 2. Sustainable Irrigation Program for feed production | 2.1 Survey and Mapping of irrigation needs and conditions of established forage farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 3 months |
| | 2.2 Designing of water banking systems and sustainable irrigation systems | USD 144.000 | Difficult planning and adequate geological conditions. Risk level: low | National Water Banking plan for adapting livestock feed production to climate change | 1 National Water Banking plan for feed production is produced | 12 months |
| | 2.3 Water banking and related irrigation systems construction | USD 13.000.000 | Technical difficulties and cost management. Risk level: Medium | Optimal water balance between flood and drought years is established and resilence to extreme events is improved at the national level, contributing to mitigating CC impacts | Optimal water requirements for feed production are met also in drought years | 24 months |
| | 2.4 Best practices for input-efficient feed types diversification | USD 1.000.000 | Technical difficulties and cost management. Risk level: Medium | New and more input-efficient feed types are introduced, tested and commercialized | At least 25 farms diversified their feed production types with water-efficient varieties | 24 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD 180.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| | 3.2 Organization of trainings for farm owners on improved techniques and management of water banking systems for sustainable irrigation in drought years | USD 50.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan feed producers are familiarized and trained to manage water banking and diversify feed types | 100 farmers are trained to deploy and manage water banking and irrigation systems, in addition to increased diversification of feed types | 12 months |

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| 4. Monitoring and reporting | 4.1. Selection and adaptation of MRV systems for monitoring feed farms sustainability performance | USD 108.000 | Complexity of MRV systems and lack of practicality. Risk level: Low | The country is equipped with ad adapted MRV system to monitor aquaculture farms sustainability | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 4.2. Monitoring campaign and analysis of introduced technology | USD 144.000 | Lack of data and high data collection costs and time requirements: Risk level: Low. | The sustainability impacts of water banking for feed production in Moldova are published | At least 25 monitoring reports for feed farms using water banking and irrigation are produced and published | 24 months |

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| **Sector** | Agriculture |
| **Subsector** | Livestock |
| **Technology** | Construction of manure management and organic fertilizer production platforms |
| **Ambition** | The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At the demonstration level, the construction of platforms for the accumulation of manure and the production of organic fertilizers will be implemented in 5 farms. The farms are in the northern part of Moldova. Currently, each of these dairy farms produces about 140 tons of milk per year and a decreasing production trend is observed compared to 2008 average values, because of lack of quality organic fertilizers for the feed production industry. The ambition of this TAP at demonstration level is to produce 5,500 tons of organic fertilizers in the form of composted, mature manure. This goal will be achieved through the construction of special platforms for each farm, and the development of 2 programs to train personnel and maintain the increased productivity in the case study farms.<br>At full scale level implementation, this technology is targeted to interest a total of 100 farms. These comprise established livestock farms in the northern, central, and southern part of Moldova, distributed for a 30% percent in the North, 34% percent in the Center and 36% in the South of the country. Currently, each of these dairy farms produces about 650 tons of milk per year and a decreasing production trend is observed compared to 2008 average values, because of lack of quality organic fertilizers for the feed production industry. The ambition of this TAP at the national level is to |

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| | produce 941 000 tons of organic fertilizers per year after implementation. This goal will be achieved through the construction of construction of manure maturation and composting structures (e.g. pits) for each farm for a total of 100 platforms, and the development of training campaigns to maintain manure composting production in the farms. |
| **Benefits** | Organic fertilizers use will have relevant implications in the production of feed in the context of CC in Moldova. Increased nitrogen and other nutrients administration will result in sustained feed yields. In addition, environmental benefits will include increased organic carbon fixation into the soils and increased soil biodiversity. Also, water retention potential of soils will be improved with enhanced resilience to climate change as a result. |

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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing livestock | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |

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| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |
| 2. Planning and construction of organic fertilizer production platforms | 2.1 Survey and Mapping of organic fertilizers needs and conditions of established forage farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 3 months |
| | 2.2 Designing of manure management structures and platforms | USD 144.000 | Difficult planning and adequate geological conditions. Risk level: low | National Plan for manure management for organic fertilizer production and guidelines | 1 Organic fertilizer production platform plan developed | 12 months |
| | 2.3 Manure management and organic fertilizer production systems construction | USD 1.500.000 | Technical difficulties and cost management. Risk level: Medium | Manure is managed and organic fertilizers are produced | 941,000 tons of manure are turned into organic fertilizers every year | 24 months |
| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD 60.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 12 months |
| | 3.2 Organization of trainings for farmers on management of organic fertilizer production platforms | USD 150.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan farmers are familiarized and trained to produce organic fertilizers from manure | 100 farmers trained to manage platoforms for the production of organic fertilizers | 12 months |

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| **Sector** | Agriculture | | | | | |
| **Subsector** | Livestock | | | | | |
| **Technology** | Improved animal shelters designs and retrofitting of existing farms | | | | | |
| **Ambition** | This TAP involves two activities. The first is the planning and provision of guidance to build or retrofit animal shelters to ensure their welfare in the context of climate change. The guidelines and engineering drawings will be procured for the following livestock classes and farms:<br>For dairy cattle - 20, 40, 60, 80 and 100 animals.<br>For fattening pigs – 100, 300, 500, 700 and 1000 animals.<br>For laying birds – 20 000 and 50 000 heads.<br>For broiler chickens – 25 000, 50 000, 75 000 and 100 000 heads.<br>Subsequently, these guidelines will be employed to retrofit existing farms. The level of ambition for the deployment of this technology is proposed in the short term, at demonstration level, and in the long term, at full scale level. At demonstration level, the construction of improved shelters (modernization of microclimate systems) for animals will be implemented in 4 poultry farms in total of which 2 layers (2 halls) and 2 broilers (6 halls) farms. Farms are located in the northern, central and southern parts of Moldova. Currently, these farms produce around 8,000 tons of poultry meat and 12 million eggs annually and there is a downward trend in production during the warm period of the year due to increased heat and cold stress. The implementation of this technology will require building 8 cooling systems to equip the 8 halls with climate control units and dedicated management software and perform a full thermal insulation of the halls. In addition to poultry farms, 2 cattle farms (one for 40 dairy cattle and one for 100 dairy cattle) will also be included in the demonstration phase. A dedicated procurement contract with a local design company will be issued. The estimated cost of each demonstration case study will be comprised between USD 45,000 and 100,000.<br>At full-scale implementation level, the construction of improved animal shelters will be implemented in 100 farms nationwide (poultry farms, and pig and cattle farms). Farms are distributed equally in the northern, central, and southern parts of Moldova. Currently, these farms produce various animal products (eggs, milk, meat) and there is a tendency to decrease production during warm periods of the year because of increased heat and stress suffered by the animals. | | | | | |
| **Benefits** | Improved animal welfare will have economic benefits in terms of increased and sustained productivity, while will have relevant social benefits in terms of improvement of animal husbandry conditions and more humane treatment to producing animals. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timelin e** |

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| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding transboundary water bodies ownership, maintenance and responsibilities | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing livestock | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Low | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on livestock sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Low | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |
| 2. Improved Animal Welfare Program | 2.1 Survey and Mapping of existing livestock halls, shelters, stables and other animal husbandry structures in the country | USD 120.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Low | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 6 months |
| | 2.2 Designing of improved thermally insulated and climate control equipped halls for all livestock farm types in Moldova | USD 500.000 | Capacity of national design firms limited. Risk level: low | National Guidelines on correct construction of animal sheds to ensure welfare in the context of CC | 1 Organic fertilizer production platform plan developed | 12 months |
| | 2.3 Retrofitting of existing livestock farms with thermally optimized systems | USD 6.000.000 | Technical difficulties and cost management. Risk level: low | Existing livestock halls are retrofitted to ensure animal welfare | 100 existing poultry, pig and cattle shelters of various sizes are retrofitted with modern climate control and insulation systems | 24 months |

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| 3. Capacity building | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the livestock sector | USD 60.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 12 months |
| | 3.2 Organization of trainings for farmers on the practices to ensure animal welfare in the context of the changing climate | USD 150.000 | Lack of prepared and knowledgeable national trainers. Risk level: Low | Moldovan farmers are familiarized and trained to ensure animal welfare | 1000 farmers trained on animal welfare principles are requirements | 12 months |

## ANNEX III: Gantt Chart and Complete TAP overview for Horticulture Sector

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| **Sector** | Agriculture |
| **Subsector** | Horticulture |
| **Technology** | High-tech greenhouses with enhanced climate control characteristics and improved energy efficiency |
| **Ambition** | The construction of high-tech greenhouses with enhanced climate control characteristics and improved energy efficiency will be implemented in 25 farms. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce tomatoes, cucumber, cabbage, bell peppers, eggplants and until the 1990s they produced about 40 t/ha for tomato, 50 t/ha for cucumbers, 55 t/ha of cabbage, bell peppers yield some 25 t/ha, eggplants 40 t/ha. Current yields are decreasing as a consequence of increased climate-induced stresses, such as extreme temperature variations, heatwaves and late frost events. The ambition of this TAP at demonstration level is to deploy 25 high-tech greenhouses for tomatoes, cucumber, cabbage, broccoli, cauliflower, strawberry, raspberry, asparagus. Tomato yields in high-tech greenhouses in Europe are 300 to 600 t/ha, five to ten times those achieved in Moldova. Meeting these production targets in the context of climate change will give immense boost to the food security of the country through constant and consistent food supply. This goal will be achieved through the construction of greenhouse shells made of galvanized metal and equipped with best in class double glass and PCM walls for maximum climate control. In addition, high-tech greenhouses are equipped with shade cloth, anti-insect nets, irrigation and fertilization system, ventilation system, complete climate control systems, renewable energy powered, equipped with biomass burners for $CO_2$ supply in greenhouses, computerized control system of all systems, artificial intelligence, Internet of Things and home automation controls, for greenhouses with an area of approximately 1,000 m2 for each farm, and the development of programmes to train personnel to operate and maintain the high-tech greenhouses in the case study farms and exchange knowledge with world-class experts through study tours and training of extension agents and scientists at excellence centers in Europe and the US. |

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| **Benefits** | Controlled climate farming is the new frontier of food production in a context of climate change. Modern high-tech greenhouses can ensure constant climatic conditions and increased production efficiency per unit of surface to deliver consistent productions and abate emissions. Economic benefits are the main outcome for farmers who will be able to generate consistent harvests despite climatic variability, while | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing horticulture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |

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| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 3 months |
| | 2.2 Designing of high-tech greenhouse systems and agrovoltaics systems | USD 144.000 | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. | Availability of high-tech greenhouses and agrivoltaics system designs and construction plans | Guidelines on high-tech greenhouses and agrivoltaics system designs and construction adapted to Moldovan context | 12 months |
| | 2.3 Procurement and construction of high-tech greenhouses | USD 9.000.000 | Technical difficulties and cost management. Risk level: Medium | High-tech glasshouses with PCM-RA walls and complete climate control systems, including off-grid renewable energy sources | 25 high-tech greenhouses are built and functioning, together with agrivoltaics systems to supply renewable energy off-grid | 24 months |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | USD 1.730.000 | No risk foreseen | PhD courses and study tours to world-class greenhouse producers of vegetables in EU and in the US are organized to share knowledge and train scientists from Moldova | 10 PhD students completed specialized education courses, attending exchanges and study tours, and are employed as extension agents for knowledge transfer in Moldova | 48 months |
| | 3.2 Training of farmers on use and maintenance of high-tech greenhouses | USD 150.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan vegetable producers are familiarized and trained to manage production in high-tech greenhouses | 100 farmers are trained to manage full production cycles in high-tech greenhouses | 12 months |
| 4. Market access | 4.1. Market mapping analysis | USD 108.000 | Prices volatility of imported products might jeopardize the results of the study. Risk level: low. | Development of a detailed horticultural products market mapping study | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |

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| | 4.2. Market access development | USD 294.000 | Lack of GD qualified and interested actors: Risk level: Low. | Market access for sustainable horticulture products from high-tech greenhouses is enhanced | At least 10 retailers in Moldova established long-term direct-purchase supply contracts with producers | 48 months |

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| **Subsector** | Horticulture | | | | | |
| **Technology** | Modern irrigation systems | | | | | |
| **Ambition** | The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full scale level. At demonstration level, modern irrigation systems will be implemented in 4 horticulture farms. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce tomatoes, eggplants, potatoes, apples, strawberries, raspberries, table grapes and produced about tomatoes – 50 t/ha, aubergine – 50 t/ha, potatoes – 15 t/ha, apples – 25 t/ha, strawberries – 10 t/ha, raspberries – 15 t/ha, table grapes – 20 t/ha and a decreasing production trend is observed compared to 20-25 years ago, as a consequence of increased climate-induced stresses. The ambition of this TAP at demonstration level is to deploy 4 modern irrigation systems for tomato, eggplant, cucumber, cabbage, strawberry, blackberry, apple, cherry, grape covering some 200 hectares. This goal will be achieved through the construction of water catchment systems, water storage basin, water filtration system, distribution system, fertilization system, drippers, renewable energy systems, for 50 ha for each farm, and the development of 10 programmes to train personnel to operate and maintain the modern irrigation systems in the case study farms.<br>At full scale level the construction of modern irrigation systems will be implemented in 30 horticulture farms. The farms are located in the northern, central and southern part of Moldova, with a predominance in the the central and southern part of the country. The construction of 30 small irrigation systems connected to the existing Central Irrigation Systems will encompass the creation of rainwater catchment systems and storage basins to be used for irrigation lined with geotextile and protective polypropylene lining with a storage capacity of up to 25,000 m3 each and adduction pipelines to the beneficiaries' lands. | | | | | |
| **Benefits** | Rainwater harvesting, water banking, and distribution through improved irrigation infrastructures water to horticultural fields during periods of drought will have several quantifiable benefits. Productivity will be sustained in the face of adverse climatic conditions, maintaining a stable source of income for producers and a constant supply of food on local markets, in which women occupation is aboundant, and supporting the country's food security. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Deployment of Modern Irrigation Systems for increased resilience of horticulture sector | 1.1 Survey and Mapping of horticulture farms in Moldova | USD 132.000 | Delays in recruiting readily available qualified staff and logistical difficulties. Risk level: Low | National Survey and Mapping of feed production database created and accessible | All horticulture farms have been mapped, baseline and target irrigation regimes defined | 3 months |

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| | 1.2 Designing of modern irrigation systems and RE pumping stations | USD 312.000 | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. | Availability of modern irrigation system designs and construction plans | Guidelines on modern irrigation system designs and construction adapted to Moldovan context | 12 months |
| | 1.3 Construction of modern irrigation systems | USD 10.500.000 | Technical difficulties and cost management. Risk level: Medium | Modern irrigation systems are deployed | 30 modern irrigation systems including water reservoirs of 25,000 m3 each and drip irrigation infrastructure covering 3,000 ha of horticultural land in Moldova are deployed and fully functional | 24 months |
| 2. Capacity building | 2.1 Study tours, student exchanges, extension agents development program | USD 25.000 | No risk foreseen | 2 study tours to water management champion institutions are organized to share knowledge and train trainers from Moldova | 2 Scientists are trained to become trainers in modern irrigation systems management and maintenance | 6 months |
| | 2.2 Training of farmers on use and maintenance of modern irrigation systems | USD 120.000 | Lack of prepared and knowledgeable national trainers. Risk level: Low | Moldovan vegetable producers are familiarized and trained to manage modern irrigation systems | 30 farmers are trained to manage vegetable production using modern irrigation systems | 12 months |
| 3. Institutional and Associations Development | 3.1. Strenghtening existing and future Associations of Producers | USD 276.000 | Low participation of horticulture producers. Risk level: Low. | Associations of Producers of horticulture products are strenghtened | 1 Association of Producers is strenghtened in terms of technical staff and authority on water management issues in the context of CCA | 12 months |
| | 3.2. Support to the creation of Water Management Consortia | USD 486.000 | Low participation of horticulture producers. Risk level: Low. | Water Management Consortia are formed and staffed | At least 2 Water Management Consortia are formed in the Center and South of the Country | 24 months |

| **Sector** | Agriculture |
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| **Subsector** | Horticulture |
| **Technology** | Hydroponics |
| **Ambition** | The Ambition for the implementation of this technology foresees the construction of 50 hydroponic greenhouses, located in disadvantaged regions of the country, especially in the localities in the south of the country, with an average area of 1000 m2 each. These will be built with double glazed glass panels or with PCM-RA sandwitches panels, for maximum thermal performances. The hydroponics greenhouses will be equipped with the main components of a modern hydroponic system, including CO2 feeding system, Climate control system, Nutrient solution preparation and distribution system, Germination chamber control system, Rack system, Fertigation unit, Water treatment unit, Phyto light system, and water circulation/irrigation system. The cost per unit of surface of each hydroponic greenhouse is estimated at USD 300/m2. |
| **Benefits** | Hydroponics systems can shorten the growing cycle of many crops and produce year round, thus with two or more harvests per year. An estimated production of 1250 tons of tomatoes or 300 tons of cucumbers in two production cycles or 100 tons of strawberries, salads, spinach, greens, etc. is expected for each of the 1000 m2 greenhouses to be built. This technology is suitable for growing fruits and vegetables in two or more production cycles per year thus ensuring market supply more constantly and at more stable prices, in turn impacting positively on economic actors as well as on food security, in spite of climate change. |

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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding authorizations to build structures and import equipment for specialized production in horticulture | USD 30.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing horticulture | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |

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| | | | structure. Risk level: Medium | | | |
| | 1.4 Amendment of normative acts for horticulture sector development in the context of climate change, development of corrective action plan in the regulatory framework. | USD 92.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining livestock | 12 months |
| 2. Deployment of High-tech Greenhouses for increased resilience of horticulture sector | 2.1 Survey and Mapping of horticulture farms in Moldova | USD 90.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping of feed production database created and accessible | All 100 current feed and forage producing farms have been mapped, baseline and target irrigation regimes defined | 3 months |
| | 2.2 Designing of hydroponics systems | USD 144.000 | Difficult planning and adequate local conditions for maximization of results. Risk level: Low. | Availability of hydroponics systems designs and construction plans | Guidelines on hydroponics systems designs and construction adapted to Moldovan context | 12 months |
| | 2.3 Procurement and construction of hydroponic systems in Moldova | USD 15.000.000 | Technical difficulties and cost management. Risk level: Medium | Complete hydroponics systems are built | 50 hydroponics systems are built and functioning | 24 months |
| 3. Capacity building | 3.1 Study tours, student exchanges, extension agents development program | USD 519.000 | No risk foreseen | PhD courses and study tours to world-class greenhouse producers of vegetables in EU and in the US are organized to share knowledge and train scientists from Moldova | 3 PhD students completed specialized education courses, attending exchanges and study tours, and are employed as extension agents for knowledge transfer in Moldova | 48 months |

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| | 3.2 Training of farmers on use and maintenance of hydroponic systems | USD 75.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Moldovan vegetable producers are familiarized and trained to manage production in hydroponics systems | 50 farmers are trained to manage full production cycles in hydroponics systems | 12 months |
| 4. Market access | 4.1. Market mapping analysis | USD 108.000 | Prices volatility of imported products might jeopardize the results of the study. Risk level: low. | Development of a detailed horticultural products market mapping study | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 4.2. Market access development | USD 294.000 | Lack of GD qualified and interested actors: Risk level: Low. | Market access for sustainable horticulture products from high-tech greenhouses is enhanced | At least 10 retailers in Moldova established long-term direct-purchase supply contracts with producers | 48 months |

# ANNEX IV: Gantt Chart and Complete TAP overview for Cereals Sector

| **Sector** | Agriculture | | | | | |
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| **Subsector** | Cereals | | | | | |
| **Technology** | Conservation Agriculture | | | | | |
| **Ambition** | The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full scale level. At demonstration level, Conservation Agriculture will be implemented in 20 farms of an average surface of 58,000 ha. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce 58,000 ha with a productivity of 3,4 t/ha of winter wheat and a decreasing yield trend is observed compared to 3 years ago, when yields were comparatively higher at 3,6 t/ha on average. The ambition of this TAP at demonstration level is to increase yields from the current average of 3,0 t/ha to 3.6 t/ha.<br>At full scale level implementation, this technology is targeted to interest a total of 340,000 ha and an estimated volume of approximately 1,565,000 tons of cereals. These comprise established cereal farms in the northern, central and southern part of Moldova, distributed for a 70% in the North, 15% in the Center and 15% in the South of the country. Currently, these farms produce winter wheat with a yield of approximately 3,0 t/ha, sunflower at 1,5 t/ha and maize at a yield of 3.5 t/ha showing a marked decrease in yields compared to year 2020, when yields were comparatively higher at - 3,5 t/ha for winter wheat; 2,0 t/ha for sunflower and 4.5 t/ha of maize on average. The ambition of this TAP at national level is to establish the conditions that sustain optimal yields even in the face of adverse climatic conditions to 2020 levels. | | | | | |
| **Benefits** | The implementation of this technology will have relevant benefits on economic, social and environmental sustainability of the sector. Market benefit will be realized through increased productivity and production efficiency, which in turn will translate into reduced price volatility and increased food security. Environmental benefits will be paramount. Moldovan agricultural land used for wheat production is degraded and key soil functions will be restablished by this TAP. Healthy soils will provide habitat for several species and fix more carbon, thus with beneficial impacts on biodiversity conservation and GHG emission reductions. Crop establishment with direct drilling/no-tillage requires as little as one pass for planting compared to two or more tillage operations, as well as seeding, in conventional tillage farming. Fewer passes save an estimated 97 €/ha on machinery depreciation and maintenance costs. That is about 1,950 € savings on a 200 hectare farm. Direct sowing/no-tillage also permits a fuel saving of some 30-40 litres per hectare annually compared to conventional tillage systems. These savings normally compensate for or exceed the extra costs of Conservation Agriculture (direct sowing machinery and application of herbicides). The annual cost reduction in direct sowing of annual crops compared to conventional tillage ranges between 40 and 60 € per hectare. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |
| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing agriculture and the cereals sector | 6 months |

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| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining the cereals sector. | 48 months |
| 2. National Conservation Agriculture Programme | 2.1 Cereal farmers associations strengthening and representation enhancement | USD 72.000 | Reluctance to associate and share risks and benefits. Risk level: Low | The coverage, composition and membership of farmers association is enhanced | Cereal producer associations grow in members by at least 50 new associates | 12 months |
| | 2.2 Creation and upgrading of 5 wheat breeding facilities in the country | USD 875.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | The country has enough breeding supply to cover polyculture needs | 5 cutting-edge breeding nurseries have been modernized or created in Moldova | 24 months |
| | 2.3 Support to national research institutions for research and development of novel breeding technologies and practices to support the national cereals sector | USD 432.000 | Long-term results available only beyond project duration. Risk level: Medium | PhD laurates complete a formation period with tangible research outcomes | 4 PhD students complete their doctorate and produce at least 3 peer-reviewed publications which support enhanced breeding efforts in the country | 48 months |

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| | 2.4 Credit support to acquisition of direct seeding drillers for Conservation Agriculture | USD 56.780.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | A supportive mechanism based on an efficient mix of loans, equity and grants is provided to sustain the retrofitting of wheat farm equipment with direct sowing and CA-ready machinery | 3 Credit support instruments and delivery structures (North, center and south) are created and operational in Moldovan to support full conversion to CA of the cereals sector | 120 months |
| 3. Capacity building on CA and soil stewardship | 3.1 Strengthening the capacities of the institutional framework of the Ministry of Agriculture and subordinated institutions in promoting support actions in the field of adaptation to climate change of the cereals sector | USD 180.000 | Lack of commitment and participation. Risk level: Low | The capacity of MAFI to support actions to adapt aquaculture to climate change is strengthened | 3 training courses are organized with at least 10 technical MAFI staff, and at least 90% of participants pass a final verification | 36 months |
| | 3.2 Organization of trainings for cereals farmers on improved techniques and management for wheat production in CA | USD 600.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Cereal farmers are fully able to manage the introduced technologies in a CA regime | Average yields of enrolled farms are restored at at least 3.5 t/ha for wheat | 120 months |
| | 3.3 Nationwide campaign on soil stewardship for long-term ownership of land and responsible management of natural resources | USD 130.000 | Low attendance of remote farmers and smallholders Risk level: Medium | Farmers understand their role in protecting soils for the benefit of current and future generations and are empowered to monitor and actively protect their soils. | 24 workshops have been carried out nationwide and attended by at least wheat 1,000 farmers in total | 48 months |
| 4. Promoting awareness-raising, knowledge-building and awareness-raising activities | 4.1 Promote awareness raising activities on future risks and vulnerabilities associated with CC on the sector, gender policies for all relevant stakeholders, including public institutions, academia and the media | USD 200.000 | Lack of participation of stakeholders. Risk level: Low | Consumers, public institutions and academia are aware and recognize the risks and vulnerabilities to CC posing a burden of food security | 3 Conferences organized to present and discuss risks and vulnerabilities to CC posing a burden of food security | 40 months |
| | 4.2 Strengthening knowledge and awareness raising on benefits of a climate resilient national cereals sector to retailers and consumers. | USD 100.000 | Lack of participation of stakeholders. Risk level: Low | Market actors are aware of national actions and efforts to produce climate-resilient cereals sector | At least 80% of tonnage of climate resilient products produced in the context of the project reach the | 40 months |

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| | 4.3 Dissemination campaign among manufacturers, presentation of results of pilot projects, and outreach to potential interested farmers | USD 60.000 | Lack of capable local disseminators. Risk level: Low | Potential interested farmers are aware of the opportunities of polyculture and the supporting system created by the project | At least 10 potential new fish farms are informed about the opportunities of polyculture and sustainable aquaculture | 40 months |
| 5. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring cereals farms sustainability performance | USD 108.000 | Complexity of MRV systems and lack of practicality. Risk level: Low | The country is equipped with ad adapted MRV system to monitor wheat farms sustainability | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 144.000 | Lack of data and high data collection costs and time requirements: Risk level: Low. | The sustainability impacts of CA in Moldova are published | 2 yearly monitoring reports for cereals farms enrolled to date applying CA principles and techniques | 24 months |

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| **Sector** | Agriculture | | | | | |
| **Subsector** | Cereals | | | | | |
| **Technology** | Climate-smart rotations and Organic Fertilizers administration | | | | | |
| **Ambition** | The ambition level for implementing this technology is proposed at short-term, demonstration level, and at long-term, full-scale level. At demonstration level, climate-smart rotations and organic fertilizer production will be implemented in 2 farms of a cumulated surface of 500 ha. The farms are located in the northern, central and southern part of Moldova. Currently, these farms produce winter wheat, corn for grain, and sunflower with a productivity of 3,0 t/ha, 3,5 t/ha and 1,5 t/ha respectively. A decreasing yield trend is observed compared to 2020 (- 0,5 t/ha for wheat, maize and sunflower). The ambition of this TAP at demonstration level is to increase yields to 3,5 t/ha for winter wheat; to 4,0 t/ha for maize and to 2 t/ha for sunflower within the first 2 years of implementation. To do so, the use of synthetic nitrogen fertilizer will be decreased to 90 kg/ha and 2.5 tons of organic fertilizer like cattle manure (or equivalent) will be added to the soils. This will require to dispose of some 1,250 tons of organic fertilizer per year.<br>At full scale level implementation, this technology is targeted to interest a total of 200 farms annually, for a total surface of 50,000 ha. These comprise established cereal farms in the northern, central and southern part of Moldova, distributed for a 70,0 percent in the North, 15,0 percent in the Center and 15,0 in the South of the country. Currently, these farms produce winter wheat, corn for grain, and sunflower with a productivity of 3,0 t/ha, 3,5 t/ha and 1,5 t/ha respectively. A decreasing yield trend is observed compared to 2020 (- 0,5 t/ha for wheat, maize and sunflower). The ambition of this TAP at full-scale level is to increase yields to 3,5 t/ha for winter wheat; to 4,0 t/ha for maize and to 2 t/ha for sunflower within the first 2 years of implementation and sustain such productivity long-term. This three-year TAP will deliver an additional 25,000 t/year of wheat, corn and sunflower, while preserving the producing capacity of the land. To do so, the use of synthetic nitrogen fertilizer will be decreased to 90 kg/ha and 2.5 tons of organic fertilizer like cattle manure (or equivalent) will be added to the soils. This will entail disposing of some 125,000 tons of manure per year. | | | | | |
| **Benefits** | Within 2 years from the full implementation of this technology, wheat production will increase by 25,000 tons of grain per year and seat stably at 3.5 t/ha. Similarly, maize production will increase to 4.0 t/ha and deliver an additional 25,000 tons of product to national food markets. Sunflower output will also increase by 25,000 tons per year reaching a sustained yield of 2 t/ha. Organic fertilizers incorporation into soils will increase SOC content, water retention capacity and biodiversity in soils. An important co-benefit will be the decreasing reliance on synthetic N fertilizers and consequent reduced GHG emissions. | | | | | |
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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timeline** |

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| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing agriculture and the cereals sector | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 96.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining the cereals sector. | 12 months |
| 2. Implementation of Climate Smart Rotations and Organic Fertilizer Use | 2.1 Organic fertilizer production and delivery infrastructure development | USD 30.000.000 | Lack of sufficient supply of quality manure | Enough organic fertilizer is produced and delivered to cereal farms, purchased through agreements between livestock and cereals farms supported by adequate financial mechanism (e.g. microloans) | 125,000 tons of manure per year are collected and delivered to cereals farms | 36 months |

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| | 2.2 Climate-smart rotations implementation | USD 6.000.000 | Procurement difficulties, prices volatility, climatic events. Risk level: Medium | A supportive mechanism based on an efficient mix of loans, equity and grants is provided to sustain the retrofitting of wheat farm equipment with materials and equipment for Climate-smart rotations | 200 farms are equipped to implement Climate-smart rotations | 36 months |
| 3. Capacity building on Climate-Smart Rotations and Organic Fertilizer Use | 3.1 Organization of trainings for cereals farmers on Climate-smart rotations and wheat predecessors selection | USD 400.000 | Lack of prepared and knowledgeable national trainers. Risk level: Medium | Cereal farmers are fully able to manage Climatae-smart rotations | At least 200 farmers demonstrated capacity to manage Climate-smart rotations | 36 months |
| | 3.2 Training and education doctoral degree on Climate-smart agriculture | USD 288.000 | Difficulties in completing the PhD courses on time. Risk level: Medium | Doctorate students are trained expressively on Climate-smart agriculture | At least 4 PhD candidates (50% females) complete their doctorate degree | 36 months |
| | 3.3. National interdisciplinary research program for achieving a more resilient and sustainable food system in Moldova | USD 3.360.000 | Logistical difficulties to obtain authorizations, and timely organization and coordination among Universities. Risk level: low. | The country has a National research program on sustainable food systems | 10 research projects on sustainable food systems are funded every year | 36 months |

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| **Sector** | Agriculture |
| **Subsector** | Cereals |
| **Technology** | Network of shelterbelts and ponds to reduce soil erosion and increase humidity of the air |
| **Ambition** | Soil erosion impacts Moldova severely. It is estimated that about 1.4 million ha of land are subject to erosion and a 0.86% growth rate is observed annually. Wind erosion makes up a share of this total, but virtually every high-tillage field where annual crops are produced contributes to soil erosion. It is estimated that as much as 30 t of soils are eroded every year per ha. Considering that wheat production takes place on some 340,000 ha, every year Moldova loses the equivalent of 10 million tons of soil due to erosion. Shelterbelts networks are a necessary contributor to limiting such trend, although not capable alone of annihilating the transport of soil away from its original position. Based on national statistics, at least 50% of cereals field (approx. 170,000 ha) are at high risk of erosion and require immediate action. For every hectare of land, about 250 meters of doubled row shelterbelts are necessary to stop wind erosion. Species selection is key to maximise performance and so is planning and accurate plant spacing. For this TAP it is proposed to use two rows of walker poplar (growth rate of about 1 m per year) plus one row of evergreens. The walker poplar (Populus x Walker) is the only woody species with horizontal branches at ground level. This allows it to stop ground winds very effectively for the entire duration of its life, up to 50 years. At full scale implementation, this technique will interest about 170,000 ha of cereals land in Moldova, with a linear development of shelterbelts of about 42,500 km. The planting and management of two-rows shelterbelts has an approximate cost of USD 409 per ha or USD 1,636 per km (250 meters belt for each ha of land to protect). |
| **Benefits** | The implementation of this technology will have relevant benefits on economic, social and environmental sustainability of the sector. In dry years, the soil is more prone to suspension by the wind resulting in erosion and sandblasting of crops<br>by suspended soil particles. This may lower yields and protein content, and cause delayed maturity, or even mortality. Shelterbelts trap suspended dust and soil particles and help to reduce the physical damage to crops by soil erosion. Long term effects of shelterbelts are therefore the lower transport of soil particles and increased soil availability, including the availability of soil organic matter and carbon, and the reduced impact on existing crops, thus leading to sustained productive capacity of the land. A network of shelterbelt coupled with a network of ponds to increase the humidity of the air can magnify the aforementioned benefits to the point of interacting also with temperatures and overal plant vigor in any agrifood system. Incorporating shelterbelts into management regimes has the potential to improve the ecological health of agricultural landscapes. One of the major environmental benefits is the provision of ecological goods and services to producers as<br>well as to society. These include carbon sequestration, maintenance of biodiversity both above- and belowground, and protection of soil and water resources. In addition, potential for increased property values and improved recreational opportunities (i.e., hunting, bird watching, and hiking) are also credited to shelterbelts in and around yard sites or where people live. Providing habitat for pollinators is considered a benefit recognized by farmers that could be promoted to increase shelterbelt adoption. Shelterbelts also provide an increased level of underground biodiversity, water infiltration, and soil moisture retention compared with the monoculture that surrounds them; this is due to the extensive rooting zones and aboveground biomass of the perennial plants associated with shelterbelts. |

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| **Actions** | **Activities** | **Budget** | **Risks** | **Success Criteria** | **Indicators of completion** | **Timelin e** |

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| 1. Enabling policies development | 1.1 Stocktaking of existing policies surrounding agriculture and cereals production in Moldova | USD 60.000 | No risk foreseen | Stocktaking of existing policies completed on time | 1 stocktaking report on existing policies governing agriculture and the cereals sector | 6 months |
| | 1.2. Multistakeholder dialogue, discussions and workshops | USD 10.000 | Lack of participation of stakeholders. Risk level: Low | Multistakeholder discussions and workshops carried out | Working group established and at least 2 workshops held, report on summary produced | 12 months |
| | 1.3 Policy gaps identification and production of key amendments and new statutes proposition | USD 48.000 | Change of country priorities and administrative structure. Risk level: Medium | Policy gaps identified and key amendments discussed with stakeholders | 2 meetings and 1 report of policy gaps identified and amendments proposed | 6 months |
| | 1.4 Amendment of normative acts on rights and duties of cereals producers, rebalance subsidies to conventional agriculture and development of corrective action plan in the regulatory framework for subsidies to virtuous agriculture practitioners. | USD 240.000 | Change of country priorities and administrative structure. Risk level: Medium | Draft Law Amendments submitted for further processing and adoption | 4 meetings of working group and Approved Review of amendments on laws pertaining the cereals sector. | 48 months |
| 2. National Shelterbelts program | 2.1 Mapping of erosion risk areas, prioritization and planning of execution | USD 550.000 | Difficulties in recruiting readily available qualified staff and logistical difficulties. Risk level: Medium | National Survey and Mapping soil erosion database created and accessible | All 340,000 ha of annual crop lands have been mapped, baseline and target erosion volumes defined | 30 months |
| | 2.2 Creation and upgrading of 5 tree nursery facilities in the country | USD 875.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | The country has enough breeding supply to cover shelterbelt trees supply | 5 cutting-edge breeding nurseries have been modernized or created in Moldova | 24 months |

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| | 2.3 Development of network of ponds in Moldovan cereals sector | USD 24.285.714 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | Network of ponds for increased air humidity is constituted in Moldova | 2,400 ponds are build over 170,000 ha of land to increase the humidity of the air | 120 months |
| | 2.4 Development of network of shelterbelts in Moldovan cereals sector | USD 69.530.000 | Procurement difficulties, prices volatility, authorization delays. Risk level: Medium | Network of shelterbelts for soil erosion control is constituted in Moldova | 42,500 km of two-rows shelterbelts are built and managed to reduce soil erosion | 120 months |
| 3. Monitoring and reporting | 5.1. Selection and adaptation of MRV systems for monitoring soil erosion at the landscape level | USD 108.000 | Complexity of MRV systems and lack of practicality. Risk level: Low | The country is equipped with ad adapted MRV system to monitor soil erosion levels | 1 Nationally-agreed Set of Indicators for sustainability and accompanying methodologies are available to Moldovan authorities and extension services | 12 months |
| | 5.2. Monitoring campaign and analysis of introduced technology | USD 504.000 | Lack of data and high data collection costs and time requirements: Risk level: Low. | The sustainability impacts of shelterbelts on erosion control in Moldova are monitored and published | 1 yearly monitoring report for cereals farms enrolled to date applying soil erosion control techniques | 84 months |