Ukraine

TECHNOLOGY NEEDS ASSESSMENT REPORT

ADAPTATION

August 2019

Ministry of Ecology
and Natural Resources of Ukraine

TECHNOLOGY NEEDS ASSESSMENT REPORT ADAPTATION

TECHNOLOGY PRIORITIZATION

National Consultants:

Dr. Oksana Ryabchenko	Agriculture Sector
Dr. Sergiy Snizhko	Water Sector
Dr. Galyna Trypolska	Water Sector

National TNA Coordinator (Team Leader):

Mr. Anatolii Shmurak	Senior Expert of Climate Policy and Reporting Division of the Climate Change and Ozone Layer Protection Department of the Ministry of Ecology and Natural Resources of Ukraine
Dr. Yevheniia Anpilova	Assistant of Team Leader

TNA Global Project Coordinator

Dr. Sara Lærke Meltofte Trærup	UNEP DTU Partnership

TNA Consultants:

Dr. Ala Druta	Republic of Moldova
Dr. Debbie Sparks	University of Cape Town
Dr. Jiska De Groot	University of Cape Town

This publication is an output of the Technology Needs Assessment project, funded by the Global Environment Facility (GEF) and implemented by the United Nations Environment Programme (UN Environment) and the UNEP DTU Partnership (UDP) in collaboration with University of Cape Town. The views expressed in this publication are those of the authors and do not necessarily reflect the views of UNEP DTU Partnership, UN Environment. We regret any errors or omissions that may have been unwittingly made.

Foreword

Ukraine plays an active role in international climate change cooperation processes. Being a Party of United Nations Framework Convention on Climate Change and Paris Agreement, our country puts significant efforts through its policies and measures to reduce overall national GHG emissions as much as possible.

However, GHG emission reduction activity itself is not an end in itself, it should be a stimulus for growth of innovative economy sector, population welfare and creation of fare market conditions. Such goals could not be achieved without transfer of technologies.

Ukraine has submitted its 1st NDC in 2016 where committed not to exceed 60% of 1990 GHG emissions level in 2030. Now Ukraine is working to undertake even more ambitious commitments on GHG reduction which will be recognized in 2nd NDC that is planned to be accepted till the end of this year.

For us, the ongoing Technology Needs Assessment project in Ukraine is an excellent opportunity to accelerate environmentally friendly technology transfer that should become the basis for Ukraine to reach the ambitious GHG emission reduction targets and promote low carbon and climate-resilient development of the country.

Ostap Semerak
Minister of Ecology and Natural Resources of Ukraine

Executive Summary

The Technology Needs Assessment project provides a great opportunity for Ukraine to perform a country-driven technology assessment to identify environmentally sound technologies that might be implemented with a substantial contribution towards addressing climate change adaptation needs of the country.

The aim of the Technology Needs Assessment project is to support developing countries and countries with economies in transition to develop their potential for adapting to Climate Change, in accordance with their obligations under the United Nations Framework Convention on Climate Change (UNFCCC). The main contribution of Ukraine in this project is the following:

- Better understand climate risks and identify causes of vulnerabilities for selected sectors;
- Prioritize technologies which can be used in environmentally safe technology packages, consistent with national development goals and priorities;
- Facilitate access to and transfer of environmentally sound technologies;
- Facilitate the implementation of paragraph 4.5 of the United Nations Framework Convention on Climate Change on know-how access;
- Identify barriers that prevent primary / preferred technology acquisition, implementation and dissemination;
- Develop a Technology Action Plan to overcome barriers, define the scope of activities, and create a favorable environment to facilitate technology implementation and dissemination.

Technology prioritization is the first step in the Technology Needs Assessment project implemented by applying the methodology proposed by the UNFCCC and the UNEP/DTU partnership. Technology prioritization aimed to elaborate country framework for the Climate Change adaptation and mitigation includes sector technological information, sectoral vulnerability assessment, stakeholder engagement and capacity building , technology prioritization according to developed criteria, understanding the mechanisms for technology transfer.

The applied methodology allows for flexibility and has been elaborated to take into account consideration of country-specific conditions and needs. Technology prioritization for adaptation has been conducted through the following steps: identifying critical sectors with regard to Sustainable Development Goals (SDG) and national security; assessing country-specific climate change risks; creating a preliminary overview of key sectors vulnerabilities; facilitating adequate for TNA assessment institutional arrangements and engagement of relevant stakeholders; identifying current stage of technological development in the prioritized sectors; developing the criteria and context for technology prioritization; identify technologies suitable for country-level implementation; impact verification of identified technologies through expert and stakeholder consultation; prioritization of technologies that are to be involved in the next stage of the TNA elaboration.

According to VI National Communication of Ukraine on Climate Change to UNFCCC (2012) , the most vulnerable to climate change sectors of Ukraine are considered agriculture, forestry, energy, water, tourism and human health. During the TNA stakeholder workshop of August 21, 2018, in Kyiv, the agriculture and water sectors were prioritized as key sectors in the TNA assessment, as being most exposed and vulnerable to changing climate , at the same time, having a significant contribution to food security and population wellbeing. There were several criteria for sector selection, such as the importance for the national economy and country development, impact to food security, and contribution to meeting country's UNFCCC obligations. Details on the processes and reasons used in selection are provided in the first chapter of the TNA report.

During the TNA assessment, a review of existing in the country climate-related policy documents, regulations, national reports, other relevant information was undertaken to understand how adaptation component is addressed in the policy framework of Ukraine. Despite the crucial importance of both agriculture and water sectors in the economic and social development of the country, comprehensive strategic and legislative documents concerning these sectors adaptation to climate change are scarce. Furthermore, the water sector was not sufficiently addressed as an important part of the economic development and national security. A lack of strategic vision of sectoral adaptation to climate change was noticed for both water and agriculture sectors. Thus, the

TNA project of Ukraine and the present report are the first steps to help addressing the lack of national adaptation policy for climate change in terms of technological needs for the agriculture and water sectors.

The Ministry of Ecology and Natural Resources of Ukraine is the designated national institution, which leads and coordinates the TNA process in Ukraine. The essential elements of the institutional arrangement of the TNA process in Ukraine include a TNA Coordinator, a National TNA Committee, National Expert Consultants and Sector working groups.

TNA is a country-driven process, therefore, the primary purpose of involving stakeholders is to help identify technological and institutional gaps and interests, along with identifying more immediate opportunities which can assist to maintain sector's sustainable development or increasing its productivity, while minimizing the impact of climate change. Five main groups of stakeholders were identified as most relevant and involved in the TNA process: f: (i) decision makers from the government ministries and agencies with responsibilities for developing a framework of relevant national policy and beneficiaries of international agreements; (ii) local and regional authorities who enact the policies, (iii) academics who are the leading developers and disseminators of innovation and knowledge in the country; (iv) business and private sector representatives as end consumers of technologies; (v) international organizations and NGOs as mediators, consultants and supporting component in the development of relevant adaptation policy. The beneficiary of the TNA in Ukraine is the Ministry of Ecology and Natural Resources of Ukraine. The key government stakeholders participating in the TNA process are the Ministry of Agrarian Policy and Food of Ukraine, State Agency on Energy Efficiency and Energy Saving of Ukraine, State Agency of Water Resources of Ukraine.

Up to now, climate-gender nexus was not well addressed in Ukraine's policy framework, therefore, the current report represents the first attempt to address this gap in the context of the adaptation component. Gender issues can influence the process of technology transfer and implementation for the agriculture sector and water management, therefore, during the implementation of TNA activities and preparation of the TNA report, the attention was payed to gender balance, including both women and men as a target audience and mainstreaming gender dimension throughout the process. Furthermore, the proposed adaptation technologies are gender-neutral and offer equal benefits for both men and women.

The third chapter of the current work provides information on how climate adaptation in agriculture should be aimed both at preserving and supporting the ecological and social functions of natural systems, as well as maintaining the agricultural productivity. The main consequences of climate change impact currently recognized for agriculture production in Ukraine are:

1. changing of vegetation periods and crop rotation due to changing temperatures, with a high risk of losing production function;
2. shifting of agro-climatic zones;
3. reduction of productive land due to the increasing droughts, loss of available water and increasing soil erosion;
4. expansion of non-typical diseases and weeds.

The main agriculture capacity of the country is placed in two agroclimatic zones (Steppe and Forest-Steppe) with a level of significant risk due to the fast-changing climate conditions. On average, 70 percent of the country's arable land belongs to these zones. This fact is evidence of significant dependence on the future of agriculture production and national food security from the character of climate changes. Considering the analysis of the national agricultural production and agro-climatic conditions, the selection of technologies have to (i) increase resilience to climate change in the sub-sectors of crop production, animal husbandry, and poultry farming; (ii) provide resilience and adaptation to heatwaves, wind erosion, and water shortages; and (iii) be available for small, medium and large size farms. Based on these concerns and analyzing the international experience, the adaptation technology list may include but not limited to conservation agriculture practices and climate-smart agriculture approaches, integrated pest management approaches agroforestry practices and improving breeding processes. Climate-smart agriculture can provide justification for plant species and crop rotation. Combining irrigation and agricultural practices can have co-benefits and synergy effects on the water sector, and assist with developing agriculture based on sustainable water management approaches.

Furthermore, it is crucially important to promote activities that facilitate capacity building and stakeholder engagement , as well as planning for climate change variability. As an example, climate smart agriculture requires reclamation and irrigation technologies based on the upgrade of hydro amelioration infrastructures and water regulation facilities for meeting the modern economic and environmental requirements, to reduce water losses from channels. Additionally, adaptation technologies can mitigate climate change through the reduction of emissions from soil cultivation and livestock production due to changing feeding approaches.

As described in Chapter 4, since 1990 Ukraine has undergone a sharp decline in overall water consumption due to a significant reduction in water consumption by industry and agriculture. The structure of water use in Ukraine is as follows: 48% - industry, 26% - agriculture (irrigation), and 25% - utilities. Water intensity of domestic output is 0.3 m3 per UAH 1 of finished goods, which is much higher than in the developed European countries.

Water consumption by utilities in Ukraine is also significantly higher than that in the EU countries. The average water consumption in 27 cities of Ukraine amounted to 275 liters per person per day whereas in the EU countries this figure is 100-200 liters per person per day.

Climate change impact may reduce the water flow in the future, with significant changes in the hydrological regime of water bodies. The most dangerous manifestations of the change in the hydrological regimes are catastrophic floods and flash floods.

Climate change adaptation activities are already being implemented in the framework of national and state programs, along with national and regional programs and plans. In order to ensure the continuity of activities on adaptation to climate change, the State Environmental Investment Agency of Ukraine implemented in 2012 -2013 the Plan of priority measures on adaptation to climate change, however, they are not sufficient for addressing sectoral and country's vulnerabilities to current and future climate change risks.

Based on proposed TNA methodology, national experts have prepared the long list of possible technologies and technological fact sheets. Criteria for prioritization of technologies have been clustered under Economic, Social, Environmental, Climate Related, Political, Technological and other groups. Based on current national strategy documents and expert judgments, the following criteria were selected for prioritization of mitigation technologies:

Agriculture sector	Water sector
Economic: 1. *Cost* 2. *Farm economic resilience*	**Economic:** 1. *Investment cost* 2. *O&M cost* 3. *Potential to attract private investments* 4. *Availability of domestic technologies*
Social: 1. *Increasing potential for rural development* 2. *Improvement of the employment environment*	**Social:** 1. *Applicability in rural areas* 2. *Job creation* 3. *Poverty reduction*
Environmental: 1. *Increasing Efficiency of Natural Resource Use* 2. *Ecosystem services improvement*	**Environmental:** 1. *Protection of environment* 2. *Protection/maintenance of biodiversity*
Climate related:	**Climate related:**

1. *Strengthening of climate change resilience*	1. *Increasing climate change resilience*
Development Potential 1. *Alignment with state policy priorities* 2. *Potential for replication in the country* 3. *Time of implementation*	

Expert evaluation of the technologies and further scoring based on the weights assigned to each criterion resulted in the list of prioritized technologies for each of the two sectors.

The top adaptation technologies for the agriculture sector are:

1) Drip irrigation in combination with conservation agriculture practices
2) Agroforestry practices (shelterbelt reconstruction)
3) Integrated Pest and Disease Management
4) Development of an agrometeorological early warning system

For the water sector, the list of prioritized adaptation technologies includes:

1) Climate-smart irrigation
2) Drought risk assessment and mapping
3) Flood hazard assessment and mapping

The results of technology prioritization exercise were shared among all interested stakeholders to ensure project result dissemination and to provide the opportunity to give feedback and comments, that have been considered and incorporated into the TNA report. Stakeholders inputs and recommendations will be taken into account during the next steps of the TNA process, which include assessment of barriers to implementation of prioritized technologies and preparation of technology action plans.

CONTENT

List of Acronyms

AA	Association Agreement
APD	German – Ukrainian Agricultural Policy Dialogue
BA&EF	Barrier Analysis and Enabling Framework
BMEL	Federal Ministry of Food and Agriculture, Germany
BOC	Biological oxygen consumption
CC	Capital Costs
CCLM	COSMO—Climate Limited area Modelling
CH4	Methane
CMU	Cabinet of Ministers of Ukraine
CO2	Carbon dioxide
CS	Compressor Stations
CTCN	The Climate Technology Centre and Network
DHI	DHI Water & Environment Company
DTU	Technical University of Denmark
ECHAM	General circulation model developed by the Max Planck Institute for Meteorology
EC	European Commission
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
GCM	Global Climate Model
GDS	Gas Distribution Systems
GEV	Generalized Extreme Value
GFDL	Geophysical Fluid Dynamics Laboratory
GGGI	Global Green Growth Institute
GHG	Greenhouse Gas
GIS	Geographical Information System
HPP	Micro-Hydroelectric Power Plant
GTPU	Gas Turbine Pumping Units
GTS	Gas Transmission System
HW	Heat Waves
ICPDR	The International Commission for the Protection of the Danube River
INDC	Intended Nationally Determined Contributions
ISIS	Integrated Spatial Information System
ISO	International Organization for Standardization
IWPIM	Institute of Water problem and Reclamation
KazGU	Kazakh National University
KazNUAl-Farabi	Kazakh National University
MCA	Multi Criteria Analysis
MENR	Ministry of Ecology and Natural Resources
MPM	Multi Objective Programming Model
NAS	National Academy of Sciences
NDC	Nationally Determined Contribution
NDE	National Designated Entities
NES	National Environment Strategy
NGO	Non-Governmental Organization
NME	Natural Meteorological Events
NPP	Nuclear Power Plant
NTFP	Non-timber forest products
NUBIP	National University of Life and Environmental Sciences
O&M	Operation and maintenance
OC	Operating Costs
OECD	Organisation for Economic Co-operation and Development
PSH	Pumped-Storage Stations
R&D	Research and development
RBS	Rule-based System

RCA	Rossby Centre regional climate model
PCA	Partnership and Co-operation Agreement
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
SAWR	State Agency of Water Resources
SDGU	Sustainable Development Goal: Ukraine
SMP	Spontaneous Meteorological Phenomenon
SNRM	Sustainable Natural Resource Management
SRES	Special Report on Emissions Scenarios
STAR	System for Transparent Allocation of Resources
SWAT	Soil and Water Assessment Tool
SWIM	Soil and Water Integrated Model
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UAH	Ukrainian hryvnia
UAN	Universal Account Number
UKMO	United Kingdom Meteorological Office
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
WBM	Water Balance Method
WFD	Water Framework Directive
WHO	World Health Organization
WWTP	Waste Water Treatment Plants
XDS	Expanded Downscaling

List of Figures

List of Tables

Chapter 1 Introduction

1. About the TNA project

The Technology Needs Assessment (TNA) is a country-driven set of activities directed mainly at the identification and prioritisation of climate change mitigation and adaptation technologies. TNA supports national sustainable development, builds national capacity and facilitates the implementation of prioritized climate technologies.

The concept of TNA was formalized at 7th Conference of Parties under the United Nations Framework Convention on Climate Change (UNFCCC) process in 2001 by establishing the technology transfer framework with the purpose of increasing and improving transfer and access to environmentally sound technologies and know-how. The overall approach involves cooperation among various stakeholders (private sector, governments, donor communities, bilateral and multilateral institutions, non-governmental organizations as well as academic and research institutions), including activities on TNAs, technology information, enabling environments, capacity building and mechanisms for technology transfer (COP 7, 2001[1]).

Since 2001, during the three phases of the TNA Global Project more than 80 developing countries have undertaken TNAs to assess their technology needs to address climate change.

TNAs are conducted under the support of the Global Environment Facility, through its Poznan strategic programme on technology transfer and under technical and methodological support from UNEP Danish Technical University Partnership (UNEP DTU Partnership).

In 2017, Ukraine submitted a letter of endorsement to conduct a TNA in order to contribute to the priorities prescribed by Ukraine's nationally determined contribution (NDC), in particular:

(i) development of a long-term action plan for climate change mitigation and adaptation;
(ii) designing and implementation of long-term actions aimed at reducing greenhouse gas emissions; and
(iii) development and implementation of measures aimed at increasing the absorption of greenhouse gases.

Ukraine was included as an emerging economy country in Technology Needs Assessments - Phase III (TNA Phase III) Project (GEF-6, 2017[2]). In 2018, the Ministry of Ecology and Natural Resources of Ukraine signed a Memorandum of Understanding with UNEP DTU Partnership for Conducting a Technology Needs Assessment Project in Ukraine. Project activities include in-depth analysis and prioritisation of technologies, analysis of potential barriers hindering the transfer of prioritised technologies and analysis of potential market opportunities at the national level.

The key deliverables of the TNA are the following:

1. TNA report describing the prioritised technologies for mitigation and adaptation in selected sectors including the process followed and the rationale for the latter;
2. Barrier Analysis and Enabling Framework (BA&EF) report on existing barriers for the prioritised technologies and enabling framework to facilitate the deployment and diffusion of technology priorities;
3. Technology Action Plan (TAP) report for mitigation and adaptation describing the approach for the uptake and diffusion of prioritised technologies that will contribute to the country's social, environmental and economic development.

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

The major document that defines the innovative policy in Ukraine is the Concept of scientific, technological and innovative development of Ukraine[3] (1999). There are three priority areas of state

[1] https://unfccc.int/process-and-meetings/conferences/past-conferences/marrakech-climate-change-conference-october-2001/cop-7

[2] https://www.thegef.org/gef-period/gef-6

[3] Decree of Supreme Council of Ukraine # 916-XIV dated July 13th, 1999 "On the Concept of scientific, technological and innovative development of Ukraine" https://zakon.rada.gov.ua/laws/show/916-14

support of innovative activities in Ukraine: 1) scientific development, 2) technological development (includes development of resource- and energy saving technologies); 3) production development. The Concept's provisions were not implemented, mainly due to insufficient funding.

There are a number of state laws for defining, regulating and supporting the innovation activity in Ukraine (Table 1.1.).

Table 1.1. Laws of Ukraine related to technological innovation

Title of the Laws of Ukraine	**Year of entering in force**
On Scientific and Technical Information	1993
On Special Regime of Investment and Innovative Activity of Technology Parks	1999
On Innovation Activity	2002
On State Program of Forecasting of Scientific and Technological and Innovative Development	2004
On the All-Ukrainian Integrated Program for the Development of High-Tech Technologies	2004
On Priority Areas of Innovation Activity in Ukraine	2011

The Law "On Innovation Activity" initially included provision that 1.7% of GDP is to be spent on science and innovation, but this provision was never fulfilled, so it was rejected by 2013.

National policies related to adaptation to climate change and development priorities are based on ratified international agreements and conventions and on different national documents (Tabl.1.2).

Table 1.2. Ratified international agreements, conventions and national documents on climate change and development priorities that incorporate adaptation component.

Title of the documents	**Year of entering in force, or ratifying**
UN Framework Convention on Climate Change	1996
Kyoto Protocol	2004
Paris Agreement	2015
VI National Communication	2012
EU-UA Association Agreement	2016
Water Framework Directive 2000/60/EC	2016
Floods Directive 2007/60/EC	2015
Marine Strategy Framework Directive 2008/56/EC	2016
Urban Waste Water Directive 91/271/EEC	2015
Drinking Water Directive 98/83/EC	2016
Nitrates Directive 91/676/EEC.	2017
Water Code (Law of Ukraine)	1995
Law of Ukraine "On Nature Environment Protection"	1995
National Water Programme	2002
Plan of Measures for implementation of the Concept for the Implementation of the State Policy in the Field of Climate Change for the Period until 2030	2017

Agriculture Sector Development Strategy	2013
National Action Plan to Combat Land Degradation and Desertification until 2020.	2016

In Ukraine, activities on adaptation to climate change in 2010-2013 have significantly increased. In December 2010, under the Presidential Decree No.1119 "On the decision of the National Security and Defense Council of Ukraine of 17 November 2010 "On the challenges and threats to the national security of Ukraine in 2011" the State Environmental Investment Agency of Ukraine was ordered to prepare National Action Plan on Climate Change Adaptation. In order to ensure the continuity of activities on adaptation to climate change the State Environmental Investment Agency of Ukraine implemented the Plan of priority measures on adaptation to climate change in 2012-2013.

In Ukraine, the discourse on the need to mitigate the effects of climate change and adaptation to climate change begins to sound. The strategy of Ukraine's adaptation to climate change until 2030 is to be developed and adopted in 2020[4]. The main body empowered to implement the state policy on the fulfilment of Ukraine's obligations under the UN Framework Convention and the Kyoto Protocol is the Ministry of Environment and Natural Resources, MENR (formerly the Ministry of Environmental Protection natural environment of Ukraine).

At the level of legislation, by the Decree of the President of Ukraine in 2010, the State Environmental Investment Agency was given task with developing a National Climate Change Adaptation Plan, identifying the sources of funding for the proposed adaptation measures. During years 2011-2012, two editions of the draft National Action Plan on Adaptation to Climate Change were produced and during 2013 - the third edition. However, none of them was approved by the Government, mostly because of the lack of funding sources for the National Plan.

In 2012, the State Environmental Investment Agency signed the Plan of priority measures for adaptation to climate change for 2012. According to it, there was an Interagency Working Group on Adaptation to Climate Change at the Interdepartmental Commission for Enforcement of the UN Framework Convention on Climate Change in charge to produce medium and long-term scenarios of Ukraine's climate change ; maps of the future climate conditions of Ukraine were developed; has conducted a spatial assessment of future climatic conditions for the production of grain crops, and for the spatial changes in water basins; a set of recommendations for assessing the impact of climate change on people's health and on the economy was developed along with recommendations for the development of regional measures for adaptation to climate change, etc. In 2007-2013, the State Agency of Internal Affairs of Ukraine has organized 9 awarness rasing and information seminars on the issues of climate change in Ukraine for all relevant stakeholders.

In spite of the lack of a programmatic approach for adaptation to climate change, there were several tangible programs in Ukraine that indirectly address the issues of climate change.

The National Target Program for the Protection of Population and Territories from the man-caused and natural emergencies for 2013-2017 included work on:

- landslide protection of territories;
- shore protection of the Azov and Black seas and other water objects;
- improvement of the system of control over the rocks of hydraulic structures and bringing the Dnipro gateways to a safe state;

[4] Decree of the Cabinet of Ministers of Ukraine. "On Approval of the Concept for the Implementation of the State Policy in the Field of Climate Change for the Period until 2030". No. 932-r. December 7, 2016.

- improvement of the state system of hydrometeorological observations and the basic network of monitoring of environmental pollution;
- hydrometeorological service modernisation;
- reconstruction of Early Warning Systems (EWS);
- improvement of the information and telecommunication system of the Ministry of Emergency Situations of Ukraine.

The Strategy for State Environmental Policy of Ukraine has a wide range of objectives by 2020, among which are:

1. The improvement of the environmental situation and increase of the level of environmental safety (reduction of the emission of pollutants through stationary sources by 2015 to 10% and by 2020 to 25%) , the protection of water resources, land and soils;
2. By 2020 , the reduction of an average of 5-10% of the area of arable land in the regions by eliminating from the arable lands slopes more than 3 degrees steepness, water bodies of the land and conservation of degraded, unproductive and technogenically contaminated agricultural land, followed by their afforestation in the forest, forest-steppe zones and in the steppe zone, by 2020 an increase of the area of afforestation of the territory to 17% of the state by restoration of forests and afforestation on the land plots of the forest fund, the creation of protective forest plantations on non-agricultural land and lands set aside for afforestation, restoration and creation of new field-protective forest bands, except steppe areas;
3. Modernization of the national system of informing the population on natural and man-made emergency situations by 2020 ensuring the functioning of local alert systems of the population; strengthening of coastal water bodies within settlements by 2020, etc.;
4. Achievement of the environmentally safe human health (prevailing (90%) compliance with the sanitary and hygienic requirements for the quality of surface water in settlements with the population more than 250 thousand by 2020;
5. Compliance with regulatory requirements for sources of centralized drinking water supply by 2015, prevailing (70%) compliance with the sanitary and hygienic requirements for water quality up to 2020 used for the need of drinking water supply and cooking of the rural population;
6. Introduction of environmental risk management (including cases of man-made and natural emergencies) up to 2020th year;
7. Development of an environmental insurance regulatory framework based on the determination of the harm caused to the health of the population by 2015). The Strategy does not contain estimates of the funds necessary for its implementation.

At the end of 2017, the Plan of Measures for the Concept for the Implementation of the State Policy in the Field of Climate Change for the Period till 2030 was approved. The plan of measures provides for the following actions:

1. Establishing a system for monitoring, reporting and verification (MRV) of greenhouse gas emissions and trading in greenhouse gas emission quotas;
2. Every five years, starting from 2020, revision of the nationally determined contribution of Ukraine to the Paris Agreement;
3. In 2019, approval of the State Scientific and Technical Program in the field of climate change;
4. To develop the procedure for monitoring and reporting of greenhouse gas emissions;
5. The order of preparation of the National plan for allocating quotas between plants;
6. The order of functioning of the permit system for greenhouse gas emissions;
7. During 2019-2020, elaboration and approval of a plan for measures to adapt the population to climate change (health sector);
8. During 2019-2024, the inclusion of climate change adaptation measures in river basin management plans as part of the implementation of integrated approaches to water management based on the basin principle;
9. In 2020, the adoption of a comprehensive National Energy and Climate Plan for 2021-2030;

10. Approval of the Strategy for Adaptation to the Climate Change of Ukraine for the period up to 2030;
11. International negotiations on the preparation and implementation of cross-border projects on adaptation to climate change;
12. Participation of the representatives of Ukraine in the work of the Intergovernmental Panel on Climate Change on the preparation of regular and special reports, guidelines and methodologies on various aspects for the issue of the climate change;
13. Participation of the representatives of Ukraine in the Intergovernmental Council of the World Meteorological Organization for Climate Services; in international climate change talks;
14. Ukraine should report annually to the international inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not regulated by the Montreal Protocol on Substances that Deplete the Ozone Layer. Every two years, starting in 2018, to prepare a national biennial report on climate change and every four years, starting in 2018, to publish a national communication on climate change;
15. Preparation and submission to the Interdepartmental Commission for the implementation of the UN Framework Convention on Climate Change proposals for a mechanism for integrating measures to prevent and adapt to climate change in regional development strategies and action plans for their implementation;
16. Introduction of the latest financial instruments and mechanisms of public-private partnership in the field of climate change;
17. Analyses of possible risks and advantages of the development of domestic nuclear power in achieving the state's goals for reducing anthropogenic emissions of greenhouse gases;
18. To identify climate change adaptation measures for the key sectors of the country's economy and incorporate them into sectoral planning. To identify the best approaches to stimulate business entities of all forms of ownership to implement project-based climate actions, taking into account the best worlds practices:
19. To ensure the functioning of the specially authorized body on monitoring, reporting and verification of greenhouse gas emissions and trading of greenhouse gas emission quotas;
20. During 2019-2020, the development of recommendations on adaptation of agriculture to climate change for the period up to 2030, to develop the medium-term plan of actions for the adaptation of forestry sector of Ukraine to climate change;
21. Creation of forecasting maps of possible flooding as a result of climate change of objects of civil and industrial use, engineering and transport infrastructure in the coastal areas of the Black and Azov seas during the planning, construction and reconstruction of such facilities;
22. Improvement and implementation of state building regulations taking into account the factor of climate change.

The National Action Plan to Combat Land Degradation and Desertification by 2020[5]provides for a range of actions that address water resources, land planning, forest and agriculture sectors vulnerabilities and promote climate resilience and adaptation to climate change. It presumes implementation of integrated water resources management system based on the basin principle through the development and implementation of river basin management plans, including:

1. Creation, restoration and protection of forests, including forest protection strips and other protective plantations; provision of forest management, inventory, inspection, monitoring and accounting;
2. Creation and restoration of grassland and pastures according to scientifically grounded indicators taking into account regional features and natural and climatic conditions;

[5] https://zakon.rada.gov.ua/laws/show/271-2016-%D1%80

3. Accelerating work on the conservation of degraded, technogenically contaminated and unproductive land, reclamation of disturbed lands; implementation of anti-flood coastal, anti-slip and anti-landslide measures, protection of territories against flooding;
4. Announcement of new and expansion of the areas of existing territories and objects of the nature reserve fund;
5. The design of regional schemes and programs for the development of the ecological network as well as pilot land management projects for the management of land holdings and land use of territories and ecological networks, taking into account the EU experience in the field of landscape planning; conducting of solid ground surveys of lands of Ukraine;
6. Zoning of land taking into account the consequences of climate change; introduction of modern ecologically safe resource-saving technologies for balanced use, protection and restoration of land and soils, prevention of their degradation; conducting analysis of the use of soil protection agricultural technologies, in particular traditional, No-Till and flat-rolled cultivation in the zones of water and wind erosion of soils and developing a plan of measures for their wider application, etc.

The Plan about the implementation of government Concept in the field of climate change contains the particular list of activities, a number of which are directly related to climate adaptation of *agro production complex*:

- Recommendations development on climate change adaptation of the agriculture sector for the period till 2030;
- Development and approval of the medium-term plan of actions for Ukraine forestry adaptation to climate change;
- Preparation and submission for consideration to the Interagency Commission on enforcement of the UN framework convention about climate change of proposals for realizing the potential, increasing the volume of absorption of greenhouse gases by 2030 in the field of rational use and protection the land and forestry.

While the mitigation component keeps the main focus of state climate policy, there is still lack of sufficient attention to the adaptation component.

Currently, climate change adaptation is not sufficiently prioritized within the existing policy-regulatory framework of Ukraine, therefore, the enabling environment for the implementation of adaptation action, including through technological transfer is undeveloped. Urgent measures are to be adopted and put in place in order to respond to real resilience and adaptation needs of economic sectors, natural ecosystems and population of the country.

Guided by the principles of the Paris Agreement regarding the consideration of national particularities and achievement of sustainable development and for achieving synergies of climate and sectoral policies and strategies, when the priority areas for mitigation and adaptation activities were determined in agriculture of Ukraine, the current regulatory documents were taken into account, particularly:

1. Strategy of the agricultural sector of the economy for the period up to 2020, approved by the order of the Cabinet of Ministers of Ukraine dated 17th October, 2013 No. 806-p.
2. The Strategy of sustainable development and institutional reforming of forestry of Ukraine for the period up to 2022 ", approved by the order of the Cabinet of Ministers of Ukraine dated November 15, 2017

The water resources sector is regulated by Water Code (Water Code,1995) in Ukraine, the Law of Ukraine "On Nature Environment Protection" and other legislative acts. The last edition from the 28 December 2014 together with the amendments passed on on 4th October 2016 has completed the harmonization of Ukraine regulation with the EU Water Framework Directive (WFD). The current legal framework for EU-Ukraine relations is provided by the Association Agreement (AA), which replaced Partnership and Co-operation Agreement (PCA) in 2014. The signing of the political part of the agreement on 21th March 2014 was a step forward in the implementation of the results of 10 years work in Ukraine on the harmonization/approximation of environmental legislation to the EU legislation, including EU water legislation, particularly the EU Water Framework Directive.

Under this AA, Ukraine has begun the implementation of the next directives:

• Water Framework Directive 2000/60/EC;
• Floods Directive 2007/60/EC;
• Marine Strategy Framework Directive 2008/56/EC;
• Urban Waste Water Directive 91/271/EEC;
• Drinking Water Directive 98/83/EC;
•Nitrates Directive 91/676/EEC.

A wide range of other state documents – the resolutions of the Cabinet of Ministers (CMU), Parliament, MENR provide the regulations of water use, protection, conservation and adaptation to climate change. Among them the following should be called (Table 1.3.):

Table 1.3. National legislation in the water sector of Ukraine

Title of document	Art of document	Issue	Entered in force
On drinking water and drinking water supply	Law	Parliament of Ukraine, No 2918-III	January 10, 2002
State Program ‘Drinking Water of Ukraine’ for 2011–2020”;	Parliament Resolution	Parliament of Ukraine, No. 3933-VI (3933-17	October 20, 2011
Approval of State-Targeted Program of Development of Water Industry and Ecological Sanitation of Dnipro River’s Basin up to 2021	Law	Parliament of Ukraine, № 4836-VI	May 24, 2012
On Approving the Procedure for the Development of the River Basin Management Plan	Decree	Cabinet of Ministers of Ukraine No. 336	May 18, 2017
Environmental Impact Assessment	Law	Parliament of Ukraine, No. 2059-VIII	December 18, 2017

1.3 Vulnerability assessments in the country

Till now, in Ukraine, there are no standard methodologies for assessing vulnerability, for measuring or weighing the effectiveness of risk reduction, taking into account the large number of stakeholders and a wide range of activities undertaken[6]. For this reason, we used the available results of the study of historical and projected climate data, economic data from different sectors and published relevant information on vulnerability assessments undertaken in Ukraine.

[6] Methods for the improvement of Vulnerability Assessment in Europe. Available at: https://cordis.europa.eu/project/rcn/88645/reporting/en

Ukraine has a temperate continental climate. In the western and northwestern regions of Ukraine, the climate is mild with excessive moisture and moderate temperature conditions, while the eastern and south-eastern regions are characterized by the lack of precipitation and slightly elevated temperatures. The study of the Ukrainian climate indicate that in recent decades the air temperature and some other meteorological parameters differ from the long-term average (average values for the period 1961−1990). Currently, the longest period of warming for the entire period of meteorological observations is noted in Ukraine.

During 1989–2015, average annual air temperature exceeded the climate norm (1961−1990) by 1° C and in last decade (2006–2015) – on 1.5° C, which is ahead the global average rate of warming. [7]

According to the reports of Ukrainian researchers, the average annual air temperature will increase by the end of the XXIth century over the entire territory of Ukraine by different(low-end, intermediate, high-end) RCP scenario on 2-5 ° C (Snizhko S., at all, 2019) SRES scenario: B1 from 0.7 to 3.0 ° C, A1B from 2.4 to 4.2 ° C, A2 from 2.6 to 4.6 ° C (Krakovska S. at al., 2013). These climate projections do not show significant changes in annual amounts of precipitation, but there is evidence of rising rainfall in the cold season of the year and the reduction of precipitation in the summer.

Together with the high uncertainty of precipitation changes trend, the intensive warming exacerbates risks and increases the threat related to (Adamenko T. I. at all, 2016):

- strengthening the climate extremes due to the increase in the air temperature maximum by 1–4° C and the numbers of hot days by 2–3 times. The increasing number and intensity of severe weather events (extreme temperatures, heat waves, heavy rains, squalls, whirlwinds, hail, frosts, droughts, floods, and sudden weather changes affecting public health and effectiveness of different sectors of the economy;
- strengthening the aridity of the climate, as evidenced by three severe droughts observed in the last decade (2007, 2010, 2015) and affected 50–80 % of the country territory. The heat wave recorded at the end in July−August 2010 was the most powerful and durable recorded during the summer season in the period 1911–2010 for the eastern and southern regions of Ukraine (Snizhko et al., 2012) (Shevchenko et al., 2014).
- reducing of the efficiency of rainfed agriculture, especially in the South and South-East due to almost annual droughts;
- decreasing of yield of early grain crops and late crops because of high temperatures and reduction of vegetation periods;
- extension of the fire periods and increasing fire risks in forests and peatlands;
- decreasing the groundwater levels, drying the shallow wells and sources of drinking water;
- changes in the composition of plant pathogens and weeds, the existing of which is limited by the temperature factor, pathogens' spreading and migration into favorable climatic conditions;
- increasing the probability of mass breeding pests or outbreaks of infectious and parasitic diseases, which were not typical/ not existed before in Ukraine;
- increasing soil erosion due to the variation of temperature and precipitation quantity and intensity;
- decreasing the spring flow of large rivers due to reduction in winter season, duration of laying snow cover, and decreasing winter precipitation quantity and depth of soil freezing, what inhibits the formation of normal spring floods on the rivers of Ukraine;

[7] Krakovskaya S.V. at al., Report on research work on developing scenarios for changing the climatic conditions in Ukraine in the medium- and long-term period using global and regional models

- uncertainty about the reduction of annual runoff of the large rivers, in recent years the large river flow forms mainly due to the summer flesh-floods and winter floods;
- the growing threat of water scarcity for the small rivers flow formation, appearing the water problem due to the growing water demands, especially for irrigation;
- deterioration of ecological status of large and, in particular, small rivers due to droughts and, especially, their combination (in 2015 the meteorological, hydrological and soil droughts occurred simultaneously);
- increasing evaporation from water surfaces as a result of frequent "heat waves", increasing the temperature of the air and water.

According to experts' assessments, the increase in the air temperature by 1° C results in a decrease of annual runoff by 2–5 % and increase of evaporation by 2–5 % per year (Adamenko T. I at all, 2016). Most likely the frequency of dry years on the territory of Ukraine can increase and lead to very low or critically low water availability for the population.

Ukraine's 6th National Communication Report to the UNFCCC summarizes the following key sectors of vulnerability to climate change impacts:

1. Agricultural sector – Grain yield may decrease by 10–16% due to increase in the frequency and severity of drought during the growing season, decrease in the frequency of precipitation and an increase in the intensity of rainfall, and lack of sustainable snow depth needed for crops to weather sub-freezing temperatures.
2. Forests – Long-term climate change is very likely to show generally negative impact on forests, the impact of increasing climate variability on terrestrial ecosystems are expected to be negative and significant. Increasing the fire danger is very possible in the various regions of the country.
3. Human health – The above mentioned report expects that human health will be affected through changes in environment as well as impacts of extremes of temperature (cold season and heat waves).
4. Energy – Climate warming will reduce output from nuclear power plants (NPP) and hydropower plants (HPP), leading to daily fluctuation of energy production in the summer;
5. Water supply systems- Climate change and extreme weather events (floods, droughts, heat waves, etc.) can affect both the water availability (in particular, lack of access to water during the drought due to drying and/or decreasing of water level in the springs, shallow wells, small rivers) and water quality (deterioration of water quality).

At the same time, climate change causes interconnected or cross-sectoral processes in all these sectors. For example, the growth of energy demand indirectly affects the growth of water use, and overcoming the consequences of impacts of flooding on buildings and constructions as a result of natural disasters and rising sea levels will require the increased use of various resources, including energy.
Expected impact is provided in the sub-chapter 1.4.1

Supply side:
Carbon source energy production:

- high temperature will reduce output from nuclear power plants (NPP) through operating restrictions, reduce capacity and efficiency of coal and nuclear power plants and power grids capacity as a result of rising water temperature in cooling systems, increase electricity losses in networks and the construction of new coal and nuclear power plants will be limited;
- the deterioration of the working conditions of circulating cooling and chemical water treatment will reduce the available capacity of coal and nuclear power plants (VI Nat. Com. on Climate Change) and gas turbine plants;
- change in technologies of extraction and transportation of natural gas since unpredictable temperature changes alter the physical and chemical properties of gas;

- in case of increasing the number of floods, an increased risk is associated with gas pipelines, especially those located above the reservoirs, for example, in the Carpathian region.

Energy production from renewable sources:

- developing hydro energy production could be limited by river drying up and salinization;
- algal bloom increases operating costs of the micro-hydroelectric power plants (HPP) and reduce the power generation capacities at the HPPs and pumped-storage stations (PSH);
- failure of wind power equipment due to storm winds.

Energy supply:

- change of load conditions of heat generating capacities and unbalanced hot and cold water supply (Sidenko, 2016);
- changing pick loads time and its daily fluctuation in the summer;
- raising the average temperature will require a revision of the installed heat supply capacity;
- storm winds, hurricanes, and tornadoes will contribute to the growth of emergencies in power grids, which leads to significant economic losses by the population and industry, the increase of social tensions and increased requirements to emergency services and the Ministry of Emergencies due to more frequent power outages;
- acid precipitation contributes to the corrosion of steel structures (VI Nat. Com. on Climate Change).

Energy demand:

- an increase in temperature reduces the energy consumption of gas for heating in the winter autumn period;
- summer heat will increase the number of days with extreme temperatures, which will require more electricity to cool the premises.

Agricultural sector. At present, the vulnerability assessments for the agriculture sector was not carried out on the national level. However, the agriculture sector of Ukraine is an essential player in the global scale of food security.

At the same time, agriculture is one of the most depending areas from environmental conditions. This dependence is reversible, such as intensive agriculture production is accelerating the climate change and uses it for its own benefit.

The main climate change consequences on ***agriculture*** are as follows:

Future Climate Oportunites:

1. an increase in the yield of major crops in short-term period by 2030;
2. shifting crop-growing zonality from south to north;
3. the development and application of biotechnology;

Future Climate Risks:

1. Critical decline in yields by the period of 2050;
2. Reduction in productivity due to the lack of adequate technical equipment in rapid climate change;
3. The increasing erosion and loss of soil productivity due to the increasing droughts;
4. Loss of production capacity as a result of migration processes due to adverse climatic phenomena;
5. Increased risk of plants suffering from diseases and pests due to favorable conditions for the active development of many of their pathogens;

6. Bees-decline;
7. Reducing the adaptive ability and efficiency in all types of live organisms breeding with an agricultural purpose;
8. The transmission of infectious diseases as a result of changing migration routes of wild birds, animals, and insects;
9. The reduction of the gross production of traditional fodder crops and the need for increased production of non-traditional crops (sorghum, triticale, etc.);
10. The mismatch of existing microclimate maintenance systems in the premises for keeping animals in new climatic conditions;
11. Natural disasters (hurricanes, snow, droughts, etc.) can cause animals' stress and affect the efficiency of production.

The expected and observed impacts and vulnerabilities of climate change on the processes of agriculture production in Ukraine:

1. Due to an increase in the heat supply of the growing season by 200-400 ºC the vegetation period has increased by 10 days or more. The vegetation period is likely to be prolonged for another 10-15 days by 2030,. That opens additional opportunities for growing all types of macrothermophytes.
2. In the south of Ukraine, a new thermal zone with a cumulative annual temperature of more than 3400ºC appeared (the northern climatic limit of subtropical agriculture). This is the reason for changing crop rotation. The cool weather crop production would reduce and will move further north. Increase in temperature can provide harvesting two times per year.
3. The frequency of days with the maximum temperatures in the daytime >35 and 40°C, which are related to dangerous meteorological phenomena, has almost doubled. There is the threat of increasing drought, increasing the number and duration of heat waves and fire hazard.
4. Due to winter warming, the risk of death of winter crops has significantly decreased. There are "vegetative winters", when in the winter crops also undergo growth processes.
5. The installation of snow cover in certain years occurs earlier than the average dates, but it is extremely rare to last during the whole winter, and in the south, it may not occurs at all. Increase in total cumulative winter temperature influenced soils and early readiness for the beginning of spring field work, the extension of the growing season, the creation of favorable conditions for the conservation and spread of pests and diseases on agricultural crops.
6. The rapid growth of heat resources and almost unchanged precipitation, both in the summer and in the spring-summer period, that affect the humidity regime of the territory and contributes to increasing the repeatability of drought.
7. During the vegetative period, there was an increase in the dryness of territories that previously belonged to areas with sufficient moisture. The area of the moisty agroclimatic zone (Polissya) and the zone of unstable moisture (Forest-steppe) decreases and the arid zone (Step) expands.

Future climate vulnerabilities in *forestry*:

- high temperature in warm seasons contribute to forest fires, and traditional methods include water dowsing and spraying fire retardants to extinguish existing fire;
- as a result of climate change, forestry will continue to decrease in Ukraine by 2030 due to the reduction and even the disappearance of valuable tree species, the reproduction of harmful insects, the increase in the number and frequency of forest fires;

- early studies indicated that, provided that there is sufficient moisture, the forest massifs can grow by 10-30% by 2050 (Sidenko, 2016), but now it is doubtful due to reduced precipitations level;
- deforestation is a factor that contributes to the negative effects of floods;
- forests can be replaced with woody biomass plantations in order to meet the growing demand for renewable energy. Therefore, a new, moderately dry forest zone for our country may appear in Ukraine (Orlenko, 2010).

The expected impact of climate change on water resources of Ukraine:
- drought causes non-replenishment or insufficient replenishment of groundwater, which can deepen soil erosion. The insufficiency of groundwater negatively affects soil moisture and crop yields;
- the expected warming in Ukraine will lead to instability of the snow cover and a decrease in the flow of meltwater to the rivers, so that the shallow and average rivers, especially the mountain rivers, will continue to dry up;
- drought worsens the quality of water in rivers, increasing its algae blooming and reducing the volume of oxygen in reservoirs that negatively affects fish farming;
- there is an assumption that an increase in water use for economic requirement may be of the same magnitude as predicted climate change (Climate Change Post);
- there is evidence both about an increase in the average annual precipitation and its decrease. In case of the increased rainfall, it will not be uniform, so in any case, the summer rivers can decrease by half in all of Central Europe and Ukraine (Alcamo, 2007). In the case of reducing the water content of the rivers of the Dnipro river basin, avoiding water shortage by changing the management of the Dnipro River cascade reservoirs is impossible (II Nat.Com. on Climate Change);
- lakes are expected to reduce the amount of oxygen, the volumes of algae and bacteria will increase, even in deep waters. It will negatively affect fishing. In the north of Ukraine, annual runoff can grow by 15-25%. Winter drains will increase, and spring will decrease. In the South and Southeast of Ukraine, the annual runoff of rivers can be reduced, which increases the risks of drought and extreme floods. In the south and south-east, the quality of surface water will deteriorate, which will require both additional measures for water purification and possible transport of water to these regions. The quality of water is expected to deteriorate in the Dnipro river. Considering that its water is already heavily contaminated, deep groundwater is expected to be used as drinking water in the future. (II Nat.Com. on Climate Change);
- About 2.5% of the population in Ukraine, reside at an elevation of lower than 10 m above sea level, which are the most vulnerable (houses, infrastructure, arable land will suffer more from soil erosion, especially after 2050).

1.4 Sector selection

The process of sector selection was openly conducted during the initial workshop of 21st August, 2018. (Annex VI)).

The full set of sectors were selected and discussed with potential to be considered in the adaptation component of the TNA. Workshop participants proposed various industries and areas — the energy, transport, water management, agriculture, human health, urban management, hydrometeorology.

As a result, stakeholders’ recommendations were grouped as three criteria of sector selection: (i) the sector priority in the national strategy of economic development; (ii) the sector impact in terms of conducting international obligations; (iii) the level of legislation support and development strategy of the sector.

As an example, there are essential documents in the direction of energy (Energy Strategy and Ukraine's commitments EU Ukraine Association) and ther is no urgent need to strengthen this area.
At the same time, agriculture is the top sector in the list of national development priorities. However, the lack of national strategies of agriculture development in terms of climate change adaptation and mitigation may be observed.

Otherwise, the sustainable development of the agriculture sector in terms of climate change is a matter of national food security and economy development. In recent years, there have been obvious changes in the structure of the Ukrainian economy. Agriculture and forestry come to the fore (following statistic data), they generate about 17-18% of GDP. Mining and metallurgical complex account for another 14% of GDP. However, in the last four years, the share of mining has been fallen (by 9%), while in the agrarian sector has been significantly increased (by 39%).

Since 2000, the agricultural export of Ukraine has grown 13 times - from $ 1.4 billion to nearly $ 18 billion. None of sectors has made a comparable breakthrough.

Ukraine is dependant on the water sector reconstruction to develop the government system of water management in correspondence with European Union standards. It is hardly possible to speak of any systematic management in the water sector by this time in Ukraine. In compliance with the requirements of the Association Agreement with the EU, the relevant legislation was developed, and the water management system was switch to the baseline EU water management principals.

Finally, in accordance with the recommendations of the organizers of the 3 stages of the project (UNEP, UNFCC, Technology Transfer Mechanism, UNEP DTU Partnership) developed based on the experience of the previous two stages, all 23 countries were recommended to choose 4 sectors (2 from the direction of mitigation, 2 from the direction of adaptation) and focus on them (Fig 1.1.).

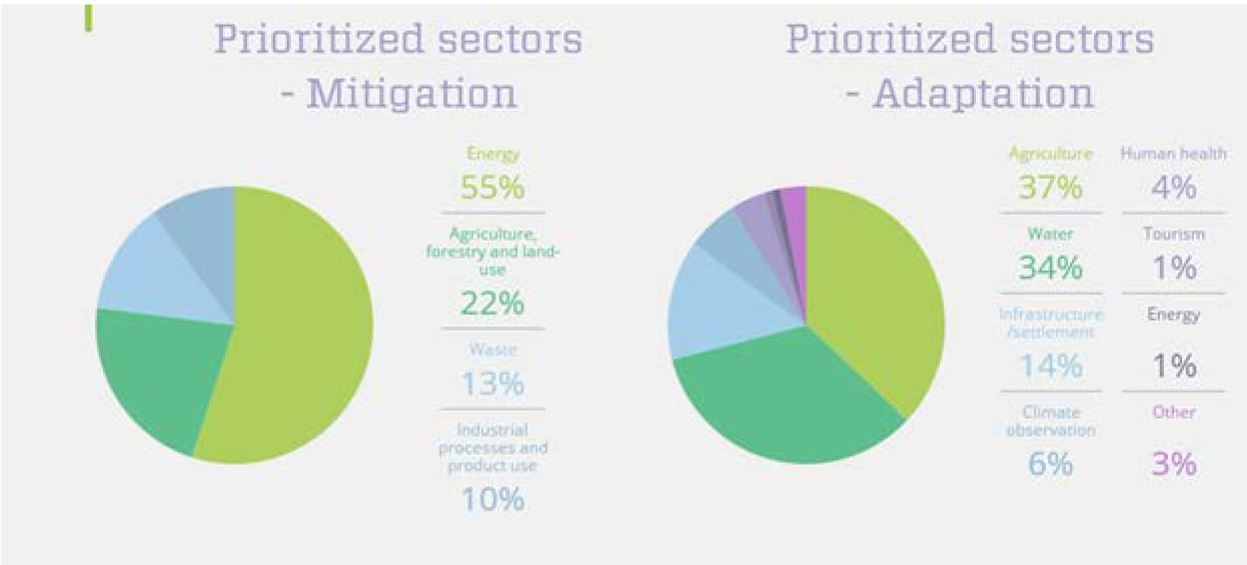


Figure 1.1. Sector prioritization
(Source: https://unfccc.int/ttclear/tna)

Both agriculture and water sectors received the highest support from participating stakeholders and have been prioritized for adaptation component to conduct a technological needs assessment with technology prioritization.

1.4.1 An Overview of Expected Climate Change and its Impacts on Sectors Vulnerable to Climate Change

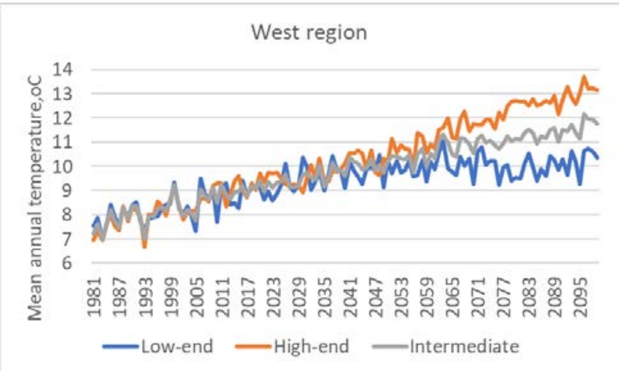
The current climate of Ukraine is characterized by asymmetric warming (more significant in the north than in the south), pronounced in the winter and summer months. The most important meteorological parameters that determine the climatic and agro-climatic resources of each territory are air temperature and precipitation.

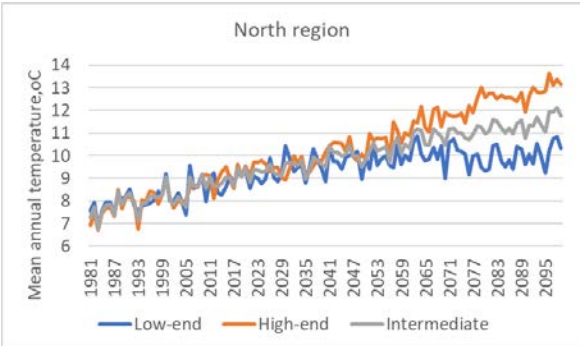
The assessment of expected climate change was made in Ukraine till 2100 on the base of climate scenarios from the FP7-funded IMPRESSIONS project (Impacts and Risks from High-End Scenarios: Strategies for Innovative Solutions, 2016[8]) at the Taras Shevchenko National University, the Department of Meteorology and Climatology in frame of collaboration with Potsdam Institute for Climate Impact Research (PIK) (Snizhko S. at al., 2018). The climate projections constitute a set of seven GCM-RCMs coupled climate simulations with 0.5◦ resolution under RCP 4.5 and RCP 8.5 forcings by 2100. These GCM/RCM projections were selected to cover the range of projected temperature's increases in Europe and in Ukraine, which vary according to the RCP forcing as well as to model. The climate simulations were obtained from the CORDEX database (for territory of Ukraine used climatic data from 400 grid points with resolution 50×50 km) and bias-corrected in the IMPRESSIONS project to the WFDEI dataset. These seven climate projections were combined in IMPRESSIONS into three sets of low, intermediate, and high-end scenarios. The high-end scenarios include three projections under RCP 8.5: HadGEM2-ES/RCA4, CanESM2/CanRCM4, and IPSL-CM5A-MR/WRF. The intermediate scenarios include the GFDL-ESM2M/RCA4 scenario under RCP 8.5 and the HadGEM2-ES/RCA4 scenario under RCP 4.5. The low-end scenarios include two projections under RCP 4.5: GFDL-ESM2M/RCA4 and MPI-ESM-LR/CCLM (Kok K. and all, 2017).

To estimate climate change induced signals of changes in temperature and precipitation, the period from 1981 to 2010 was taken as a reference period (corresponding to the bias-correction period), and the future period was subdivided into three time slices: near future, 2011–2040; middle future, 2041–2070; and far future, 2071–2100—simulations for which were later compared to those in the reference period.

The Assessment of expected changes in temperature and precipitation was made for 5 socio-economical and geographical regions of Ukraine: west, north, central, east, south).

Figure 1.2. presents the expected change in air temperature in the five regions of Ukraine obtained with set of low-end, intermediate and high-end scenarios. All projections demonstrate an increase in average annual temperature from the near future to the end of the XXI century.





---

[8] Impacts and Risks from High-End Scenarios: Strategies for Innovative Solutions. Available online: http://www.impressions-project.eu/ (accessed on 18 January 2016)

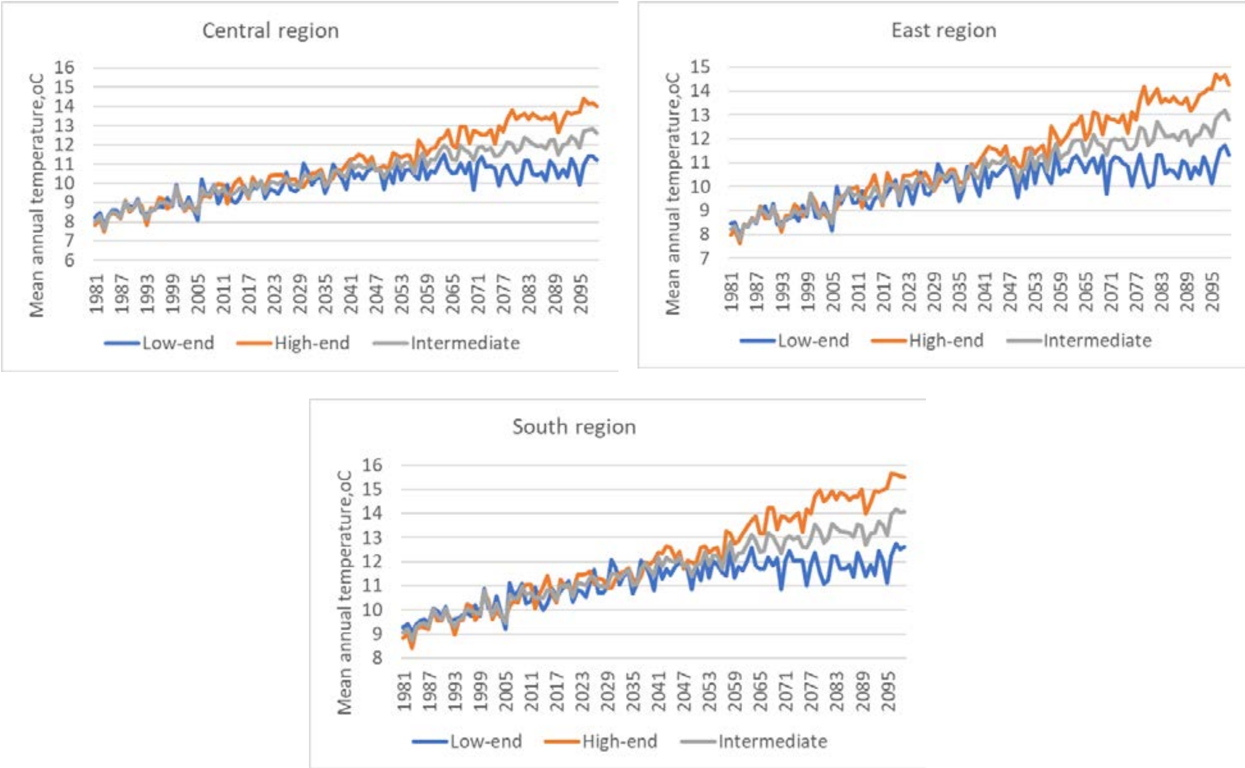


Figure 1.2. Expected air temperature changes in the five regions of Ukraine from the near future to the end of the XXI century calculated under RCP scenario
(Source: Snizhko S.at al., 2019)

In the reference period (1981-2010) the average annual temperature across the territory of Ukraine was from 8 °(north) to 10 ° C (south). In the end of the century, there will expects increase in the average regional annual temperature by different scenario on 2-5 ° C. The average regional temperature values will reach 10 ° (north) - 15 ° C (south). Expected changes in the air temperature during XXI century across different regions of Ukraine is presented in the Table 1.4.

Table 1.4. Expected changes in the average annual air temperature during XXI century across different regions of Ukraine

	Near future, 2011–2040	Middle future 2041-2070	Far future 2071-2100
Low-end scenario			
West region	1,1	1,8	1,9
North region	1,1	1,8	1,9
Central region	1,1	1,8	1,9
East region	1,0	1,8	1,9
South region	1,0	1,8	2,0
Intermediate scenario			
West region	1,2	2,3	3,2

North region	1,2	2,3	3,2
Central region	1,2	2,3	3,2
East region	1,2	2,4	3,3
South region	1,3	2,4	3,4
High-end scenario			
West region	1,3	2,8	4,5
North region	1,4	2,9	4,5
Central region	1,4	2,9	4,6
East region	1,4	3,0	4,7
South region	1,4	3,1	4,9

An increase in the air temperature in the near future (2011–2040) in the low-end scenario in comparison with the reference period (1981-2010) in all regions estimates from 10,6 (south) to 13,8% (west) % (Figure 1.4.). These changes are not sufficient and comparable with natural long-term oscillation of temperature.

In the middle future (2041–2070), these changes are become more evident: from 18,1% in the south to 22,6% in the north.

In the far future (2071–2100), average annual temperatures will increase on 19,9% in south and on 23,9% in north and in west by comparison with the reference period.

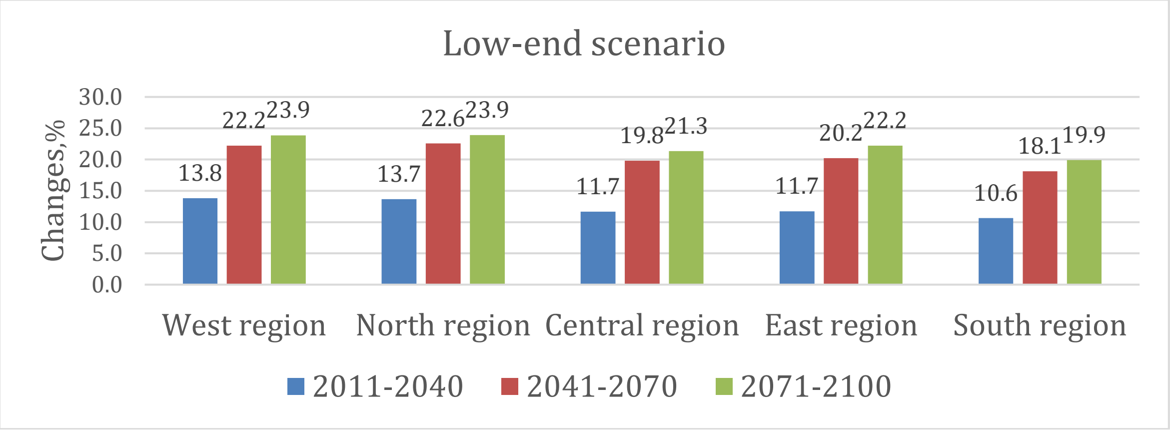


Figure 1.3. Increasing of the average regional annual air temperature in Ukraine by low-end scenario *(Source: Snizhko S.at al., 2019)*

An increasing in the air temperature in the near future (2011–2040) by high-end scenario in comparison with the reference period (1981-2010) in all regions estimates from 14,8% (south) to 17,7% (north) % (Figure 1.5.).

In the middle future (2041–2070), these changes are become more evident : from 31,4% in the south to 35,8% in the north.

In the far future (2071–2100), average annual temperatures will increase by 49,9% in south and on 56,6% in north by comparison with the reference period.

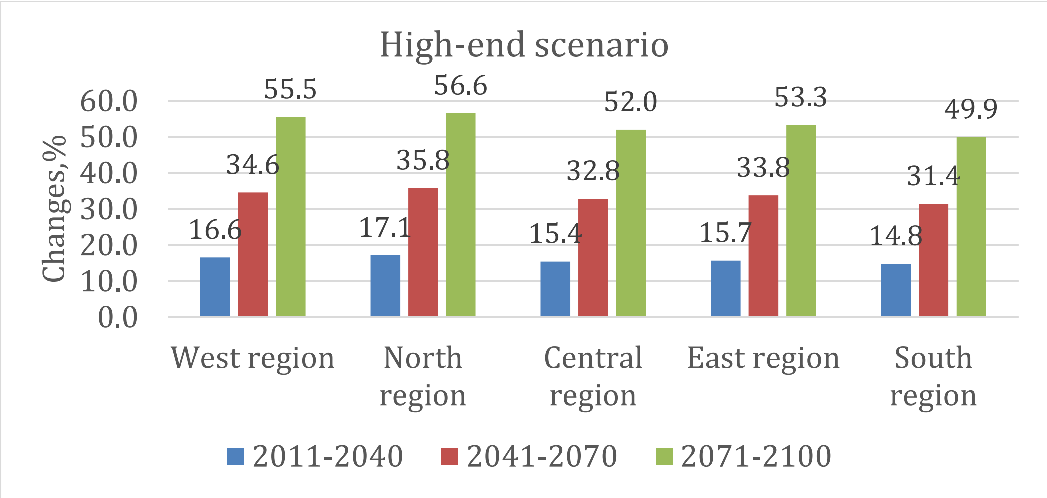
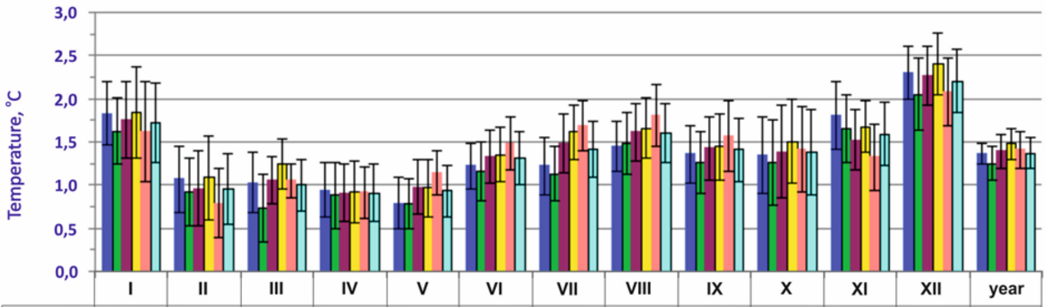


Figure 1.4. Increasing of the average regional annual air temperature in Ukraine by high-end scenario *(Source: Snizhko S.at al., 2019)*

Very similar estimates were obtained earlier by the research team from Ukrainian hydrometeorological institute (Krakovskaya S. at al) using SRES scenario from the IPCC Third Assessment Report (TAR), published in 2001 and climate projection from the EU project “ENSEMBLES”. They report that by the end of the XXIth century average temperature increases in the entire territory of Ukraine in relation to 2001-2010 for scenario B1 from 0.7 to 3.0 ° C with an average value of 2.0 ± 0.8 ° C, for scenario A1B from 2.4 to 4.2 ° C with an average value of 3.1 ± 0.7 ° C and for scenario A2 from 2.6 to 4.6 ° C with an average value of 3.8 ± 0.8 ° C.[9]

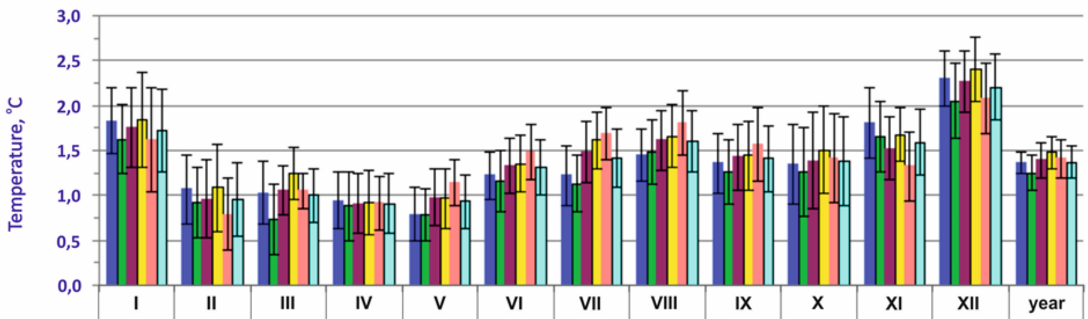
In addition to average annual temperature, they showed expected changes in the average monthly air temperatures by region (Figure 1.5.)

[9] VI National Communication of Ukraine on climate change. State Agency of Ecological Investment. 2013. -304 p.)



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
North	1,83	1,07	1,03	0,94	0,79	1,22	1,23	1,45	1,36	1,35	1,80	2,31	1,36
West	1,62	0,92	0,74	0,88	0,78	1,16	1,13	1,48	1,26	1,27	1,66	2,05	1,24
Centre	1,75	0,96	1,05	0,91	0,98	1,33	1,49	1,61	1,42	1,38	1,52	2,27	1,39
East	1,85	1,08	1,24	0,92	0,97	1,35	1,61	1,66	1,44	1,51	1,68	2,40	1,48
South	1,61	0,79	1,05	0,91	1,14	1,48	1,68	1,81	1,57	1,42	1,33	2,08	1,41
Ukraine	1,72	0,95	1,00	0,91	0,93	1,31	1,42	1,60	1,41	1,38	1,59	2,21	1,37

Figure 1.5. The projection of changes in the average monthly air temperatures by region in 2031-2050 relative to 1991-2010 with confidence intervals for an ensemble with 10 RCMs
(Source: Krakovska at al.,2013).



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
North	1,83	1,07	1,03	0,94	0,79	1,22	1,23	1,45	1,36	1,35	1,80	2,31	1,36
West	1,62	0,92	0,74	0,88	0,78	1,16	1,13	1,48	1,26	1,27	1,66	2,05	1,24
Centre	1,75	0,96	1,05	0,91	0,98	1,33	1,49	1,61	1,42	1,38	1,52	2,27	1,39
East	1,85	1,08	1,24	0,92	0,97	1,35	1,61	1,66	1,44	1,51	1,68	2,40	1,48
South	1,61	0,79	1,05	0,91	1,14	1,48	1,68	1,81	1,57	1,42	1,33	2,08	1,41
Ukraine	1,72	0,95	1,00	0,91	0,93	1,31	1,42	1,60	1,41	1,38	1,59	2,21	1,37

Figure 1.6. The projection of changes in the average monthly air temperatures by region in 2081-2100 relative to 1991-2010 with confidence intervals for an ensemble with 10 RCMs
(Source: Krakovska at al.,2013).

To estimate climate change induced signals of changes in the precipitations under RCP scenario, the period from 1981 to 2010 was taken as a reference period, and the future period was subdivided into three time slices: near future, 2011–2040; middle future, 2041–2070; and far future, 2071–2100 — simulations for which were later compared to those in the reference period.

The assessment of expected changes in the precipitation was made using the same methods as in case of temperature for main river basins of Ukraine only for intermediate scenario (Figure 1.7.).

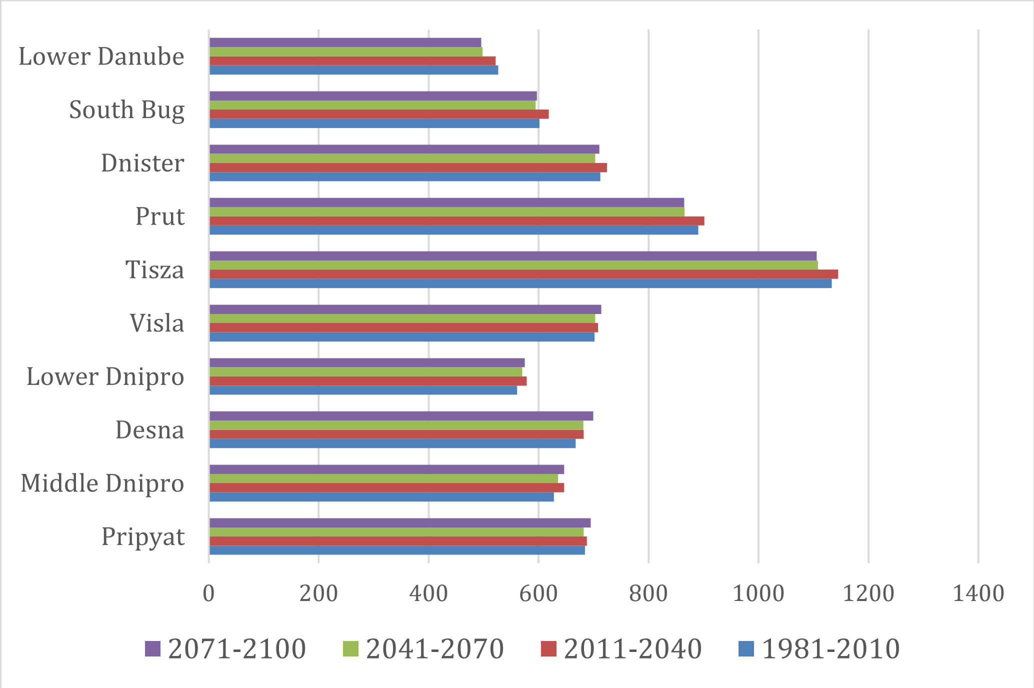
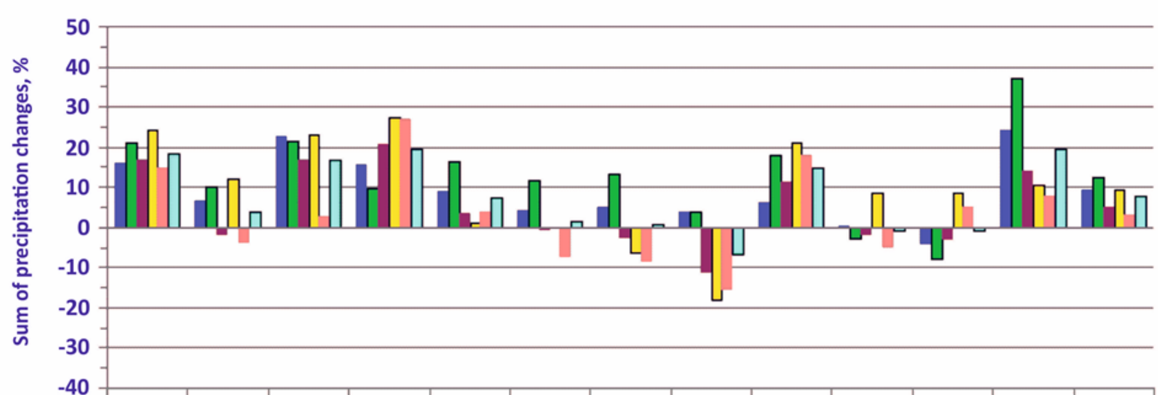


Figure 1.7. Expected changes in the average annual precipitation within the territory of the main river basins of Ukraine for intermediate RCP scenario

Changes in the average annual precipitation during XXI century by intermediate scenario by comparison with the reference period (1981-2010) in all river basins are insignificant (increasing on 0,5-6%).

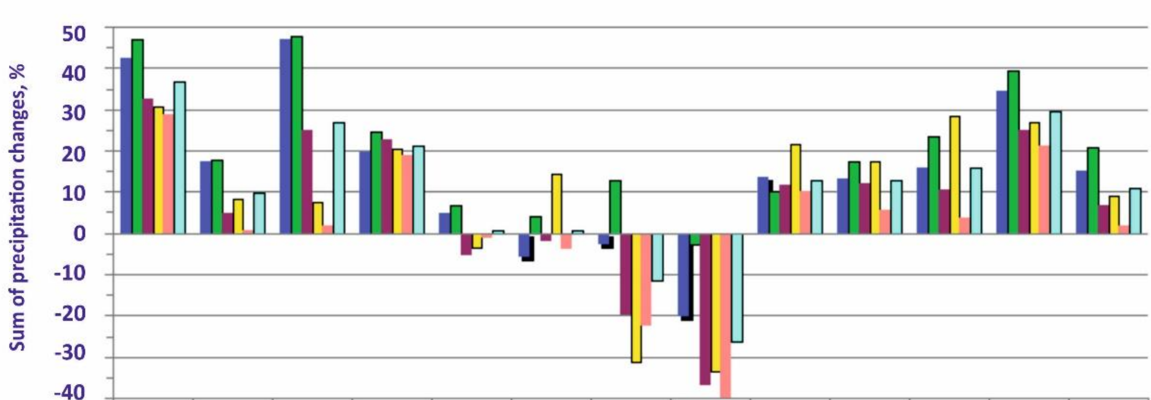
Calculations for previous generation of climatic scenario (SRES scenario) showed that the smallest changes in precipitation are predicted for scenario B1: except for the middle century, when a decrease of -0.3% is predicted, and in all other decades a slight increase in precipitation is predicted to 2.3% with a final value of 1.8 ± 5.1% (State Agency of Ecological Investment, 2013.

In 2013, there was presented detailed information about expected changes in the average monthly and yearly sum of precipitation in Ukraine (Krakovska at al.,2013) using SRES scenario (Figure 1.8. and Figure 1.9.). These projections also do not show significant changes in annual amounts of precipitation, but there is evidence of rising rainfall in the cold season of the year and the reduction of precipitation in the summer.



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
North	16	7	23	16	9	4	5	4	6	0	-4	24	9
West	21	10	22	10	16	12	13	4	18	-3	-8	37	13
Centre	17	-2	17	21	3	-1	-3	-11	11	-2	-3	14	5
East	24	12	23	27	1	0	-6	-18	21	9	9	10	9
South	15	-4	3	27	4	-7	-9	-16	18	-5	-5	8	3
Ukraine	18	4	17	20	7	2	1	-7	15	-1	-1	19	8

Figure 1.8. Projection of changes in average monthly and annual sum of precipitation (%) by region in relation to 1991-2010 for the ensemble with 4 RCMs in 2031-2050
(Source: Krakovska at al.,2013).



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
North	43	17	47	20	5	-6	-3	-20	13	13	16	34	15
West	47	18	48	25	7	4	13	-3	10	17	23	39	21
Centre	33	5	25	23	-5	-2	-20	-37	11	12	11	25	7
East	31	8	7	20	-4	14	-31	-34	21	17	28	27	9
South	15	1	2	19	-1	-4	-23	-40	10	6	4	21	2
Ukraine	37	10	27	21	1	1	-12	-26	13	13	16	29	

Figure 1.9. Projection of changes in average monthly and annual sum of precipitation (%) by region in relation to 1991-2010 for the ensemble with 4 RCMs in 2081-2100
(Source: Krakovska at al.,2013).

Thus, from the analysis of the results of modeling using models of the general circulation for the atmosphere and oceans, it can be seen that an increase in the average annual air temperature should be expected in Ukraine during the twenty-first century. Regarding the annual amount of precipitation, there is no such definite answer.

The predicted climate changes in Ukraine will obviously have a pronounced seasonal and regional nature, which needs further research, particularly the involvement of regional climate models, in which it is possible to significantly reduce horizontal calculation steps (up to 10 km in hydrostatic models and up to several km in non-hydrostatic).

Temperature projections show a general warming trend in the next century with the possibility of considerable temperature rises during the summer months leading to increased aridity throughout the country with the possibility of increased heat waves.

During the period from 1911 to 2010, the greatest number of heat waves was observed in the last decade (2001-2010). (Figure 1.10.). Moreover, exactly during the last decade most stations recorded the most powerful heat waves. The heat wave recorded in 2010 was the most powerful and durable for the summer season in 1911–2010 for eastern and southern regions of Ukraine.

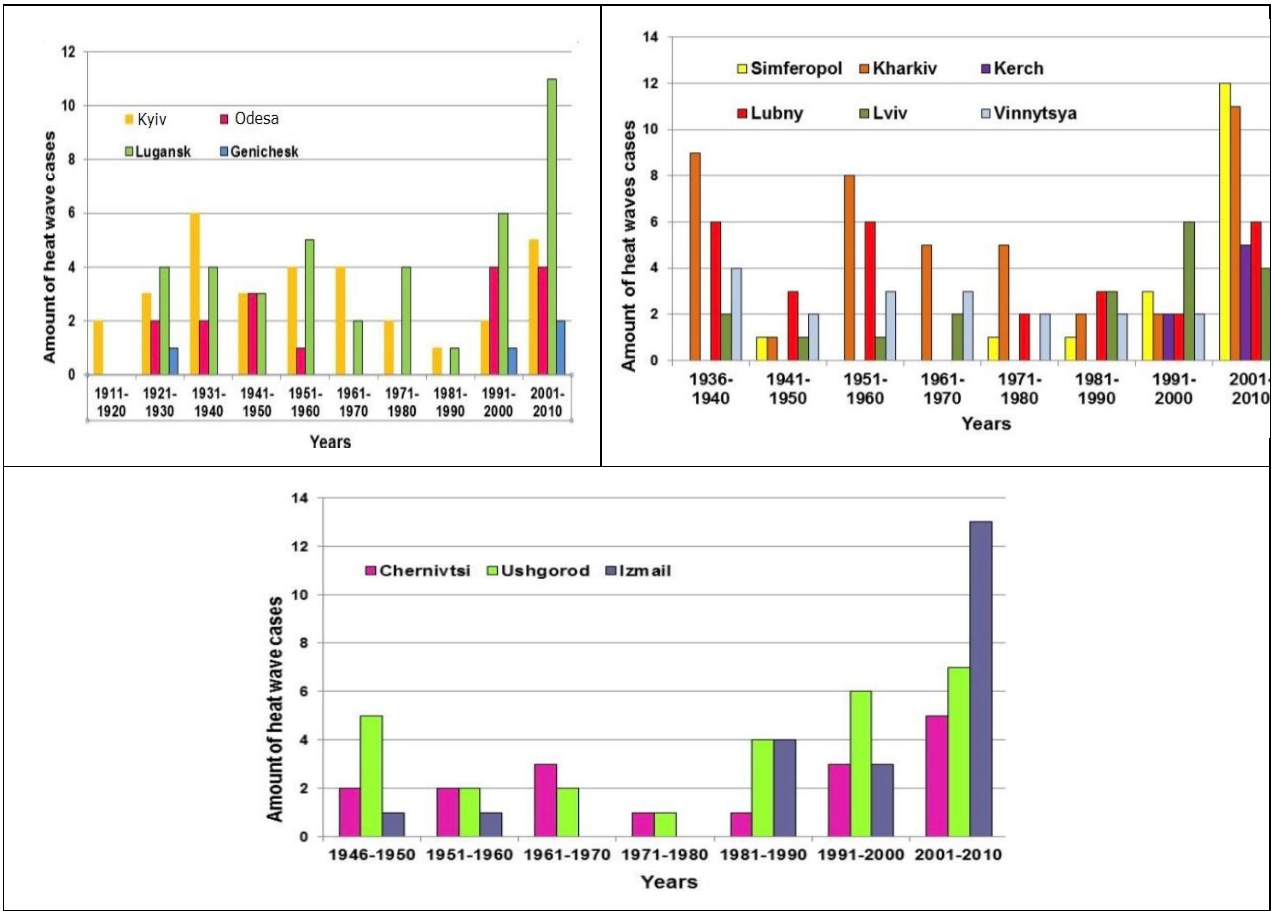


Figure. 1.10. Dynamics of HW incidence in Ukraine, by observation points

(Source: Shevchenko at al.,2013)

Precipitation is expected to increase during winter and decrease during summer; with an increase in rainfall intensity during warmer periods. This could lead to more incidents of flash flood.

The repetition of heavy rain can vary considerably from year to year, depending on synoptic processes, but according to Osadchyy et al, 2012, its number has significantly increased throughout Ukraine by almost 1.5 times in the five-year period (2001-2005) compared to 1986-1990.

Very heavy rain (30 mm or more for 12 hours or more) is common for the entire territory of Ukraine in the summer season – 61% (20% falls in June, 24% in July and 17% in August) (in September, the possibility of heavy rainfall up to 13% due to lower air temperature. In winter, heavy snowfall are often enough recorded in Ukraine, which can lead to disruption of the normal functioning of public utilities, road and rail transport, power transmission and communication lines breakdown, disruption of rhythm of work at construction sites. A very heavy snowfall means a snowfall with precipitation amount of 20 mm for 12 hours or less. In recent years, the number of cases of heavy snowfall has permanently increased in Ukraine. The number of cases of severe snowstorm also increased.

The most vulnerable to the manifestation of climate change are the following sectors of the economy: agriculture, forestry, and water, energy, and transport.

Agriculture. The analysis of the main characteristics of climate change in Ukraine shows the rapid growth of thermal resources and the almost unchanging precipitation, annual level and amount in the summer period, which in the complex affects the humidification of the territory, promotes an increase in areas and the repeatability of droughts.

There is a tendency to the deterioration of moisture (increased dryness) in the vast part of Ukraine. Some improvement of humidification amount in the last decades was observed only in some regions of Luhansk, Volyn, Kirovohrad regions in comparison with the standard climatic period.

Drought spreads to a zone of sufficient moisture, covering more and more territory. The area of the moisty agroclimatic zone (Polissya) and the zone of unstable moisture (Forest-steppe) decreases, and the arid zone (Step) is expanding (Figure 1.12.).

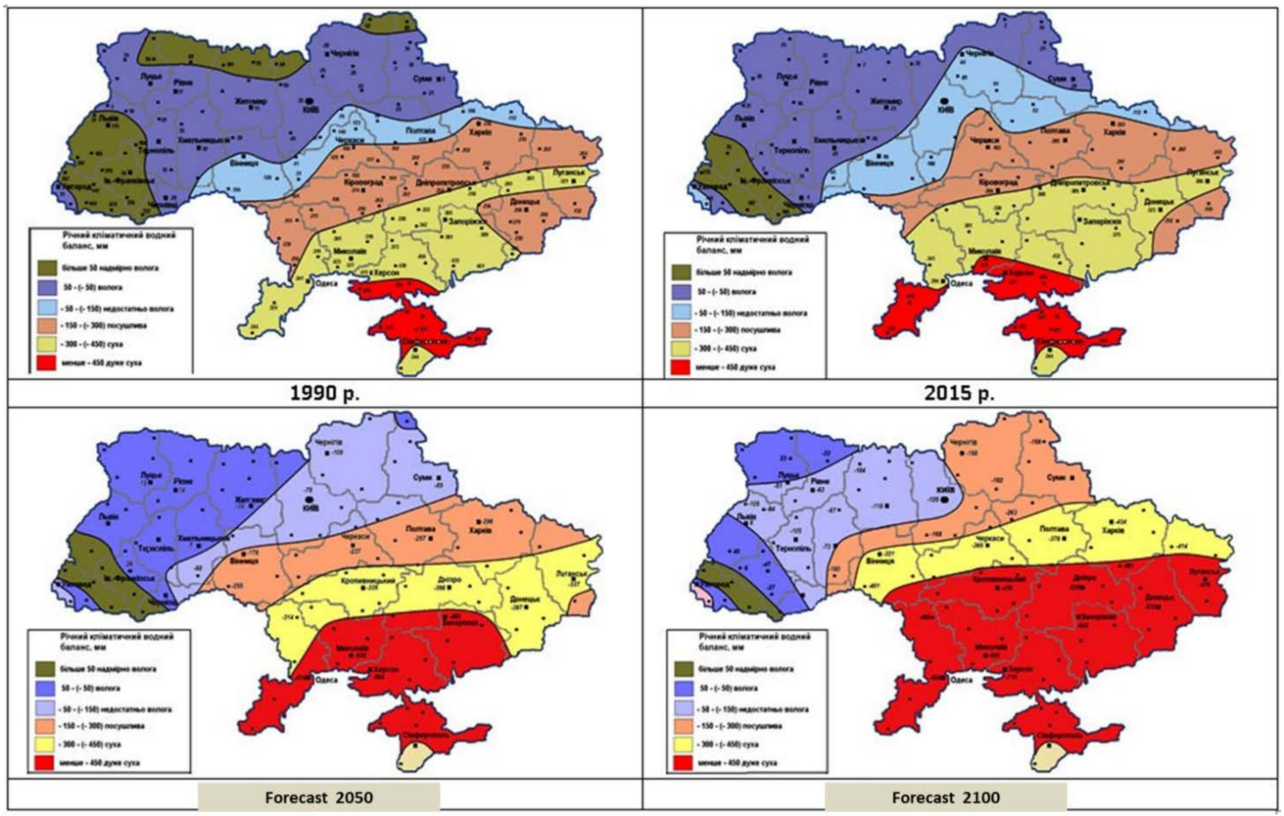


Figure 1.11. Mapping of zones by annual water balance. Comparison of the baseline time horizon to current and long-term time horizons.

(Source: Institute of Water Problem and Reclamation, 2018, http://igim.org.ua/?page_id=1097)

The consequences of climate change for agriculture will be related not only to changes in temperature and humidity conditions, but also to the following:

- The reduction of soil fertility (due to the negative influence of water erosion, soil compaction, desertification, mineral starvation, soil salinization and changes in the structure of soil biota);
- Activation of the humus decomposition in soils;
- Increase of fertilizer efficiency;
- Increase in the distribution of pests for agricultural crops caused by more favorable conditions for their wintering (among risks associated with different levels of distribution of harmful organisms, scientists distinguish the emergence of foreign species, increase the number of generations and transition to a category of "traditional" the organisms that previously caused economic damage);
- Increase of the frequency of Natural Hydrometheorological Phenomena (intense precipitation, hailstones, squall winds, etc.);
- The deterioration of soil moisture in the south;
- Shift of sowing dates, but preservation of the threat of death of plants due to spring frosts;
- The improvement of conditions for winter crops and perennial grasses and others.

Transport. Climate change makes vulnerable transport sector generally and its infrastructure part particularly (Table 1.5.).

Table 1.5. Major potential outcomes of climate change manifestations in transport sector

Climate change manifestation	Potential outcomes
Reduced number of days with very cold weather	easier maintenance in areas without snow;
	positive impact on marine transport;
	reduction of ice congestions;
	reduction of ice build-ups on deck floors;
	positive impact on road transport, especially on road safety;
Increased number of days with very hot weather	bends of the railways, the higher risk of accidents on the railway, failures in the work of infrastructure, fires on the slopes of the railroad, problems with electronics and signaling devices, shortening the life of equipment and intervals between repair works.
	damages of asphalt covering on motorways, formation of ruts on roads, shortening of operation time of roads and intervals between repair works;
	increase in the need for cooling in the transport of passengers and cargo and fuel expenditures;
	bridge damages due to the softening of iron parts under the very high temperature
Overall warming	reduction of the period for glaciation of roads and freezing of soil on rural roads;
	increasing the period with liquid precipitation and reducing the season with hard precipitation and stable snow cover and, accordingly, facilitating the maintenance of highways;
Increase in the number of cases	transport delays and increased number of accidents;
	local flooding;
	damages of bridges, roads and railways;

of heavy precipitations	problems with drainage systems and tunnels, flooding of underground objects;
	erosion of the earth's canvas and landslides, climbing of mud flows;
Increase the number of days with the transition of temperature through 0°C	damage of roads, bridges and other elements of road infrastructure;
Strong winds and thunderstorms	destruction of fencing structures, increase in the number of traffic accidents;
	problems with navigation and mooring in the ports;
	damages of infrastructure objects and a contact network on the railway transport, tension fluctuations.

Water sector. Changes in precipitation and increasing temperature caused by climate change may have an impact on water resources and their dynamics.

Climate change can lead to two opposite effects:

- Surface runoff decrease (which may mean reducing water supply and threatening economic development). Water stress is expected to become severe with increasing periods of drought. This could increase the vulnerability of both the agriculture and hydropower sector (especially for the Dnieper). River flows are expected to decrease in the long-term significantly impacting inland shipping and navigation;
- Surface runoff increase (which threatens the overflow of built reservoirs and the potential for the development of floods). Warmer temperature, incidences of flood could lead to an increase of water borne diseases.

Quite often, in a given area, in the face of a general decrease in runoff, floods can be observed, caused by strong rains or rapid melting of snow.

Reducing, increasing or growing variability in water supply can lead to conflicts between water users (agriculture, industry and households). Water management organizations that define the standards of water use will play a major role in regulating social tensions in case of a change in water availability, as well as in the distribution of benefits and losses in various sectors of society.

Vulnerability of energy complex of Ukraine. Expected climate change imposes considerable hazards as to a reliable energy supply of the country. This could have extremely negative consequences without the implementation of appropriate measures for its adaptation. The country's power, coal and gas industries will be the most vulnerable to this change.

The negative consequences of global warming for coal industry include (State Agency of Ecological Investments, 2013.):

1. Reducing the demand for thermal coal in winter due to shortening of the heating season.
2. Deterioration of mine air conditioning due to the increased ambient temperature.
3. Acceleration of corrosion and destruction of metal structures of the surface complex of mines, mining and transport equipment of cuts due to an increase in rainfall, especially acidic.

4. Flooding of areas adjacent to mines at the sites of ground subsidence due to rising of groundwater levels caused by increased rainfall and its intensity.
5. Danger of flooding cuts due to rising groundwater caused by increased rainfall.
6. Increase in the number of fires in heaps, dumps, mines' coal storage areas and ore-processing plants.
7. Danger of dam's breakthrough with regard to gathering ponds, clarifiers, sumps, slime pit etc. due to increase in rainfall.
8. Growing incidence of emergency shutdown of coal mining industry production facilities from the power mains due to strong winds.
9. Growth of equipment failure, especially at open-pit, due to high temperatures and strong winds.

Growth in average air temperature can lead to lowering of the average river flow, increase in quantity and seasonal fluctuations in rainfall, increased frequency of extreme rainfall and drought, increased salinity of rivers and reservoirs. These phenomena can lead to the lack of water resources.

Environmental change significantly affects the efficiency of the gas industry. First, input parameters are the atmospheric pressure and ambient temperature for designing the gas production and transportation facilities (compressor stations (CS), line pipelines, gas distribution systems (GDS). With their deviations from the design values, a reduction in the efficiency of the equipment takes place, thus, due to the increase of ambient temperature from 15 °C to 35 °C efficiency of gas turbine pumping units (GPU) at compressor stations is reduced. Thus, the power of a simple cycle gas turbine is reduced to 75% of nominal, and its effective efficiency - about by 3%. The efficiency of electrically driven compressor unit is reduced with the reduction of air cooling. Because the gas temperature after compression and before entering the pipeline is lowered by air cooling units, the efficiency of devices will decrease due to higher ambient temperature, and each degree of increase in temperature of gas supplied into the pipe after the compression causes reduction of the performance of the pipeline by 0.4%. Due to insufficient cooling of gas, after compression the temperature difference between the pipe and the soil will grow, which will increase the temperature deformation of pipes. Therefore, the growth temperature can significantly degrade the technical and economic performance of the transmission system (GTS) of the country. Secondly, climate data are used in forecasting peak gas loads, planning consumption and distribution of gas, calculation of current modes of GTS, the development of promising energy balances. Therefore, when these issues are solved it is extremely important to consider the projections of climate change.

Forest sector. In addition to the clearly unfavorable for forests climate trends, the impact of the increasing climate variability on terrestrial ecosystems (and especially of forests) is expected to be negative and significant. The frequency of years, during which the forests (mainly in the southern part) will experience a significant water stress, will increase. This will affect the vitality and sustainability of forests and, very likely, will provoke considerable fire and outbreak of dangerous pests. The latter can be extremely dangerous for pure pine plantations established on the sand of the Dnieper region and other steppe regions.

An increase of fire danger is very likely in various parts of the country, especially where forests are mainly represented by pine stands with its high flammability. A special and dangerous problem is associated with forest fire in the radioactively contaminated areas as such fires lead to secondary infection of the surrounding areas and are very dangerous for health of the population.

To summarize, the expected impact of climate changes on the forests of Ukraine are varied and will depend on the climatic zone, site conditions and forest type.

Cities vulnerability to climate change. Major possible adverse effects of climate change, which may occur in cities, include heat stress, flooding, reduced space and deterioration of the species composition of urban green area, increase in frequency and intensity of extreme weather and disasters, reduction and deterioration of potable water, increased the incidence of infectious diseases and allergic manifestations, disruption of the normal operation of urban energy systems (Shevchenko et al, 2014).

Human health. First of all, we can expect that the climate warming will affect the state of the natural foci of infectious diseases. Northern borders of areas of malarial mosquitoes will move north, the replacing of northern populations by southern populations is possible. The fixation in the new territories of exotic infectious disease vectors is also possible. Due to sharp fluctuations in weather, especially during the cold season, there may increase the frequency of exacerbations of cardiovascular diseases, and in summer, rise in the temperature and long periods of hot weather can lead to an increase in mortality due to overheating and the associated worsening of chronic diseases. There will also be the violation of acclimation processes in the human body due to more frequent weather events, which also leads to an exacerbation of chronic diseases.

The climate change can affect the human health through drinking water, food and other environmental factors. Rising temperatures and more frequent periods of prolonged heat can affect the supply of food and water quality, which will create even more threats to public health. Cases of acute gastroenteritis will be more frequent as the temperature rises and the water quality problems exacerbate. Extreme weather events and natural disasters can be strong enough to influence the emotional state of the population followed by the development of various pathologies and the exacerbation of chronic diseases.

1.4.2 Process and results of sector selection

The process of sectors' selection was determined by global sustainable development goals[10] as well as national priorities of economic development of Ukraine

The TNA covers Agriculture, Waste and Water sectors in Ukraine. The TNA for climate change mitigation is focused on Agriculture and Waste sectors, while Agriculture and Water sectors are the the focus of TNA in adaptation component.

These directions were identified by the Ministry of Environment and Natural Resources of Ukraine on the basis of Ukraine's international commitments (UNFCCC, Paris agreement, EU association etc.) and scientific reports (Assessment Reports of IPCC), progress in national policy (strategies, plans, laws,

[10] https://sustainabledevelopment.un.org/?menu=1300

concepts), statistical analysis (GHG emission trends, economy indicators etc.) and national socio-economical trends.

This view was openly and widely discussed during national workshop taking place in Kyiv on the 21st August, 2018. (see Annex V) where stakeholders (central and regional authorities, international donors, scientific institutions and NGOs) confirmed the relevance of above mentioned choice and recommended to approve this list of proposed directions to be conducted in TNA activity. Moreover, a number of stakeholders informed that they are interested to actively contribute to TNA process to get a solid profitable result of the project.

The main arguments for the selection of TNA activity by sectors on adaptation to climate change in Ukraine are the following:

Agriculture: around 60% of the total population's consumption refer to agriculture and it ranks second among the sectors of the economy due to export volume and remains virtually the only industry that has been running for many years provides a positive foreign trade balance. Agriculture is represented by 45 thousand enterprises and 15 million households. In addition to the economic factor, this sector is baseline in terms of livelihood for Ukraine as for the developing country. It contributes to global objectives (i) the eradication of hunger, food insecurity, and malnutrition (SDG 2) ; (ii) increase and improves the provision of goods and services from agriculture, forestry, and fisheries in a sustainable manner (SDG 15); (iii) reduce rural poverty (SDG 1) ; (iv) increase the resilience of livelihoods to threats and crises (SDG 13).

Water: in so many decades the water has not been recognized as a valuable resource; the economic status of water systems and their impact on biodiversity have not been taken into account and predicted. While the available and quality water is a vital necessity for a human being, developing energy and agriculture sectors as well as it is the source of greenhouse pollutions. Thus, TNA in water sector contributes to the strengthening of the water sector reform on the national level, referring to global target to provide the availability to clean water (SDG 6).

Chapter 2 Institutional arrangement for the TNA and the stakeholder involvement

2.1 National TNA team

The Ministry of Ecology and Natural Resources of Ukraine is a designated national institution, which leads and coordinates the TNA process in Ukraine.

The essential elements of the institutional arrangement of the TNA process within the country include a TNA Coordinator, a National TNA Committee, National Expert Consultants and Sector working groups (see fig. 2.1).

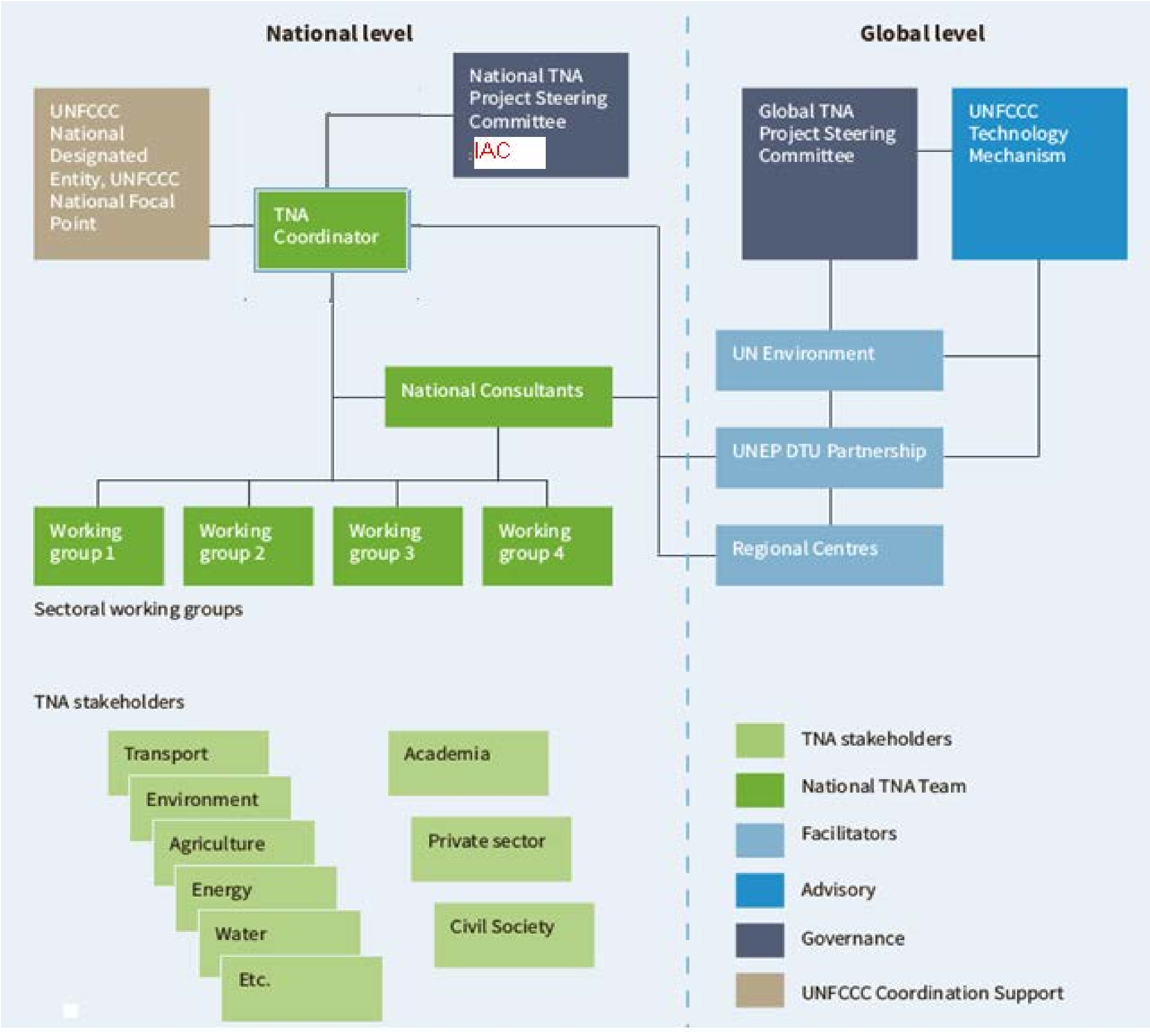


Figure 2.1. TNA Institutional set-up in Ukraine

<u>TNA Coordinator</u>

The Ministry of Ecology and Natural Resources of Ukraine designated Mr. Anatolii Shmurak as a TNA Coordinator for Ukraine. Mr. Shmurak is the Senior Expert of Climate Policy and Reporting Division of the Climate Change and Ozone Layer Protection Department of the Ministry of Ecology and Natural Resources of Ukraine, the NDE Focal Point and also nominated from Ukraine into the UNFCCC Roster of Experts.

<u>National TNA Committee</u>

The role of the National TNA Committee is assigned to the Inter-agency Commission on the implementation of the United Nations Framework Convention on Climate Change (UNFCCC). Inter-agency Commission on the implementation of the UNFCCC is an advisory body for the coordination of activities on different aspects related to climate change. The commission was created by the Cabinet of Ministers of Ukraine in 1999 and it includes officials at the level of Deputy Ministers of key ministries and other executive bodies, the members of Ukrainian parliament, representatives of R&D institutions and NGOs.

The role of the National TNA Committee is to provide the high-level guidance to the national TNA team and help to secure political acceptance for the TAP. The first meeting of the National TNA Committee has been conducted within the meeting of the Inter-agency Commission on implementation of the

UNFCCC on 15 of May 2019 and included presentation of the TNA project by National TNA Coordinator.

National Consultants

The TNA in Ukraine is performed with the involvement of national mitigation and adaptation experts. The lead National Consultants were selected by the National TNA Coordinator in close consultation with UDP, following an open and transparent selection process.

Adaptation technologies are assessed by two experts on Water sector (Dr. Sergiy Snizhko and Dr. Galyna Trypolska) and one expert in Agriculture sector (Dr. Oksana Ryabchenko).

National expert consultants are responsible for:

- leading the identification and prioritization of technologies for the specific sector through a participatory process with the broad involvement of relevant stakeholders and experts;
- leading the process of analysis, along with the stakeholder groups, how the prioritized technologies can be implemented in the country and how implementation conditions can be improved by addressing the barriers and developing an enabling framework;
- preparing TNA report.

National Consultants were responsible for the identification of the list of nominated technologies, selection criteria, development of questionnaires and guidance for technology assessment by the members of the sector working groups, as well as for the analysis of responses and preparation of the TNA report.

Sector working groups

Ministry of Environment and Natural Resources based on the suggestion of the National TNA Coordinator and National consultants established two working groups on mitigation technologies for Agriculture and Waste sectors and two working groups on adaptation technologies for Waste and Water sectors.

Working groups are comprised of experts from academic institutions, private companies, and non-governmental organizations. The members of the working groups contributed to the development of the list of nominated technologies and selection criteria and provided their assessment of the technologies based on the selected criteria.

2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

TNA process included stakeholder engagement activities. The list of relevant stakeholders was identified by national consultants in close cooperation with the National TNA Coordinator.

Identified stakeholders include government institutions and departments with responsibility for policy formulation and regulation in relevant sectors (i.e. Agriculture and Water), private and public sector industries, business associations, technology end users and/or suppliers within private sector, relevant academic institutions and consultants, as well as international organizations and donors. The extended list of stakeholders represents in the Annex III.

The dialogue with stakeholders engaged in the TNA process built upon:

- the functioning of the Intersectoral Council Committee on Climate Change Adaptation and Mitigation and project Steering Committee
- regular stakeholders' meetings with the purpose to develop the TNA project;
- conducting regular workshops, conferences, field days and other public events to discuss the implementation of the state policy in the field of climate change adaptation;
- constant consulting and methodological support to the TNA team and other engaged representatives of central and local executive bodies to develop and implement the industry (sectoral) and regional measures to adapt to climate change;

- developing common communication platforms among all relevant projects aimed to contribute to climate change initiatives such as FAO GEF project in Ukraine[11], Climate initiatives of the Federal Ministry of Agriculture (Germany) [12], USDA initiatives and EU4climate[13].

2.3 Consideration of Gender Aspects in the TNA process

There are existing gender inequalities in climate change adaptation (De Groot, 2018). These inequalities impose greater burden in developing countries, as they often significantly rely on natural resources and weather conditions. Respectively, extreme weather conditions impose significant risks on livelihood as they suffer from droughts, floods, high speed wind etc. In developing countries, the burden of water supply is mostly imposed on women. Young girls often miss school in order to supply water for their households.

In Ukraine, there are several gender aspects that need to be reviewed in relation to the vulnerability of climate change :

- There is around 30 percent of the rural population in Ukraine with a female majority[14];
- Women are much more oriented to migrate than men;
- In majority of cities and towns, people use transported drinking water. In majority of cases, women keep a check on delivery and schedule of transported water. There is no official statistics on water sector to prove this statement, however, the simple observation of regular water queues indicates that majority of people in line are women;
- In households without centralized water supply, women are usually expected to bring water, as they are mostly in charge of domestic chores requiring water such as cleaning, laundry, cooking etc.
- In food systems, women more often are responsible for cooking than men, thus they face higher burden of food supply.
- Globally, men have higher mortality rate than women. In Ukraine, circulation diseases are number one reason of death. Changing climatic conditions adversely affect population, especially men.

Both women and men are equally responsible for the sustainable use of available resources. However, women are expected to play more significant role in decision making, policy development related to climate change than they do now. In adaptation, there might be specific gender-based measures, which is especially the case for agriculture (FAO, 2017).

As for broader context, unfortunately, there are no policy documents in Ukraine that would link climate change adaptation measures and gender aspect. However, there is a general and specific legal framework in Ukraine for regulating the equal employment of women and men. The general legislation includes Law of Ukraine "On Ensuring Equal Rights and Opportunities for Women and Men", as well as Art. 10 "Protection of the Labor of Women" of the Law of Ukraine "On Work Safety". A specific regulatory framework includes the Order of the Ministry of Health of Ukraine No. 256 of 29.12.1993 and collective agreements of companies with trade unions.

---

11 https://healthy-soils.org.ua/en/

12 https://www.apd-ukraine.de/de/klimat

13 http://www.ua.undp.org/content/ukraine/en/home/projects/EU4Climate-project.html

14 State Statistical Servises of Ukraine. The main statistical characteristics of households in the rural area of Ukraine. 2017. http://www.ukrstat.gov.ua/

The Law of Ukraine "On ensuring equal rights and opportunities for women and men" dated 08.09.2005 № 2866-IV aims to achieve an equal position of women and men in all spheres of society's life. The state policy on ensuring equal rights and opportunities for women and men is aimed at the establishment of gender equality; non-discrimination on grounds of sex; preventing and combating gender-based violence; ensuring the equal participation of women and men in making socially important decisions; ensuring equal opportunities for women and men to combine professional and family responsibilities; the education of gender equality among Ukrainian people. Collection, analysis, dissemination, preservation, protection and use of statistical data on the indicators of the situation for women and men in all spheres of society life are regularly carried out by the State Statistics Service, but there is still not enough gender types of indicators in national statistic system. Publicly available data includes information on the number of men / women, the birth of children by women of different age groups, mortality rates, life expectancy. Gender-based discrimination is prohibited. According to the Law, women and men have equal rights and responsibilities in the electoral process, in the field of civil service, in work and remuneration for it, in concluding collective agreements and agreements, in the field of entrepreneurship, in obtaining education, in mass media, etc.

According to the Convention on the use of women's labor in underground work in mines of any kind, "no female person of any age can be used in underground mines." However, "national legislation may remove from the above-mentioned prohibition of women holding senior positions and not doing physical work; women engaged in sanitary and social services; women who must descend from time to time in underground parts of the mine to perform non-physical work".

Collective agreements of companies with trade unions usually stipulate that "the Administration undertakes to ensure: " (i) equal rights and opportunities for women and men", in particular in the recruitment and promotion of employees; (ii) eliminates inequality, if any, in the payment of wages for women and men; (iii)pregnant women, women who have a child under the age of 14, workers with a disabled child, or those overseeing a sick family member according to a medical opinion, etc., based on their application, are subject to part-time employment".

Nationally Determined Contribution, the Energy Strategy of Ukraine by 2035, National Communications on Climate Change do not include information on gender targets in Ukraine. Gender issues are not included in the major policy documents. The only exception is National Baseline Report «Sustainable Development Goals: Ukraine» (SDGU, 2017) stating that women are paid 30% less than men in Ukraine. According to Global Gender Gap Index, Ukraine's rank was 61 in 2017 (compared to 69 in 2016) due to gender imbalance in economic possibilities and political participation (GGGI, 2017).

There is a different level of gender influence in the process of technology implementation for the agriculture adaptation sector and water management. Thus, preparation of TNA report and setting of the entire TNA process included fair involvement of women, and the entire process of TNA report preparation was gender balanced:

Agriculture sector:

- national expert is female;
- team of adaptation agriculture experts consists 5 women and 11 men.

In water sector,

- among two national consultants there is one man and one woman.
- out of 10 experts, 6 are women.

The composition of the groups allows free expression of thoughts and ideas by both men- and women- experts and equal participation in the decision-making process of TNA for adaptation component

Chapter 3 Technology Prioritization for Sector Agriculture

3.1 Key Climate Change Vulnerabilities in Sector Agriculture

Main aspects of agriculture sector in Ukraine.

Economic. Exports of agricultural products from Ukraine in 2018 amounted to 18.8 billion US dollars. Last year, agro-industrial products accounted for 39.8% of total exports from Ukraine, retaining leadership in its commodity structure. The key products of Ukrainian agrarian exports in 2018 were grain crops, oil, seeds of oilseeds, meat and offal, which account for about 81% of exports in monetary terms. Crop production increased by 10.7%, livestock production by 0.2%. In general, Ukraine has become one of the five largest suppliers of agricultural products to the EU. Today, Ukraine is one of the world's main exporters of agricultural products. In five years, the profitability of the agrarian sector has increased from 20.5% to 31.6%, and this attracts new investments, including from abroad.

Social. There are about 15,0 million households in Ukraine. Their share in total agricultural production was 43,0% in 2016 and process about 14 million hectares of arable land. Rural population is about 32% in Ukraine (following to the approximate estimation of Statistics State Service, 2018). Thus, agricultural production is both the matter of livelihood for a significant part of Ukrainian citizenship as well as a primary economic driver in the country.

Environment. Traditionally, there are three main environmental zones specified in Ukraine: Steppe, Forest-Steppe, and Forest, also well-known as Polissya (Fig.3.1.).

Figure 3.1. Agro-climatic zoning in Ukraine

Polissya is northern part of Ukraine. It integrates 6 oblasts such as e Volyn, Rivne, Zhytomyr, Chernigov, Zakarpattya, Sumy and part of Kyiv, which occupy 12.3 million hectares (19% of the territory of Ukraine). The climate is continental with level of precipitation around 550-750 mm, the average annual temperature is +6, + 7 ° C, the vegetation period lasts from 190 to 205 days with the sum of active temperatures of 2250-2600 °. This is the most humid area of Ukraine (especially in it is western part). Low-lying relief, a considerable amount of precipitation and slight evaporation contributes to the swamping of area.

The Steppe zone is the southern part of Ukraine with coastal borders which covers 9 oblasts: Luhansk, Donetsk, Kherson, Mykolaiv, Odessa, Dnipropetrovsk, Zaporizhya, Kharkov (partly), Kirovogradska (partly). This zone is the warmest region of the country with a drought probability of 40-70% and an average annual level of precipitation about 350-540 mm. According to estimations of the scientists, the region undergoes the most significant transformation due to climate change. Thus, in the last decade, a new thermal zone appeared in Odessa and Kherson with an annual total amount of active temperature of more than 3400 ºC. The number of days with the temperature maximum in the daytime of around 35-40 °C increased twice, which may cause the dangerous hydrometeorological phenomena. The amount of arable land in the steppe that have water deficit of up to 450 mm of precipitation per year is about 79% (12.5 million hectares), and with a deficit of above 450 mm of precipitation per year about 17% (2.8 million hectares).

The slopes of the land (over 1 °) make up 48% of the agricultural land in the steppe zone. The area of eroded lands is more than 38%, or more than 11 million hectares, including about 5 million hectares are affected by wind erosion (Baluk S.A., 2010).

The number of days with dust or sand storms reaches 20-35 day during the year. Additionally, to the wind erosion, water erosion of the soil is widespread. They often combine and determine each other forming an erosion-unstable soil surface.

As usual, winter and spring are the main season of erosion appearing in the Steppe zone annually, especially in snow less winters.

Water erosion in the Steppe is due mainly to the stormy nature of precipitation in the summer. The energy of the storm measures 250-1500 J / m2.

Forest-steppe zone mainly covers the middle part of Ukraine. Ten oblasts might be recognized as a forest-steppe zones: Lviv, Ivano-Frankivsk, Sumy(partly), Kharkiv (partly), Poltava, Kyiv, Cherkasy, Vinitsa, Khmelnitsk, Ternopil, Chernivtsy (partly), Kirovograd (partly).

Currently, the forest-steppe zone is the most favorable area for agricultural activities. Simultaneously, it is defined as a zone with the highest level of shifting caused by climate changes, water accessibility, and intensive agriculture.

The main agriculture capacity is placed in Steppe and Forest-Steppe zones while they are under a significant risk referring to the fast-changing climate conditions. Due to these facts, they should be on the top line of soil monitoring and land using control. The proportion of arable land to the whole area of the zone is 70%, which is twice as high as in Polissya and on the second place after Steppe.

The climate is moderate-warm, precipitation is from 600 mm in the west and north to 500-450 mm in the south and east. But there is more evaporation than in Polissya, therefore, there is no excessive moistening. Average annual temperature is +7, + 8 ˚C. The duration of the vegetation season is 200-210 days, the sum of active temperatures is 2600-2800 ° C, up to 3000 ° in the south. Soil cover is fertile, high-yielding black soil and other.

There are the next parameters cause the vulnerabilities in the agriculture sector in Ukraine under climate changes (Figure 3.2.):

1. change in temperature regimes of different agriculture zones in Ukraine;
2. soil degradation and desertification;
3. change in the availability of water resources requiring by vegetation;
4. natural disasters appearances and structure

Modeling was done considering the speed of changes in the leading climate indicators and recent climate change, there are the next challenges and parameters may cause agricultural production fluctuations by 2030.

Changing vegetation regimes by agro climatic zones. Expecting to increase of average annual temperature by 0.5-0.8 ° C by 2030 will result in further reduction of the winter period, changes in the duration of other seasons and vegetation period as well as increase the heat resources available for all agro-climatic zones[i] (Figure 3.2.) of Ukraine.

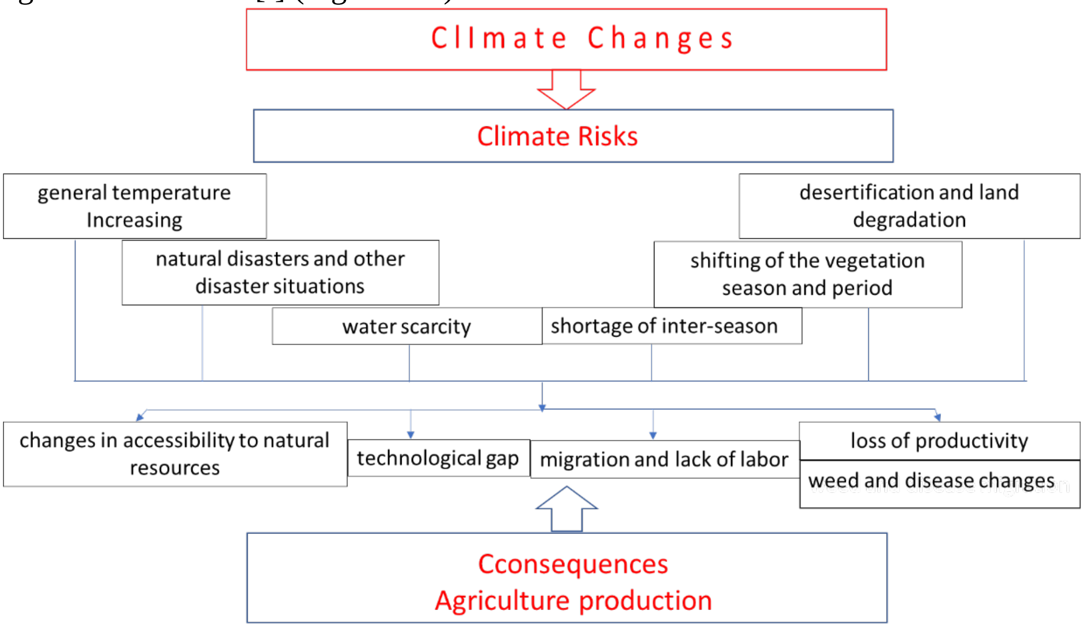
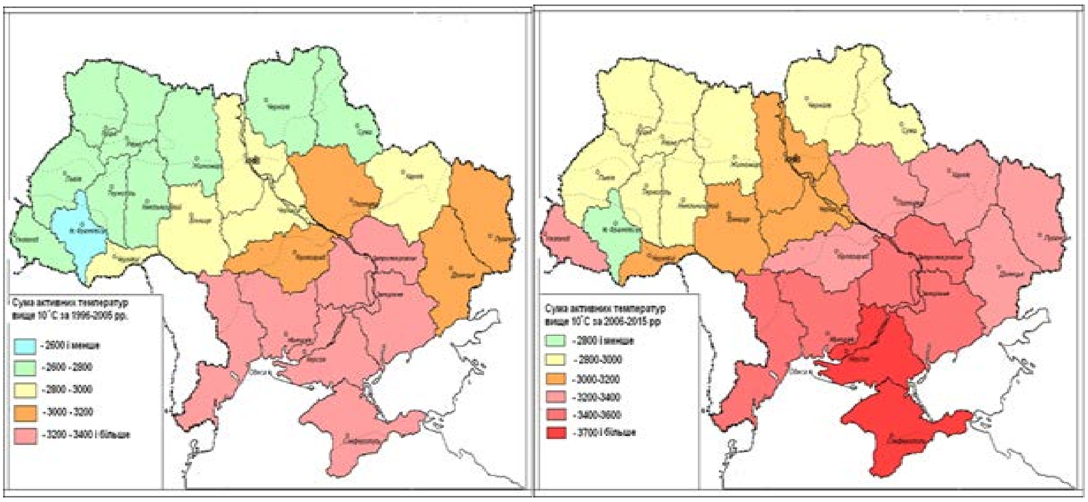


Figure 3.2. Graphical Abstract of Key Climate Change Vulnerabilities: Sector of Agriculture Adaptation

In one hand, this will allow diversifying the set of crop production and the crop's varieties, which cultivation is currently limited in some regions (west and north) by insufficient heat resource. The winter time duration of about 1-1,5 months may get more permanent character for Polissya and west part of Forrest-Steppe zones.

Simultaneously, the vegetation period (with temperatures above 5 ° C) will be extended from 215/ to 245 days for Polissya zones and up to 280 days in the Southern and West Steppe zone.

The increasing annual heating amount will change the borders of agro-climatic zones. The present borders will slowly move from South to North (Figure 3.3.). Nowadays, we can observe such kind of shifting of climatic zones about 200 km to the north.



(i) *(ii)*

Figure 3.3. Comparison of heating potential presented in summarized annual active temperature above +10 °C by oblast: (i) 1996-2005 and (ii) 2006-2015 pp.
(Source: T. Adamenko,2018)

On the other hand, the climate condition of Steppe is getting close to dry subtropical climate conditions, and the line of Steppe zones is moving north. Particularly this was observed for the last decade.

For the cultivation of the macrothermophytes (maize, sunflower, soybeans), the duration of the vegetation active period is very important, particularly, the period with temperatures above +10°C. Accordingly, data were examined on the transition date and duration of the periods with such temperatures. It was found that this period was prolonged in Ukraine by an average of 10 days or more. The biggest changes occurred in the Polissya and Forest-steppe areas. Thus, in Polissya according to norms (1961-1990), the duration of the vegetation active period was 159 days, which limited the growth of macrothermophytes with a long vegetative period. During 1991-2015, the vegetation active period reached an average of 167 days, for the decade 2006-2015 - 169 days, for 2016-2017 - 175 days. The duration of the vegetation active period was almost the same as in the steppe zone in the zone of the forest-steppe in 2016 and 2017.Thus, all crops cultivation zones shifted out of their current zones due to the change in the amount of annual active temperature. As a result, this will lead to changes in the structure of crops refer to the temperature conditions of plant vegetation. Heat-loving plants production may shift to the north while the production of the other crops would not be possible (Table 3.1.).

Table 3.1. The level of annual active temperature needs for the crop vegetation

<2800	Fodder crops (incl. vetches, perennial and annual plants, clover, lupine, medick), peas, buckwheat, rye, cabbage, potatoes, **beans**, hemp, maize for silage, carrots, cucumbers, sweet peppers, winter wheat and early spring wheat, rapeseeds, soybeans, onions, garlic
2800-3000	Sugar beet, **fodder crops** (incl. **vetches**, perennial and annual plants, **clover**, **lupine**, medick), peas, **buckwheat, rye**, cabbage, **potatoes, beans, hemp**, maize, **medicinal herbs**, flax, **rustic tobacco**, carrots, **oat**, cucumbers, sweet peppers, winter wheat and early spring wheat, camelina, rapeseeds, soybeans, onion, garlic
3000-3200	**Beetroots, sugar beet**, pumpkins, peas, **buckwheat**, vegetable marrow, cabbage, potatoes, beans, hemp, clover, **maize**, flax, **medick**, rustic tobacco, **carrot**, oat, **cucumbers**, sweet peppers, winter wheat and early spring wheat, camelina, **rapeseeds, soybeans, tobacco**, onion, **garlic**

3200-3400	Aubergines, **beetroots, sugar beet**, pumpkins, **peas**, melons, **vegetable marrow, cabbage**, potatoes, **beans, coriander, maize**, flax, medick, rustic tobacco, carrot, mint, oat, cucumber, **chili pepper**, sweet pepper, tomatoes, millet, winter and spring **wheat**, rapeseeds, **sunflower, soybeans, tobacco**, onion, garlic, barley
3400-3600	Aubergines, **pumpkins**, mustard plant, **peas**, melons, **vegetable marrow**, watermelons, cabbage, coriander, maize, **flax**, medick, carrot, oat, **cucumbers, chili pepper,** sweet pepper, tomatos, **millet,** spring wheat, **rice**, **rapeseeds, sunflower**, **sorghum**, soybeans, **onion, garlic, barley**
3700	**Aubergines, broccoli,** pumpkins, **mustard plant**, peas, **melons, vegetable marrow, watermelons, cabbage,** coriander, maize, **flax, medick, carrot**, oat, cucumbers, chili pepper, **sweet pepper, tomatoes, millet**, spring wheat, **rice**, rapeseeds, **sunflower**, sorghum, soybeans, **onion,** barley

Desertification. Further agriculture production in Ukraine in general and for the crop production mainly will be determined with climate changes caused arid (precipitation reduction) or humid (precipitation increase) conditions.

Today, warming has a small humidity (some precipitation increases), although there are areas that can be considered as arid. Arid warming can cause increasing aridity.

The most likely scenario, the increase in the number of annual precipitations with higher air temperature will increase the evaporation from the soil surface and decrease the moisture content in the soil. It is possible that the level of productive moisture present in a depth of one meter of soil will lower. The maximum soil drying occurs in the second half of June. The total content of soil moisture may decrease by 15 - 20% compared to the current one, specifically in the Steppe zone even by 20-30%. However, it will not be affected by the process of cultivation of early grain crops, instead, the deficit of moisture's content in the soil has a more negative effect on the germinating ability of later crops.

Waves of Heat that are projected to increase by a factor of 1.5 and long periods of heat (35 °C and above) will spread to the northern and western regions and cause a shortening of the length of the growing season of spring crops and reducing yield.

The number of summer and autumn drought may increase by 2030 by 15-30% due to the fact that rainfall fluctuation has been changed in comparison between last two decades to baseline 1961-1990 (Fig. 3.4.)
.

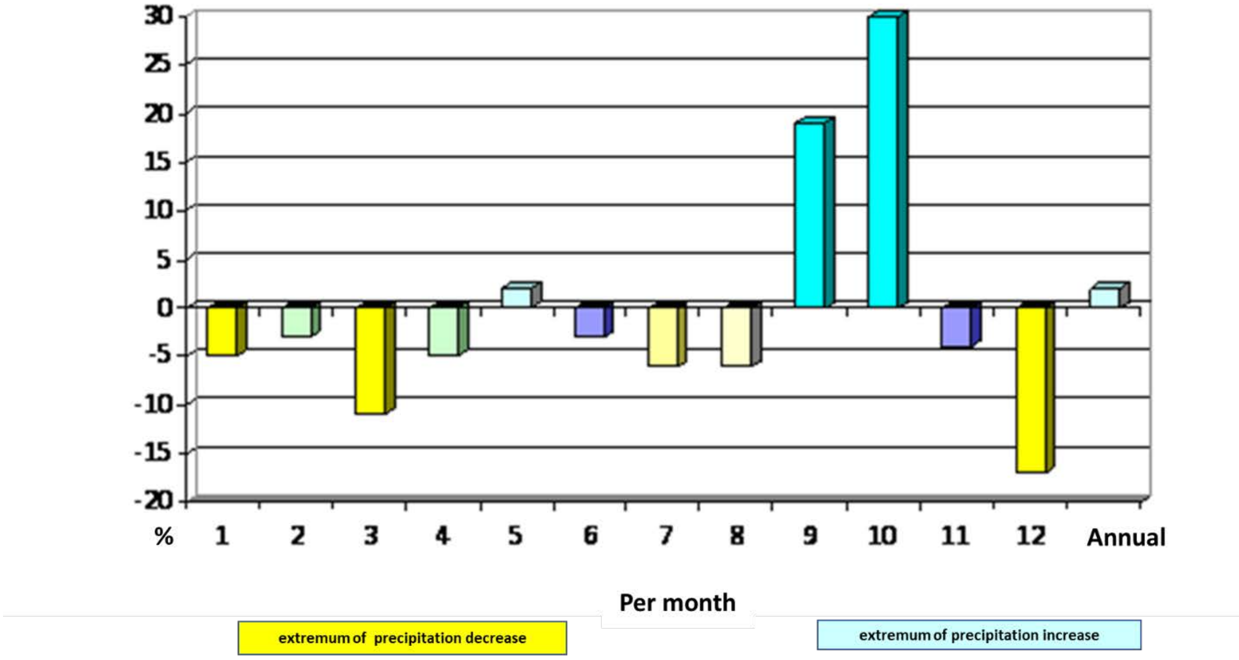


Figure 3. 4. The ratio of rainfall fluctuation monthly based: comparison between periods 1991-2016 to baseline 1961-1990.
(Source: FAO, 2018)

Expansion of a zone with insufficient precipitation (less than 400 mm) in recent years is traced over the spring-summer period (Figure 3.4.). Kyiv and Chernihiv oblasts can already be attributed to these features.

Concerning monthly climatological precipitation changes, there is a clear tendency to decrease in winter months - in January and February by 3-11%, in December - by 17%, in summer and spring more or less the same level, in September and October the monthly amount increased by 19%-30% (Figure 3.4.).The observed precipitation change indicates a tendency to increase in the number of ineffective heavy rains. For example, Odessa oblast received 100-110 millimeters from the rainstorm in October 2016, which is equal to 4 monthly rates. The most important precipitation for all crops falls out during the warm period.

Soil degradation. Traditionally, it is known that the soil cover of Ukraine consists of high-yield soil. According to the national surveys that took place in 1957-1961, there were identified more than 800 types of soils, among which black soil prevailed, the total amount of black soils exceeded 60%. According to the Institute of Soil Science and Agrochemistry, the content of humus in the arable layer varies from 0,6 to 6%, humus reserves in the profile from 30 to 600 tons per ha, and the capacity of the humus profile varies from 15 to 150 centimeters depending on the region (Medvedev V at all., 2018).

However, the soil cover has changed for the last several decades due to intensive agriculture and nonefficient natural resource usage. Despite the lack of common monitoring of soils condition, the recent studies show that around 13M hectares damaged by water erosion, including 10M hectares of arable lands.

More than 80% of agriculture land was arable land and, in many regions, more than 90 %. The most affected areas by erosion are in the Southern and Eastern regions (till 70%) Figure 3.5. The annual share of the expansion of eroded land in Ukraine varies from 80 till 90 thousand hectares. In the area of eroded lands, there are 4.5 million hectares of medium and severely eroded, including 68 thousand hectares, which completely lost the humus horizon [Medvedev].

The total loss of humus is over 32-33 million tons due to mineralization and soil erosion, which is equivalent to 320-330 million tons of organic fertilizers.

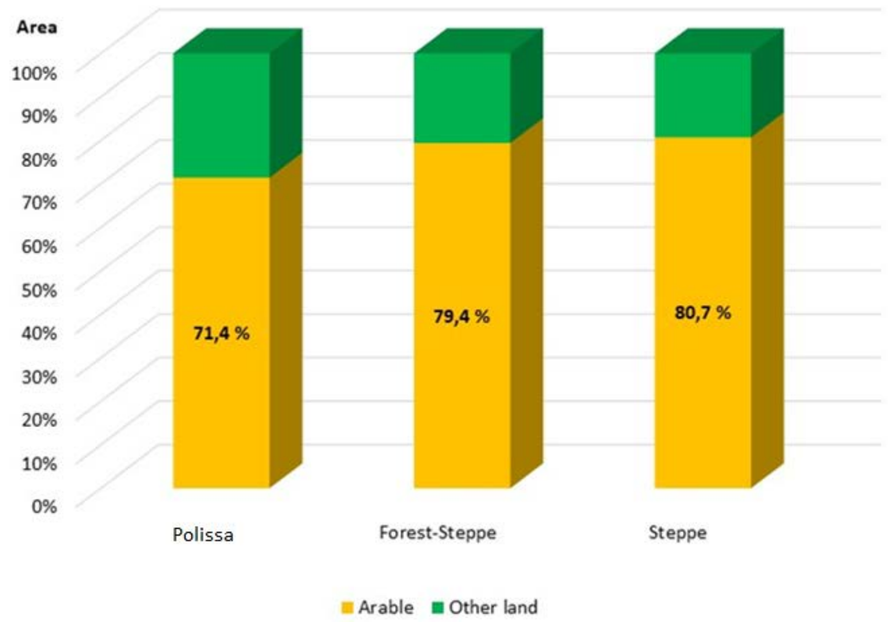


Figure 3.5. Share of Arable Lands by agro-climatic zones of Ukraine.
(Source: State statistical services (form 6-zem), 2017)

Water and wind erosion are underlying drivers of change affecting the soil degradation in Ukraine (Figure 3.6).

Due to the climate changes and soil specific, wind erosion is most typical for the steppe zone of Ukraine. Thus, the large areas suffered in 2007 from a powerful dust storm that covered the Mykolaiv, Kherson, Zaporizhzhia and Donetsk oblasts (Fig. 3.6. B.). The loss of soil was about 200-300 t / ha, which accounted for 2 to 4 cm of the upper fertile soil layer.

A. Water erosion manifestations in the Poltava region

B. The dust storm in the Mykolaiv region (March 23-27, 2007).

Figure. 3.6. Water and wind erosions traces on the fields

(Source: (FAO,2018))

Changing in the pattern of precipitation. Resources for crops moisture or water availability during the growing season are characterized by the amount of precipitation, moisture reserves in the soil, evaporation, as well as various moisture calculations coefficients. Direct indicators of water availability include the amount of precipitation for certain important for agriculture period of the year.

For crop production, an important role plays precipitates during the vegetation period and the cold season, which determines the spring soil-moisture reserves during crops sowing. Approximately, more than 60 percent of arable land in Ukraine is not sufficiently moisturized to satisfy the needs of efficient agriculture production, Table 3.2

Tables 3.2. Arable land desegregation per available water

Zone	**Total , M ha**	**Arable land desegregation per available water**											
		> 50		0		-(50-150)		-(150-300)		-(300-450)		<-450	
		M ha	%	M ha	%	M ha	%	M ha	%	M ha	%	M ha	%
Polissa	14,9	-	-	-	-	0,05	0,3	3,34	22	8,7	58	2,86	19
Forest-steppe	11,3	0,1	1	3,39	30,1	4,01	36	3,76	33	-	-	-	-
Steppe	4,9	0,57	12	3,57	73,3	0,73	15	-	-	-	-	-	-
Ukraine	31,0	0,66	2	6,96	22,4	4,8	15	7,1	22	8,7	28	2,86	9

The area of aridity regions has grown by 7% while enough humid zones have decreased by 10% over the last three decades.

Natural Disasters. Extreme weather events, those are natural and dangerous cause sometimes significant damage to agriculture. According to expert estimates, about 60-70% of the losses associated with adverse weather and climatic conditions related to agriculture.

According to the expert estimates, crop losses due to unfavorable weather conditions can range from 10 to 70% in Ukraine. The main reason for these losses is the drought, Fig.3.7. shows the comparison yields of major crops during the severe droughts of the 21st century (2003, 2007) and years with sufficient precipitation (2008, 2013, 2014).

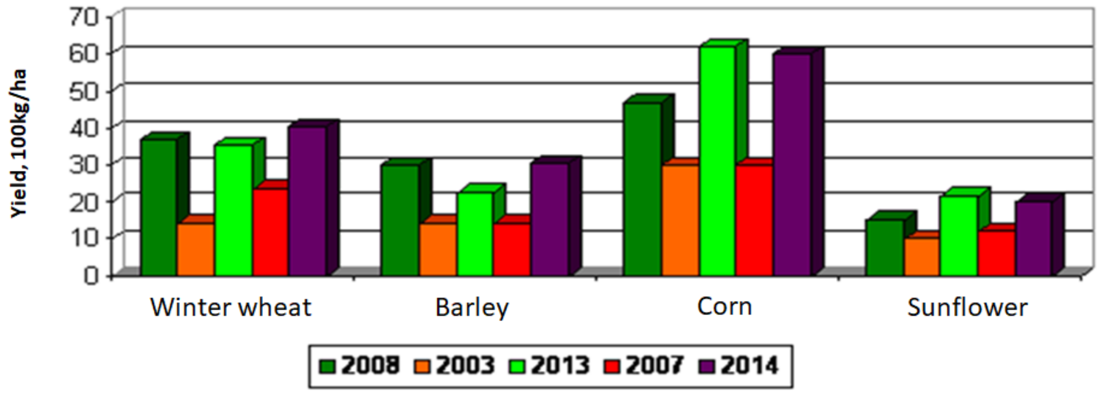


Figure 3.7. Yields of major crops during the severe droughts (2003 and 2007) and years with sufficient precipitation (2008, 2013, 2014)
(Source: FAO, 2018)

Hot winds are the types of winds that over a long period of time can significantly damages growing crops and cause yield losses. The greatest probability of occurrence of varying intensity hot winds observed in the territory of the southern and eastern oblasts (from 20% to 80%). In recent years, hot winds have been observed all around the country, even in western regions (2010, 2015, 2017).

Low temperature (e.g. freezing) can damage the seedling of heat-loving crops, fruit, grapes and vegetable crops. Frost is mostly possible in Ukraine in April (75-85% of cases) and in the first half of May (10-20% of cases). Because the spring processes begins in recent years much earlier, the most damage is early blooming fruit trees, grapes, and seedling of heat loving crops.

Dust storms were often observed by 1970 (up to 15 cases per year). The most dangerous areas (centers of dust storms) were allocated in Kherson, Zaporizhia, Dnipropetrovsk oblasts. Subsequently, the size and frequency and coverage of dust storms decreased. Over the past 20 years, significant dust storms were noted only in 2003 and 2007. According to expert estimates, this is due to some decrease in wind speed, redistribution of precipitation and land cultivation.

Freezing. Despite the warming of the winter period, the main threat for the winter crops (winter wheat, rye, barley, rapeseed) is the probability of crops freezing due to the low air and soil temperatures in the absence or insufficient height of the snow cover on the fields. This risk persists due to climate variability and the probability of some cold winters.

Hail. On the average, meteorological stations record in a year in Ukraine from 2 to 12 cases of hail that damage or locally destroy the crop. The damage depends on the size of the hail, their density, intensity of the precipitation. Most often, the hail is recorded in May, June, and July, but in recent years there have been cases of hail in spring and autumn months (March, October), that is highly uncharacteristic for that.

Heavy rains are most often observed in May-August, however, in recent years happens in the fall as well. In recent years, increasing air temperature and instability of the atmosphere have led to an increase in the number of extreme precipitations that was observed almost in all areas.

3.2 Decision context in the Sector Agriculture

The process of technology selection was divided into the following stages:

1. Analysis of the specific characteristics of agriculture in Ukraine determining the demand on technology.

2. Overview of Existing Technologies in Agriculture based on international and relevant national experience.
3. Selection and creation of the extended list of technologies.
4. Discussion of technologies with a team of national experts
5. Formation of the final list of technologies recommended for further evaluation following the national expert recommendations

National context of decision-making process. The sector of agriculture in Ukraine has a set of a specific characteristics able to determine demand for different type of technologies such as:

(i) The specific land management: about 52 percent of arable lands processed by medium-sized farmers (farm size under the 3K ha), the big agro companies, called agro holdings, manage about 30 percent of the total arable land and around 18 percent of arable lands use to satisfy the needs of 15 million households (plot size under 2 ha);

(ii) The crop production (focusing on the industrial grain production) takes a leading position while livestock is decreasing;

(iii) Lack of state supporting mechanisms for agriculture. There is not environment subsidies or other funding or supporting mechanisms available for farmers in Ukraine;

(iv) Lack of competency among farmers, gender heterogeneity and poor developed extension services;

(v) The uneven concentration of agriculture producers by region

Due to the national specifics of agriculture mentioned above, the following issues must be noticed as crucial for the process of technologies prioritization and selection:

1.*The role of different sub-sectors of agricultural production* in the state food safety and their impact on the economic, social, and environmental ensuring.

2.*The geographical location and concentration of farms*, in particularly small farms as a most vulnerable category. The location of farms in the highly risked agricultural areas (such as Kherson or Odesa oblasts) increases their vulnerability to climate change and requires intensified/specific measures.

3.*The level of resource (technological) provision.* The availability and access to natural and technical resources determine the availability and speed of adaptation activities. Resource’s provision includes the amount of agricultural land used in production, the availability and/or access to water resources, the level of technical/technological support. Also, an essential question is the structure and quality of labor resources. After all, the gender and age structure of small farms can significantly influence the recommended measures.

4.*The economic efficiency of farmers/farms*. The level of gross income, own profitability and/or payback and access to additional investments determines the level of the farm's self-sufficiency to take climate change adaptation and prevention measures.

Thus, the context of decision making for the technology prioritization based on both the relevant international experience and national agriculture production specific.

Structure of agriculture sector. National structure of economic activity consists of two large blocks such as crop production and animal derivate commodity production. Crop production includes the production of cereals, oilseeds, legumes, vegetables, fruits, berries and specific crops such as tobacco. The share of crop products is about 65 percent. The main areas of animal derivative commodity production are poultry, dairy, livestock and pork production. Sheep breeding can be classified as inclusive segment. Accordingly, its share in agriculture is about 32 percent. The share of beekeeping has risen to 3 percent.

Crop production. The production of grains is a basis of agriculture in Ukraine. Besides, Ukraine is the largest sunflower seed and oil exporter of the world. Soybean cultivation has positive effect on the soil's fertility. Soybeans and soy meal are commodities which are in demand on the European market. Ukraine has the 7th rank among the world's largest soybean exporters. Rapeseed production also has a positive dynamic Figure 3.8. Potatoes are practically the only branch of the agro-industrial complex of Ukraine, which volume of production has not significantly changed. Today Ukraine ranks fifth in the world in potato production. In the production of sugar beet a significant decrease in sugar production since 1991 can be observed. Vegetable production transition to a market-oriented environment has ended up in nearly 90 percent of the country's vegetables grown in private household plots, and only 10% is produced by agricultural enterprises. The main vegetable crops in Ukraine are cabbage, onion, beetroot, carrot, tomatoes, garlic.

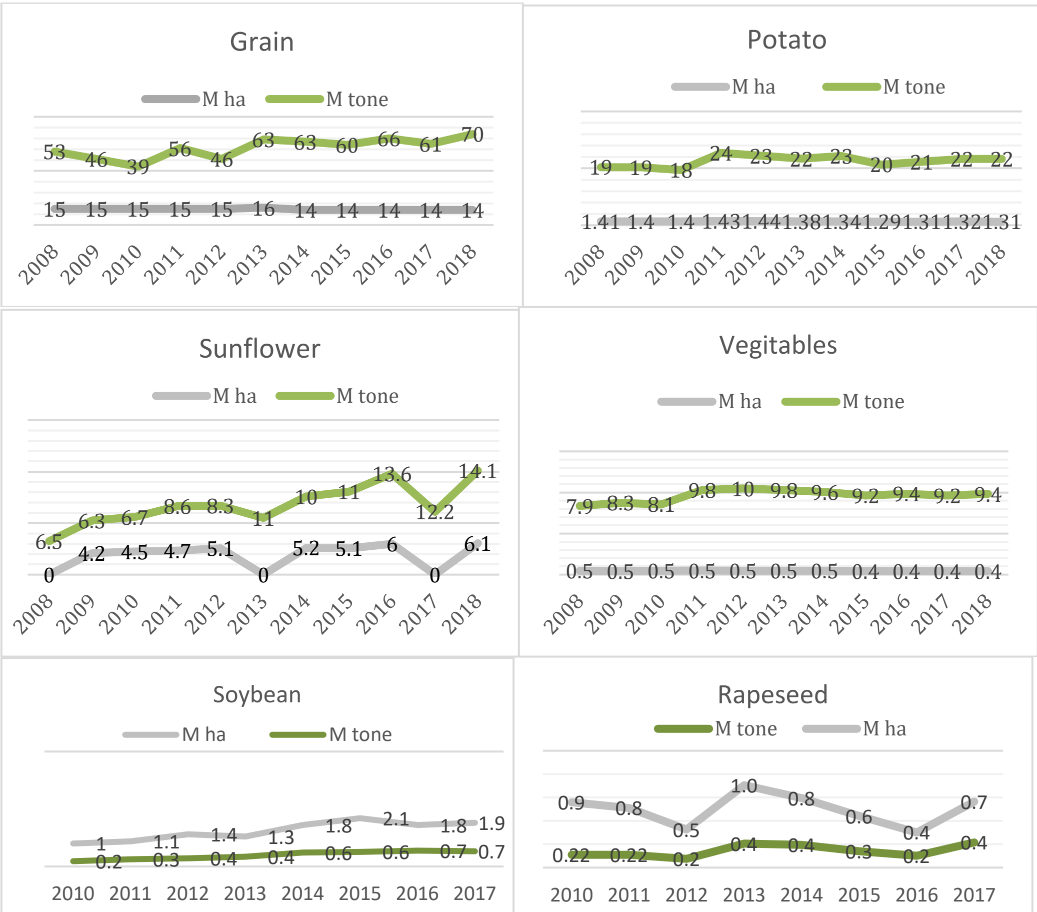


Figure 3.8. Tendency of crop production, 2008 – 2018
(Developd based on the State Statistics Service of Ukraine data 2018)

Animal husbandry. Production has decreased in Ukraine markedly in the past years, in particular, dairy and meat cattle breeding, sheep breeding and pig farming lost a significant share of agricultural enterprises and permanently reduces the number of animals. Over the period 1991-2016, the number of total cattle decreased by 3.9 times. All types of farms felt a dropdown in total cattle numbers by almost 12.8 times, while households, on the contrary, in the period 1990-2005, exceeded the 1990 indicator by

26.6-42.1%. Due to the gradual decline in livestock numbers over 2010-2016, the current state of affairs in the strong sector is deteriorating.

The total number of s heep in Ukraine has decreased by more than 10 times over the period 1991-2017 (from 7896.2 to 743.9 thousand head).

According to 2017 data, the total livestock of goats is 577 thousand heads, and almost 99% is kept in households. Dairy goat breeding business recently began to increase , with a current number of heads only 5.7 thousand.

Poultry farming is one of the most promising areas of production not only in Ukraine, but also in the world. Agricultural enterprises use intensive production technologies of egg and meat. Another segment of production is represented by small and medium-sized farms and household that applying extensive technology. Gross production of poultry meat is projected to be 1.2 times higher in 2025 than in 2016, the number of layer chickens - up in 1,4 times, and the production of eggs - up to 20.9 billion pieces.

In keeping with Ukraine's agriculture sector structure, it is appropriate to focus on the selection of technologies for the sectors of crop production, poultry farming, livestock, and dairy production. These subsectors are the baseline of national agriculture production; thus, national wellness depends on the level of their development.

Farm size and distribution. Based on an analysis of existing legislation and accounting policies for agricultural activity, and for the purposes of this document, farm was determined as a physical person and commercial organization that carries out activity on owned or leased land using its own and / or leased property to meet their personal needs and / or get economic profit from the production, processing and consumption of agricultural products, the sale of its surpluses and provision of services with the use of property, including rural green tourism services. Farm category can include all forms of farming practices listed in Table 3.3.

Table 3.3. Farm size classification

Organization form	Organizational form[15]	The purpose of agriculture activity	The total area of agriculture land managed, ha by unit	Source of information
Households	Private, non-registered	Livelihoods	0,5-2,0	[1],[2]
Family Farms	Private registered (2nd group), State registered	Livelihoods, Business	2,0-20,0	[3],[4]
Small Farms	Private registered (3rd and 4th groups)	Business	20-100	[3],[4]
Middle Size Farms	State registered	Business	100-500	[5]
Lage Farms/Agro Holdings	State registered	Business	500<	[5]

[1] The Law of Ukraine On Personal Peasant Facilities, 2003, No. 29 http://zakon2.rada.gov.ua/laws/show/742-15[2] The main agricultural characteristics of rural households in 2017. Bulletin. State Statistics Service in Ukraine 2017. http://www.ukrstat.gov.ua/
[3] Law of Ukraine on Farming Enterprises http://zakon3.rada.gov.ua/laws/show/973-15
[4] Draft Law on Amendments to the Tax Code of Ukraine and certain legislative acts of Ukraine on stimulation of the establishment and operation of small-scale farms and the deconcentrating of powers in the field of land relations
[5] By the classification of State Statistical Services. http://www.ukrstat.gov.ua/

15 Organization form defined following the national registration procedure and the taxation legislation

Farms that possess 0, 5 hectares to 100 hectares is the most volatile and vulnerable to the impact of climate change. According to the national statistical data, these farms account for 46% of agricultural land (43% belong to small farms with an average 20 ha or less in size, the remaining 3% belong to the Agricultural experiment stations, with a total land area being cultivated more than 20 ha).

The concentration and the proportional ratio of small farms in Ukraine due to landscape, climatic and historical features are quite clearly expressed. Usually, large farms are Large farms are usually consolidating land resources in different regions of Ukraine. However, it is quite clearly possible to allocate zones of concentration of small and medium farms in the regions of Ukraine (Figure 3.9.).

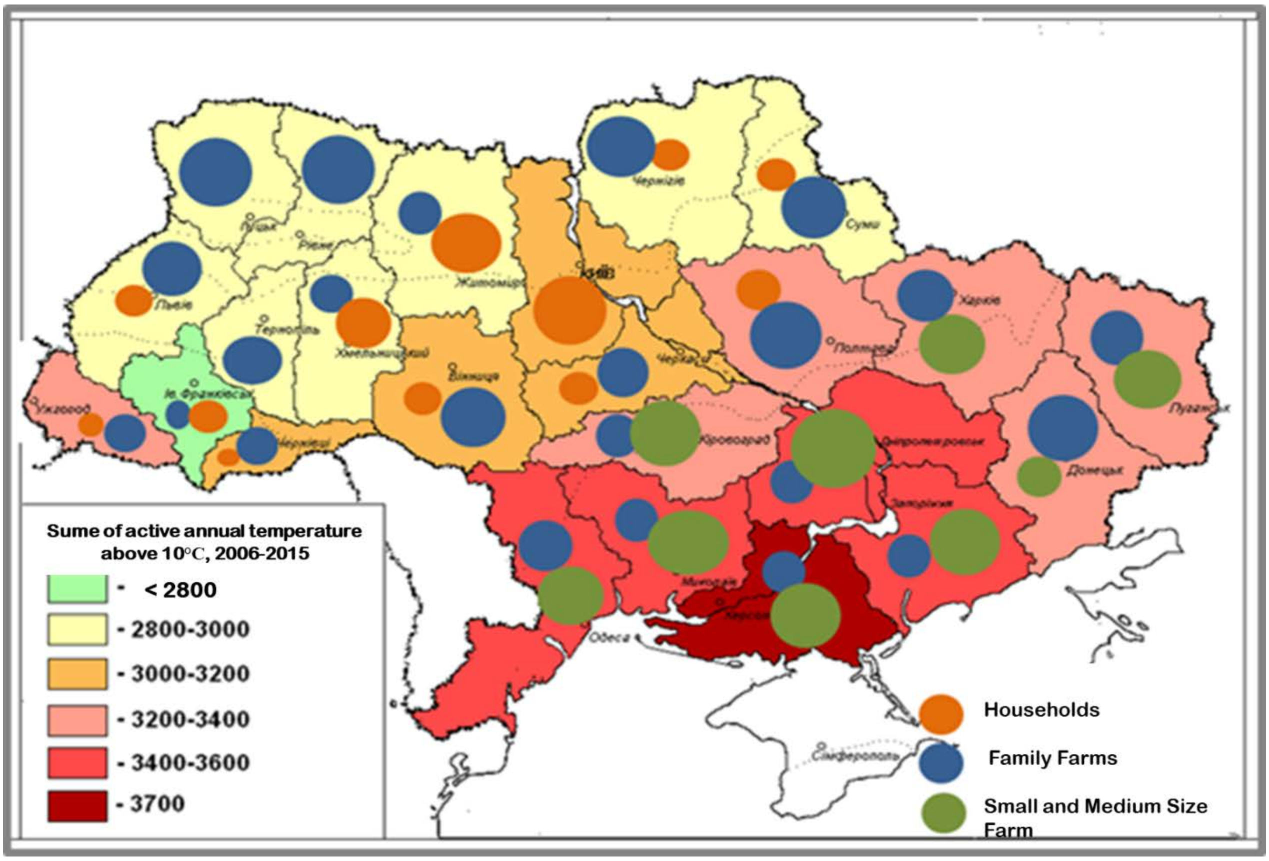


Figure 3.9. The concentration of small and medium-size farms mapped by temperature zones (with the sum of annual active temperature upper 10 °C)

(Source:O.Ryabchenko, T.Adamenko[16])

Gender issue related vulnerabilities of the agricultural sector to climate change. According to preliminary estimates, the share of the rural population is about 32 percent in Ukraine which is account for more than 14 million small households throughout Ukraine. Thus, agricultural production is the main activity and way of living in rural areas.

According to State Statistics Service, the average land area of the household headed by men is 1.49 ha, by women, 0.98 ha, Figure 3.10. (data for 2017). This difference is significant. When it comes to agricultural land structure of rural households in 2017, 90.9% and 87.4% lands owned by men and women, respectively, are arable lands, while 7.3% and 9.8%, respectively, are hayfields and pastures.

[16] FAO project. Code TCP/UKR/3601 : Title “Technical Assistance to the Ministry of Agrarian Policy and Food of Ukraine in Agricultural Support Policy, Exports of Horticultural Products and Land Consolidation”

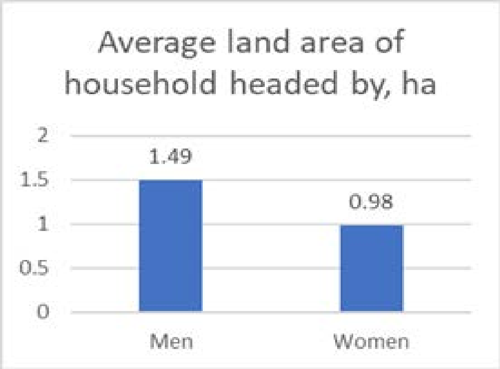


Figure 3.10. Average land area of household headed by men and women, 2017.

(Source: FAO, 2019[17])

Men-headed households also dominate among households keeping various kinds of agricultural animals. In general, the difference is not that big – 66.2% of male-headed and 64.7% female-headed households keep any kind of animals. But when it comes to keeping larger animals – which might be associated with a wealthier rural household/agricultural company – men's domination gets more significant. 36.9% male-headed vs. 29.8% female-headed households keep cattle, 35.2% vs. 28.6% keep cows, and 45.6% vs. 34.7% keep hogs and pigs. There are virtually no kinds of animals in which women would dominate. It means that male-headed households significantly prevail among those who keep several kinds of animals – yet another prove of men having more agricultural resources.

There is no sex disaggregation on the households that possess ploughs, seeding machines, harrows, cultivators, tractors, separators, peeling mills, trucks and other equipment.

However, the next Table 3.4. is very important as it shows the domination of male-headed households in terms of how much in-house produced products they sell (data for 2017).

Table 3.4. Sale of in-house products produced by households, per 100 households

Products	Female-headed households	Male-headed households
Grain and leguminous crops	414.33	1081.75
Sugar beet	6.48	36.74
Sunflower	89.33	265.49
Potatoes	30.06	64.43
Vegetables of open ground	63.10	90.30
Water-melons	35.53	19.23
Melons	1.35	1.88

[17] FAo progect. Code TCP/UKR/004/GFF. Title" Integrated natural resource management degraded land in the steppe and forest-steppe zones of Ukraine".

Fodder crops	12.65	5.82
Fruits	17.87	20.07
Nuts	0.47	0.33
Berries	3.65	3.69
Grapes	0.61	0.56
Agricultural animals:		
in live weight	19.80	30.66
in slaughter weight	0.51	0.89
Milk and dairy produce (counted as milk)	498.86	684.06
Eggs, thousands	4.40	4.92
Honey	0.11	0.79

In terms of possessing money, there are no reliable statistics on the average income and assets of male and female farmers. Interestingly, gender pay gap in agriculture is one of the lowest among other sectors – men employed in agriculture earn 8% more than women (in general, men earn 22% more than women), but it concerns salaries rather than the income of agricultural companies.

3.3 Overview of Existing Technologies in Agriculture

Since Ukraine has focused its efforts on combating climate change, mainly on reducing greenhouse gas emissions, adaptation's issues have not received enough attention from the public. On the other hand, while emission reduction techniques and technologies are already known and proven, adaptation measures tend to require significant financial resources and can be very diverse with uncertainty in expected results due to the high degree of uncertainty surrounding the magnitude and timing of climate change impacts.

Currently, Ukraine has no state regulations for agriculture adaptation to climate change[18]. Development of recommendations for agriculture adaptation to climate change is being underway, and the approval of "Strategy for adaptation to climate change by 2030" in accordance with the order of the Cabinet of Ministers, is planned in 2019. The adaptation options developed in the draft of the document summarized in Table 3.5.

Table 3.5. Recommended adaptation options for the agriculture sector

[18] Current relative documents mentioned in section 1.2.

National document	Sector of application	Proposed adaptation option
Draft Strategy for adaptation to climate change until 2030 in accordance with Action Plan for the implementation of the Concept of State Climate Change Policy Implementation until 2030.No. 878 [19]	Crop production	introduction and restoration of effective irrigation systems (in particular, drip) and melioration;
		developing of climate smart and conservation agriculture technologies;
		development of greenhouse facility and controlled atmosphere storages taking into account the latest technological developments;
		optimization of agriculture land structure in terms of proportional distribution arable land/ grassland/ forest;
		introduction of water-efficient irrigation methods in the cultivation of grain crops;
		genetic improvement of seed varieties;
		changes in the structure of sown areas with the expansion of the species and varieties of agricultural crops with a short growing season;
		growing a wide range of species and varieties of crops to increase biodiversity;
		shelterbelt establishing and reconstruction;
		shifting the timing of sowing spring crops to earlier dates, winter crops - to later dates;
		extension of crop rotation with 4 and more crops;
	Animal derivative commodity production.	genetic improvement of agricultural animals breeds highly resistant to the effects of climatic stress-factors and diseases;
		improvement and development of stress-free and adaptive technologies for farm animals' maintenance;

[19] Approval of the Action Plan for the implementation of the Concept of State Climate Change Policy Implementation until 2030. December 6, 2017, No. 878-p.https://zakon.rada.gov.ua/laws/show/878-2017-%D1%80

		improving the processes of feed production and storage;
		reconstruction and construction of animal facilities with the use of optimal ventilation systems;
	Cross-sectoral	Developing systems for climate change and the occurrence of extreme weather events early prediction;
		establishing monitoring systems for the spread of diseases, plant pests and invasive weeds;
		developing and implementation of soil monitoring system and integrated land management
		developing environment and condition for agriculture insurance;
		Improving agricultural production sustainability on complex landscapes;
		Implementation of the schemes of economical support aimed to increase adaptation potential;
		Developing research and scientific activities on the field of adaptation to climate change.

Therefore, it is appropriate to refer to the existing international experience, recommendations outlined in the draft "Strategy for adaptation to climate change by 2030" and existing research and projects (Annex VIII) in the selection of technologies.

Following the draft Strategy for adaptation to climate change by 2030, the technologies involved in the selection process should be towards reaching the next three objectives :

1. Strengthens capacity aimed to overcome natural disaster and other dangerous climate change consequences. The a pplication of technologies which may minimize agricultural production losses in case of predicted natural disasters and/or to promptly restore production potential.
2. Provide diversification of economic risks and strengthening economic efficiency.
3. Reduced climate change risk sensitivity scale.

Special attention focuses on the reclamation of ariable lands in Ukraine. The current use of the existing potential for reclaimed land is extremely insufficient. There is a considerable reduction of the area of the really irrigated lands as well as drained land with water regime control. Today less than 500 thousand hectares of irrigated land are actually irrigated, and bilateral regulation is used only on 158 thousand hectares of drained lands.

Moreover, there is a set of international projects partly aimed to increase the resilience of agriculture to climate change Table 3.6. However, all of them were not focused systematically on the agriculture adaptation to climate change and did not provide overviewing of adaptation technologies.

Table 3.6. List of international environment developing initiatives in Ukraine, 2018-2019.

	Organization	Project name
1	FAO UN (Food and Agriculture organization, United Nation)	Technical Assistance to the Ministry of Agrarian Policy and Food of Ukraine in Agricultural Support Policy, Exports of Horticultural Products and Land Consolidation
2	FAO UN	Support to improve technical and institutional capacities for CC adaptation and mitigation”
3	FAO UN	Emergency action plan for combating dieback of pine forests
4	FAO UN/GEF	Integrated Natural Resources Management in Degraded Landscapes in the Forest-Steppe and Steppe Zones of Ukraine
5	FAO UN	Support for the Recovery of Agriculture Based Livelihood in Ukraine
6	USDA	Support for Agrarian and Rural Development
7	BMEL (Federal Ministry of Food and Agriculture, Germany)/APD	Climate component of APD
8	BMEL/APD	Developing of forest monitoring in Ukraine
9	EC/UNDP	EU4Climat

The l evel of technological equipment of agricultural enterprises provides possiblity to specify the actual level of agriculture development in the regions, as well as to assess the level of its resistance and adaptation to climate change.

Besides, the availability of farm equipment is an indirect indicator of the level of farms' economic development and helps to identify regions and areas of activity that may need additional governmental support.

Based on public statistics data, it is possible to conclude that the leading areas of stockbreeding production, specifically dairy cattle and poultry, are Poltava, Kyiv, Cherkasy, Kharkiv and Vinnytsia oblasts. It corresponds to the provision of forage harvesters in these areas, but the technological capacity for coarse forage stock concentrated in areas oriented on the grain legume production.

The level of irrigation equipment indicates rather low potential resistance and adaptation capacity of agriculture in general, including small-scale agriculture enterprises of all forms, to the manifestation of drought in all regions of Ukraine. Only Kherson region is sufficiently equipped with irrigation infrastructure. The situation is the most critical in Odesa, Kirovohrad, and Luhansk oblasts, as those areas belong to high-risk due to changes in temperature.

The level of equipping farms with manure spreaders is one of the indicators related to agricultural greenhouse gas emissions. Low equipment values indicate an insufficient use of organic fertilizers. In practice, animal by-product is mostly used by the first and second groups of agricultural enterprises.

A closer look should be given to data collection methods on technological support of agricultural in terms of more detailed and expanded data collection on availability of irrigation facilities, reservoirs and volumes of accumulated water, farm access to information technologies and means of notification and the level of its use.

3.4 Adaptation Technology Options for Sector Agriculture and Their Main Adaptation benefits

Overviewing of existence of relevant technologies and international best practices recommended to be applied for the adaptation of agriculture to climate change was carried out. In the result, a first draft list of technologies was developed (Table 3.7.) satisfying with all requirements mentioned above in the subparagraph 3.3.

Table 3.7. List of adaptation technologies of agriculture on climate change (First Draft)

#	Technologies
1.	Construction of underground storage facilities for feed silage
2.	Pressing and polymeric packaging of roughage
3.	Elevation of premises using optimal ventilation systems
4.	Implementation of agroforestry practices involving the inclusion of fruit trees, walnut and bioenergy crops
5.	Development of Integrated Land Management Maps for each district/village associated community
6.	Drip irrigation in the combination with conservation agriculture practices
7.	Establishment of underground and semi-underground greenhouses
8.	Implementation of practices for the use of growth regulators and adaptogens of a wide range of biotechnological origin
9.	Transferring the crop rotation and collecting field crops at earlier periods
10.	Increasing of perennial grasses including medicinal plants, especially on slopes with steepness more than 3 degrees

This allowed us to get comprehensive and complete comments on the list of technologies revised by them. The list of technologies was shared among experts by emails in the second week of April 2019. In two weeks, final comments were collected, processed and presented as a second draft of the List of technologies of agriculture adaptation to climate change Table 3.8.

Table 3.8. First and Second Draft List of Technologies: Comparison Table

Technology Title (First Draft)*	Technology Title (Second Draft) **
Increasing efficiency of feed production from crops and crop residue	Construction of underground storage facilities for feed silage
	Pressing and polymeric packaging of roughage
Climate Smart Construction of Livestock Premises	Elevation of premises using optimal ventilation systems

Agroforestry practices (shelterbelt reconstruction)	Implementation of agroforestry practices involving the inclusion of fruit trees, walnut and bioenergy crops
Interactive Integrated Land Management Maps	Development of Integrated Land Management Maps for each district/village associated community
Agricultural Credit Unions Net	Agricultural Credit Unions Net
Development of an agro metrological early warning system	Development of an agro metrological early warning system
Seed Bank	Seed Bank
	Emergency Grain Storage
Drip irrigation in the combination with conservation agriculture practices	Drip irrigation in the combination with conservation agriculture practices
Underground greenhouses	Establishment of underground and semi-underground greenhouses
Inclusive crops production	Inclusive crops production
Integrated Pest and Disease Management	Implementation of practices for the use of growth regulators and adaptogens of a wide range of biotechnological origin
Improving agricultural production sustainability on complex landscapes	Transferring the crop rotation and collecting field crops at earlier periods
	Increasing of perennial grasses including medicinal plants, especially on slopes with steepness more than 3 degrees

In the next stage, technologies were classified corresponding to the TNA relevant typologies: the sustainable use of water and management, planning for climate change variability, soil management, sustainable crop management, sustainable livestock management, sustainable farming system, the management of land use, and capacity building and stakeholders.

The long list consisting of 15 technologies (Table 3.8. The second Draft) was reduced to 12 technologies the short list. The short description of technologies was proposed with the appointment of the current status of implementation in Ukraine as well as potential consumers were identified.

Consequently, a shortlist of technologies for the further MCA was obtained Table 3.9.:

Table 3.9. Short list of technologies

#	Technology Title	Abbreviation
1AA	Increasing efficiency of feed production from crops and crop residue	FPI
2AA	Climate Smart Construction of Livestock Premises	CSC-LP
3AA	Agroforestry practices (shelterbelt reconstruction)	AFP
4AA	Interactive Integrated Land Management Maps	IILMM
5AA	Agricultural Credit Unions Net	ACUN
6AA	Development of an agro metrological early warning system	EWS
7AA	Seed Bank	SB
8AA	Drip irrigation in the combination with conservation agriculture practices	DI-CA
9AA	Underground greenhouses	UG
10AA	Inclusive crops production	ICP
11AA	Integrated Pest and Disease Management	IPDM
12AA	Improving agricultural production sustainability on complex landscapes	CL

Finally, obtained results were grouped in Table 3.10. and shared among the experts for final clarification.

Table 3.10. Classification of adaptation technologies, agriculture sector

Type	Technology	Short description	Current status of technology	Implementation units
Sustainable livestock management	Increasing efficiency of feed production from crops and crop residue	Construction of storage facilities for feed silage; Pressing and polymeric packaging of roughage.	Technology implementation is very low and has space to be reinforced.	Small and medium-sized farms
	Climate Smart Construction of Livestock Premises	Increasing the height of premises with optimal ventilation systems application	Not popular. Often, implemented in case of interest farmer to ISO certification.	All farms, cooperatives, village associations
Sustainable farming system	Agroforestry practices	Agroforestry practices (shelterbelt reconstruction and establishing) implementation with the ability to obtain additional benefits such as food and wood goods.	Presently being implemented in few locations but need to be further reinforced. State is highly interested in the implementation	Large and medium-sized farms, village associations, road management authorities, and forestry enterprises
	Drip irrigation in combination with conservation agriculture practices	Drip irrigation in the combination with no-till technologies	Highly demanded and develop by farmers	Large and medium-sized farms
Land use management	E-base of Integrated Land Management Maps	Development of integrated natural resource management maps for each district / united territorial community, agriculture producers.	Partly developed with a high level of segregation of methods and tools applied.	All agricultural producers, members of rural and united territorial communities, financial institutions, agriculture service providers
	Improving agricultural production sustainability on complex landscapes	Increasing of perennial grasses including medicinal plants, especially on slopes with steepness more than 3 degrees	Low demand, not popular and needs additional promotion	All farms, cooperatives, village associations
Capacity building and stakeholders organization	Development of Agricultural Credit Unions Net	Development of Agricultural Credit Unions Net particularly in the rural areas	Requires improving legislation and state support	Small and medium-sized farms
Planning for climate change variability	Development of an early warning system	Creation of a network of early warning of occurrence of extreme climatic phenomena at the regional level, with resolution at least 10 km per 10 km.	Presently not being implemented	Large and medium-sized farms
	Underground greenhouses	Arrangement of underground and partly underground greenhouses	Low demand, not popular and needs additional promotion	All agricultural producers, agriculture service providers

Sustainable crop management,	Integrated Pest and Disease Management	Application of integrated crop cultivation practices based on the technical and biological protection (covering with agro fiber, sack, mulching, biopesticide, bioplastic, and bio-fertilizer usage)	Growth demand	All agricultural producers
	Bank of seeds	Creating the seed bank with the generated database about a variety of crops by climate and environment zones and the availability of the current seeds.	Presently not being implemented.	All agricultural producers, agriculture service providers
Soil management	Inclusive crop production	Increasing of the legumes and inclusive crops in crop rotation	Growth demand	All agricultural producers

3.5 Criteria and process of technology prioritization in sector Agriculture

3.5.1. Criteria selection

There are four different categories for criteria were identified: Development Potential; Economic; Environmental; Social.

These different categories include the 10 criteria for estimation further potential to the technology dissemination as well as the general meaning of technology for sector development (Table 3.11.).

Table 3.11. TNA criteria for agriculture adaptation sector

#	Category	Unit	Criteria
1	*Development Potential*	Numbers	***Alignment with state policy priorities***
2		Qualitative	***Potential for replication in the country***
3		Years	***Time of implementation***
4	*Economic*	UAH / $ US	***Cost (capital and operational)***
5		Quantitative	***Farm economic resilience***
6	*Environmental*	Qualitative	***Increasing Efficiency of Natural Resource Use***
7		Quantitative	***Ecosystem services improvement***
8	*Climate-Related*	Qualitative	***Strengthening of climate change resistance***
9	*Social*	Qualitative	***Improvement of the employment environment***
10		Qualitative	***Increasing potential for rural development***

All suggested groups and criteria correlate to the general TNA manuals and include both ‘qualitative’ (expert estimations based on the own knowledge and experience) and ‘quantitative’ (variables such as a cost or years) measures.

Category of Development Potential consists of the next three criteria:

- *Alignment with state policy priorities.* This criterion implies the highest level of application, including the replication of the technology. Amount them, national and international documents and initiatives are the highest, meaning that the technology is relevant and essential for the national-wide problem.

- *Potential for replication in the country.* This is a criterion for assessing the potential of technology scaling in Ukraine, taking into account geographical, climatic and other natural constraints, restrictions associated with access to resources (e.g. water) and infrastructure (railways, roads, electricity, etc.), as well as availability or complexity of implementation appropriate regulatory framework. The main question addressed to experts "Will the introduction of this technology have a significant potential for scaling across the entire territory of Ukraine"?

- *Time of implementation.* This criterion reflects the investment period in other words. The investment period is the period from the moment the project starts until it is operational. It helps to understand the required financial capacity of farmers implementing the technology as well as to identify the potential group of farmers which may be interested in the technology. Moreover, duration and real period (e.g., 2019-2022) may further influence **the final set of technologies (sequence of them!). The too long (unacceptable) timeframe** may be considered as non-viability (e.g., longer than three years).

Category of Economic group *consists* ***by the next two criteria:***

- *Cost.* In case of an agricultural adaptation, capital expenditures (equipment and infrastructure) and operational costs such as energy, wages, etc. were joint under one criterion. This was done due to the reason that both have the same weight in the selection technology decision-making process.

- *Farm economic resilience to climate change.* This is a critical criterion (first for farmers), which reflects avoiding lost productivity due to the production sustainability for technology implementation and remaining economic efficiency. The main question addressed to experts "Will the implementation of this technology maintain the same level of productivity or even may conduct to increase it under the coming climate change?"

Category of Environment includes the next criteria:

- *Increasing efficiency* of Natural Resource Use reflects effectiveness of technology implementation on sustainable land resources management and water resources management. The reason to represent the environment group with one indicator was caused by the two issues. First, ecological problems are still not considered a priority in the process of deciding by agro producers and/or service providers and the second one is to provide much higher weight for the united indicator. The main question addressed to experts "Will the implementation of this technology contribute to the optimization of the use of all-natural resources, or specifically water, land or bioresources?"

- *Ecosystem services improvement* (water purification, improvement of soil condition, restoration of natural landscapes, etc.). Both the direct economic and indirect environment benefits may be represented by this criterion. It provides long term influence, which may be engaged for the development of supporting financial mechanism for technology implementation such as technology with high national priority.

Climate-Related Category is represented with the criterion *Strengthening of climate change resilience.* This indicates multi-sectoral attractiveness of technology and additional benefit in terms of mitigation to climate change.

As it was mentioned above, rural development is one of the essential interests both for national policy and agriculture business development. In the first case, the rural population is the most vulnerable category, equal about 32 percent of the total population. High level of migration processes and poverty are bringing the rural area to extinction. These causes lack of labor for agriculture production development. Thus, increasing of attractiveness and economic potential of rural areas may have a significant place among criteria.

Following up mentioned above, ***Social Category*** includes two criteria:

- *Increasing potential for rural development.*
  The main question addressed to experts "Will the introduction of this technology contributes to the increased potential for rural development through the creation of additional jobs, the development of a common infrastructure, improvement of living conditions and the possibility of self-realization?"

- *Improvement of the employment environment.*
  The main question addressed to experts: "Will the introduction of this technology contribute to the formation and outbreak of new professions, training programs, activities, digitalization and modernization of the agricultural sector?"

  Considering the gender profile of agriculture in Ukraine (represented in the section), the question about gender suitability of technology was an cross-cutting criterion, therefore it was considered and addressed during the prioritization process. The task was to identify who could be more interested and who would be benefitted from the technologies' implementation: men, women, or sexes equally and prioritize technologies that promote equal opportunities to their access and implementation for both women and men

3.5.2. The process of technology prioritization

After the stages of technology identification and criteria selection, the questionnaire for experts (Annex IV) was developed, and the survey was carried out.

The questionnaire includes three blocks of questions each of them aimed differently, specifically to (i) the rating of criteria importance/weight; (ii) set of questions for technology prioritization of technology under criteria; (iii) set of clarifying the questions providing a deeper understanding of the potential of technologies.

Initially, the experts evaluated the significance of the criteria to further select technologies using the scale from 0 to 10; where "0" means the least significant criterion, and "10" is the most significant criterion.

Further, the average meaning per each criterion was calculated in four steps:

(i) The number of expert estimations from the highest to lowest estimation was summed up per each criterion;

(ii) The weight was calculated in percentage within category. The share of each criterion was identified under the total value of all criteria equal to 100.

(iii) Average weight of each criterion was calculated.

As a result, the weight of criteria was identified, Figure 3.11.

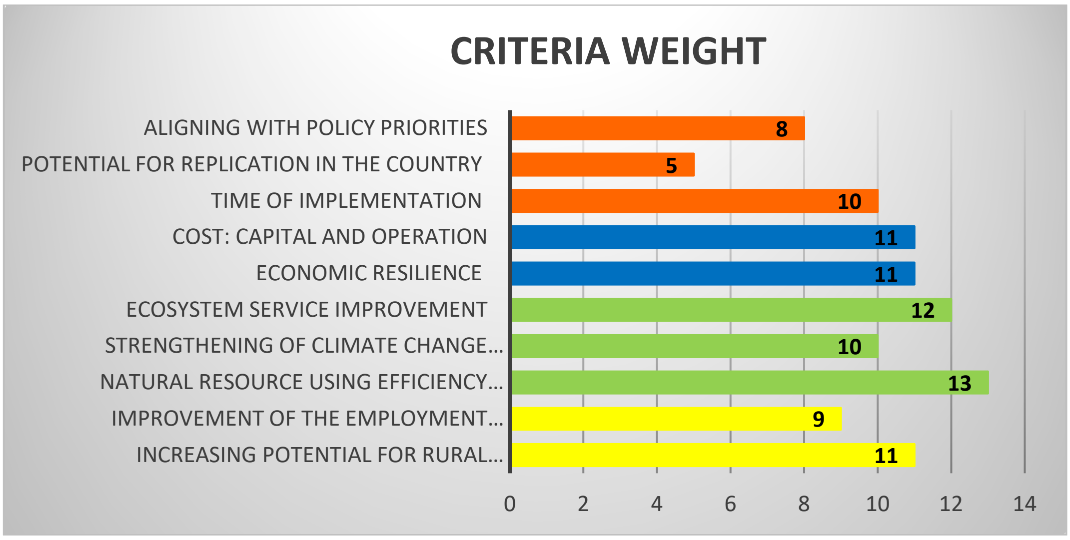


Figure 3.11. Criteria weight for the technology prioritization of adaptation technology in agriculture

The second block of the questionnaire completed with the questions aimed to prioritize technology. The experts evaluate 12 technologies following the selected criteria. The results described in the section 3.6. of current document.

The experts were free to provide any additional comments on other specific issues about technology such as geographic advisability, the implication to the soil or landscapes, following by the regime of solar radiation or wind intensiveness, availability of water and electricity, etc.

The list of experts was formed based on the principles of equal sharing between the sub-sectors representatives (crop production, animal production, breeding, lawyers, promoters, laboratory specialists) as well as representation of different types of organizations referring to agriculture, such as science, business, public (Annex IV).

The questionnaire was prepared by using the Google tools and sent to the experts and sectoral working groups. The experts had 10 working days for answering the questions, then after answers were automatically collected and processed, the results were considered in technology prioritization .

3.6 Results of technology prioritization in Agriculture sector

The prioritized technologies are in line with the recommended adaptation options of the draft for Adaptation Strategy, strengthening the interconnection and support of TNA with the ongoing development of adaptation policy's framework in the country.

As a result of multi-criteria analysis application and sensitivity analysis, the prioritization of technology was cried out. Here, the rank of technologies is presented in the Table 3.12. and it is simply visualized in a Figure 3.12. The leading three technologies (DI-CA, AFP and IDPM) do not have a significant break with the fourth one (EWS) and may be recommended for further assessment.

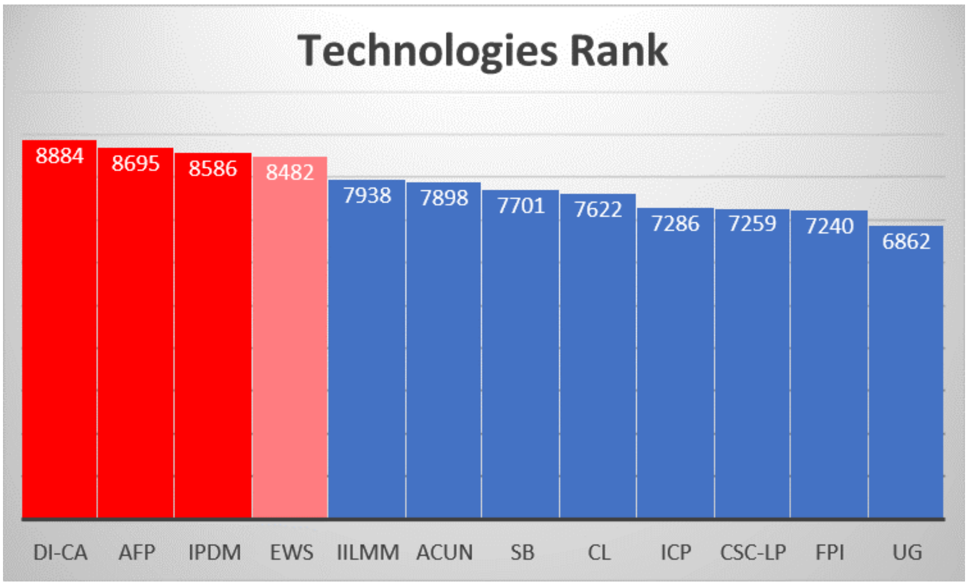


Figure 3.12. Rank of technology based on the MCA, agriculture adaptation sector

It is also necessary to notice that both highest ranking technologies belong to the type of Sustainable Farming System. The technologies listed on the third and fourth place may be classified as sustainable crop management and planning for climate change variability types of technologies correspondingly.

The technologies IILMM, ACUN, SB and CL have no significant gap in scoring. The main characteristic of this group is three technologies almost do not represent in Ukraine and have not the appropriate legislation environment for implementation However, their high estimation rating shows existent interest in these technologies and foreseen marketspace for the transfer of the best relevant international practices. Thus, the further implementation of mentioned technologies requires the strengthing of the policy framework through the development of supporting strategies, laws, regulations, other documents to speed up the deployment of these technologies.

Currently, we can see also the comparatively low level of interest in sustainable livestock management technologies. Partly, it can be explained with general depression in this sub-sector on the national level.

The Underground Greenhouse was recognized as the less attractive adaptation technology. Following the common expert opinion, there are more efficient and advanced technologies that can be applied in the greenhouse crop production's segment.

As it was mentioned above, the criterion of technology time implementation had crucial importance for the technology prioritization, as technology development and implementation in the Ukrainian conditions indirectly reflects investment period for farmers and the point of profitability. In terms of this, additionally, the comparative analysis was conducted for the leading technologies.

According to Figure 3.13., we can see that the two top technologies, such as Drip irrigation with the combination of conservation agriculture and Agroforestry Practice, have the time of implementation above three years. It may significantly decrease interest in such kind of technology, especially from the medium and small size farmers.

From the time's point of view, technologies of Integrated Pest and Disease Management may be more perspective to implementation in Ukraine as well as Early Warning System.

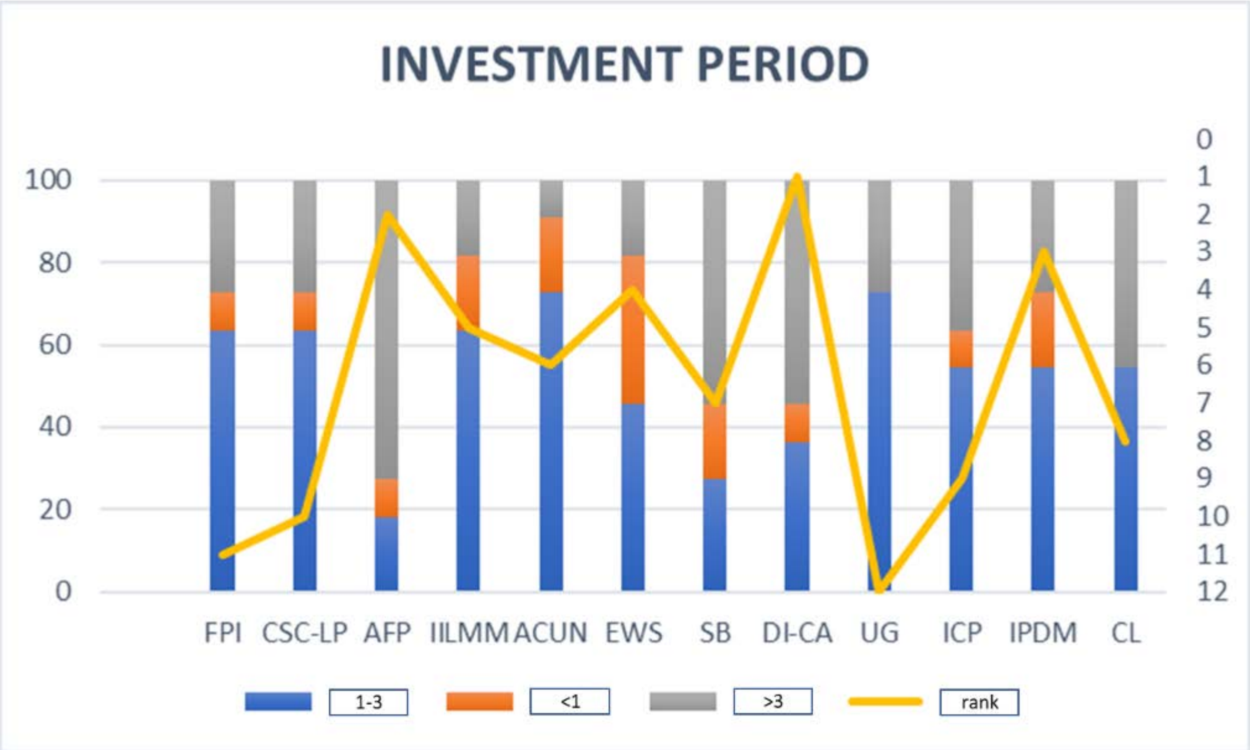


Figure 3.13. Technology rank in comparison to the criterion of time implementation, agriculture adaptation sector

In terms of gender aspects Figure 3.14., experts agree that all technologies are equally attractive for both for men and for women. However, the interesting fact is the leading two technologies (DI-CA and AFP) could be more attractive for men which totally match the gender profile of Ukrainian agriculture.

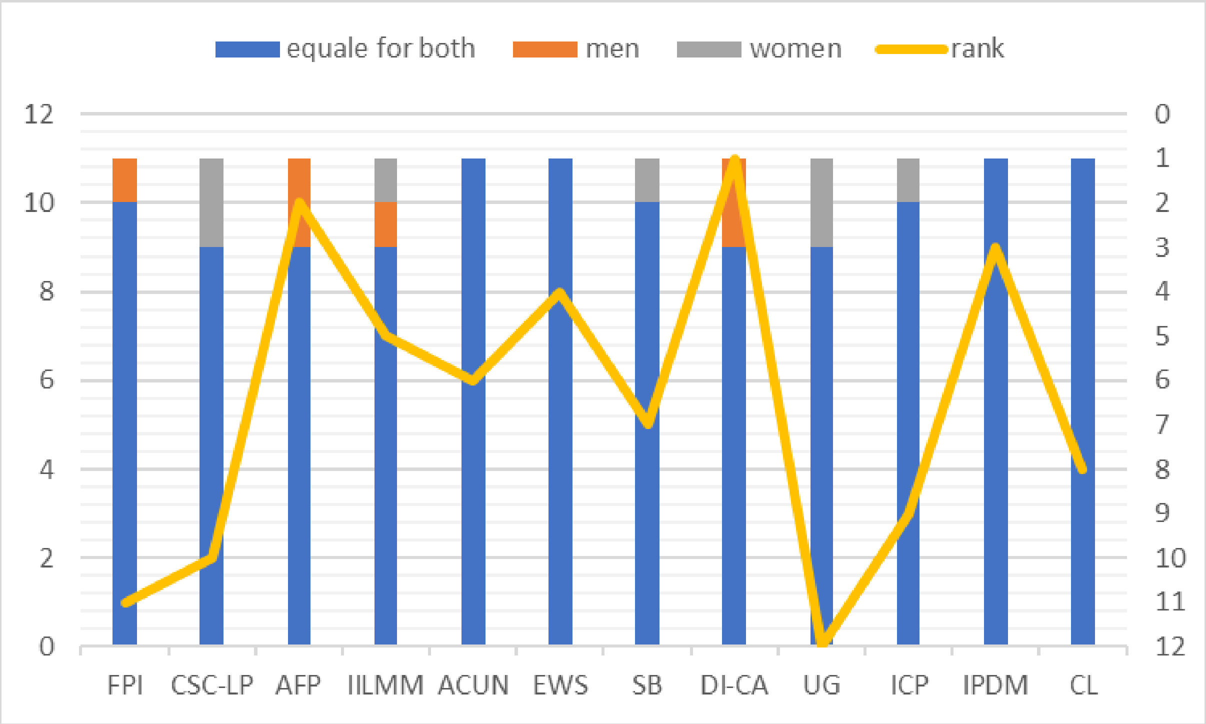


Figure 3.14. Technology rank in comparison to the attractiveness of technology by sex, agriculture adaptation sector

.

It is crucial to notice that the first three technologies are enough represented on the local market and recently highly demanded while fourth technology (development of agro-metrological early warning system) requires to be developed. Here, it is possible to guess that the Ukrainian customers (market) already open to the implementation of AEWS technology, which makes it most promising for the nearest future.

Table 3.12. Rank of technologies, agriculture adaptation sector

Rank	#	Abbreviation	Technology Title
1	8AA	DI-CA	Drip irrigation in the combination with conservation agriculture practices
2	3AA	AFP	Agroforestry practices (shelterbelt reconstruction)
3	11AA	IPDM	Integrated Pest and Disease Management
4	6AA	EWS	Development of an Agrometrological Early Warning System
5	4AA	IILMM	Interactive Integrated Land Management Maps
6	5AA	ACUN	Agricultural Credit Unions Net
7	7AA	SB	Seed Bank
8	12AA	CL	Improving agricultural production sustainability on complex landscapes
9	10AA	ICP	Inclusive crops production

10	2AA	CSC-LP	Climate Smart Construction of Livestock Premises
11	1AA	FPI	Increasing efficiency of feed production from crops and crop residue
12	9AA	UP	Underground greenhouses

The short description of all selected technologies represented in the Technological Fact Sheets, Annex I.

Table 3.13. The short list of technologies, agriculture adaptation sector

Rank	#	Abbreviation	Technology Title
1	8AA	DI-CA	Drip irrigation in the combination with conservation agriculture practices
2	3AA	AFP	Agroforestry practices (shelterbelt reconstruction)
3	11AA	IPDM	Integrated Pest and Disease Management
4	6AA	EWS	Development of an Agrometrological Early Warning System

Chapter 4 Technology prioritisation for Water Sector

4.1 Key Climate Change Vulnerabilities in Water Sector

Climate change impacts, driven by temperature rises and shifts in precipitation patterns, could lead to changes in flood or drought frequency, water availability, and seasonality of water discharge (Bates at al.,2017; Kovats at al., 2014; Vormoor at al., 2015). Such changes may have adverse effects on agricultural, energy, transport, and social sectors, dependent on water resources. Adaptation strategies have to be developed in regional water resource management in order to avoid the risks and damages associated with such impacts, so that the readiness of the water-dependent sectors could be ensured to meet the future challenges. Nowadays, there is a growing body of knowledge and understanding of the nature and scale of potential future climate change impacts. However, uncertainties associated with climate projections still make the task of quantification of the impacts challenging.

On the other hand, climate change is only one of many stressors on water resources. Non-climatic factors, such as population increase, urbanization, altered water use patterns, and changes in land use are also very important and may lead to instability of resources, e.g., decreases in water supply or increases in water demand (Cisneros at al.,2014).

Ukraine has a relatively low availability of internal water resources compared to other countries in Europe: it ranked 124th among 181 countries by the amount of internal renewable water resources available per capita in 2014 (The World Bank, 2016). Ukraine is the 17th among 20 countries of Europe by the amount of total renewable water resources available per capita.

The average perennial renewable volume of surface water is approximately 95 km^3 per year, which is equivalent to 2,0 thousand m3 per capita. Moreover, more than half of the water resources are concentrated in the Danube basin, where the need for water does not exceed 5 percent. In the dry years, the volume of surface water decreases to 1,2 thousand m^3 per capita, which characterizes

Ukraine according to the UNESCO classification as a water-insecure country and water shortage is observed practically everywhere, especially in the basins of the Lower Dnipro, Siversky Donets, Southern Bug, Ingulets, Pryazovia and Crimea.

The bulk of the water resources of Ukraine forms a river runoff of 209.23 km3 (along with the Danube River) (See Table 4.1 for details.).

Table 4.1. The average annual runoff of the main river basins of Ukraine

River basins	Average annual runoff, km^3		
	Total	Formed in Ukraine	Inflow from other countries
Bug	1.4	1.4	
Danube	133.8	10.8	123,0
Dnister	10.7	9.7	1.0
Southern Bug	3.2	3.2	
Dnipro	53.5	19.1	34.4
Siversky Donets	4.81	2.96	1.85
Black and Azov Seas river basins	1.82	1.82	
Total	209.23	48.98	160.25

Within the country, only 23.4% of the water resources is formed, which is considered as Ukraine's own water fund, and the rest of it comes from foreign countries - Romania, Moldova, Hungary, Poland, the Republic of Belarus, the Russian Federation (AQUASTAT, 2016).
Along with the water resources of rivers, water reserves in natural and artificial reservoirs are of great economic importance. 1160 water reservoirs were created on rivers in order to ensure the economic activity of the country, having the total volume of 55 km3 of water. Six large reservoirs are built with a total volume of 43.8 km3 of water on the Dnieper River (Snishko, 2001). Large reservoirs include the Dniester reservoir on the Dniester River (volume - 3.0 billion m3), Chervonooskolske on the Oskol river (477 million m3), Pechenizke on the Siversky Donets River (384 million m3), Karachunovo on the Ingulets river (308.5 million m3). About 2.3 billion cubic meters of water is concentrated in freshwater lakes.

The largest amount of water resources (58%) is concentrated in the Danube basin in the border regions of Ukraine, where the demand for water does not exceed 5% of its total reserves. The least secured water resources are in Donbass, Kryvy Rig, Crimea and the southern regions of Ukraine, where the largest consumers of water are located.

According to the international classification, only Transcarpathian region has medium provision of water resources (6.3 m^3 per person and per year); Chernihiv, Zhytomyr, Volyn and Ivano-Frankivsk regions have only 3,3-2,0 m^3 per person and per year Other areas - provision of water resources is very low and extremely low (1.98 - 0.12 m^3 per person).

Projected resources of groundwater of Ukraine are estimated at 22.5 km3 / year. The total amount of explored groundwater resources available for use is about 5.7 km3 per year; in fact, 2.5 km3 per year is actually used. Their distribution across the state is uneven: 65% are located in the northern and northwestern parts (Dniprovsky and Volyn-Podilsky artesian basins). The southern part of Ukraine has limited groundwater resources.

In terms of per capita, the largest amount of groundwater (5.54 m3 / day) is in Chernihiv region, and the smallest (0.28 - 0.43 m3 / day) - in Dnipro, Odessa, Kirovograd, Donetsk, Mykolayiv, Zhytomyr and Vinnytsya region.

Annually, a significant amount of water (15 km3) is redistributed throughout Ukraine through trunk channels and water conduits. The volume of water losses during transportation is estimated at 2.0 km3 per year. Moreover, more than a third of the water supplied to irrigation systems is lost due to the low technical level and wear of hydraulic structures (Water Strategy, 2015).
Water losses in water supply systems providing drinking and water for household needs reached 748.05 million cubic meters of water or 35.78% from the collected in 2017.

Since 1990, Ukraine has undergone a sharp decline in overall water consumption due to a significant reduction in water consumption by industry and agriculture. In 1990, total water consumption amounted to 30.2 billion m3 of water per year, and in 2014, it was reduced to 11.5 billion m^3 of water per year.

The largest water users according to territories are Dnipropetrovsk (1565 million m^3), Donetsk (1697 million m^3), Zaporizhzhya (1149 million m^3), Kyiv (911 million m^3), Kherson (1442 million m^3), Odesa (977 million m^3) regions and city of Kyiv (615 million m^3), which accounted for 72.6% of the total volume of water intake. The losses of water during transportation to consumers in 2014 were 1390 million m3 or 11.7% of the water intake.

The total volume of collection (extraction) of water from natural water bodies has been on average 15 km3 per year. Out of this volume, about 48% belongs to the industry, 26% to agriculture and 25% to utilities.

The structure for the utilization of water in Ukraine is as follows: 48% - industry, 26% - agriculture (irrigation), 25% - utilities [8,11]. Water intensity of domestic output is 0.3 m3 per 1 hryvnia of finished goods, which is much higher than in the developed European countries.

Water consumption by utilities in Ukraine is also significantly higher than that in the EU countries. The average water consumption in 27 cities of Ukraine amounted to 275 liters per person per day (Modernisierungsstrategie,2013) whereas in the EU countries this figure is 100-200 liters per person per day.

Therefore, a comprehensive assessment of climate change impacts on the country’s water resources is vital. Surprisingly, such an assessment has not been performed for this large European country until now.
The water resources of Ukraine are vulnerable due to their limited total amount, uneven annual internal and external contributions to the total renewable water resources, and heterogeneous distribution of available water within the country. In addition, water quality is also a very important issue, with surface water resources (mainly river flow) contributing 97% of the total amount. In this regard, the issue of the future is crucial for Ukraine. So far, there have been several evaluations of potential climate change impacts on future water resources availability (Snizhko et al., 2014; Buksha et al., 1998; Loboda et al., 2015).

However, to our knowledge, only a few of these studies applied numerical hydrological models (Bar et al., 2015; Fischer et al., 2014; Schneider et al., 2013; Hesse et al.,2015; Pluntke et al., 2010). For example, the hydrological effects of climate change on the upper part of the Western Bug basin have been studied in the paper (Fischer et al., 2014) using the SWAT (Soil and Water Assessment Tool) model driven by climate scenarios from CCLM (COSMO—Climate Limited area Modeling) under the emission scenarios A2 and B1. The results showed a minor change in average annual runoff for both scenarios in the period 2021–2050. In the period 2071–2100 the average annual runoff is projected to decrease by - 15% under the B1 scenario and by - 8% under the A2 scenario.

The majority of other studies dedicated to this issue used statistical approaches based on the water balance equation. For instance, Snizhko et al.,2014 performed an assessment of water resource changes in 19 representative river basins in Ukraine for the 21st century by applying a water balance method (WBM) driven by climate scenarios from the REMO model. According to this study, in the near future runoff mainly stays stable, especially in the mountainous regions, with small increases until 2040. Then, by the end of the century, a decrease in runoff was projected for almost all catchments, especially in the central and southern parts of Ukraine (Snizhko et al.,2014).

Some answers can be obtained regarding potential future changes in water resources in Ukraine from the study of Loboda et al. ,2015, who made an assessment of water resources changes in Ukraine driven by the A1B and A2 scenarios of global warming. Their study, also based on the water balance equation, exploited the method of assessment of zonal runoff using meteorological data. The results showed an increase in the semi-arid area in South Ukraine, a decrease in soil moisture in West Ukraine (including the Western Bug catchment), and also in drainage areas of the left-bank tributaries of the upper Dnipro by 2050, according to the A1B scenario: according to the A2 scenario, however, water resources would increase in North Ukraine up to 80%, and up to 20% in the central part of the country, accompanied by 20%–30% decreases in the west and up to 60% in the south by 2050 (Loboda et al.,2015).

Considering the above-mentioned publications and results of the projects dedicated to the assessment of future changes in river discharge under climate change in Ukraine, we can conclude that the studies using numerical hydrological modelling are rather limited, and they applied the older SRES scenarios. The majority of studies were based on a simple water balance method, and do not consider the complexity of possible effects of changing climate on the hydrological cycle processes.
Often, scenarios applied in the abovementioned studies show opposite signals of change, especially for precipitation. Thus, the small number of applied climate projections and the limited consideration of regional peculiarities of the hydrological conditions in WBMs lead to results with a high uncertainty.

Under A2 scenario, during the period (2031-2050), low-water runoff in the dry years will begin to decrease in a large part of Ukraine. The decreasing of the value of the75th percentile of the water runoff in the period 2031-2050 will reach 60-70% in the south part of Ukraine compared to 2011-2030 (scenario A2). (See Figure 4.1. for details).

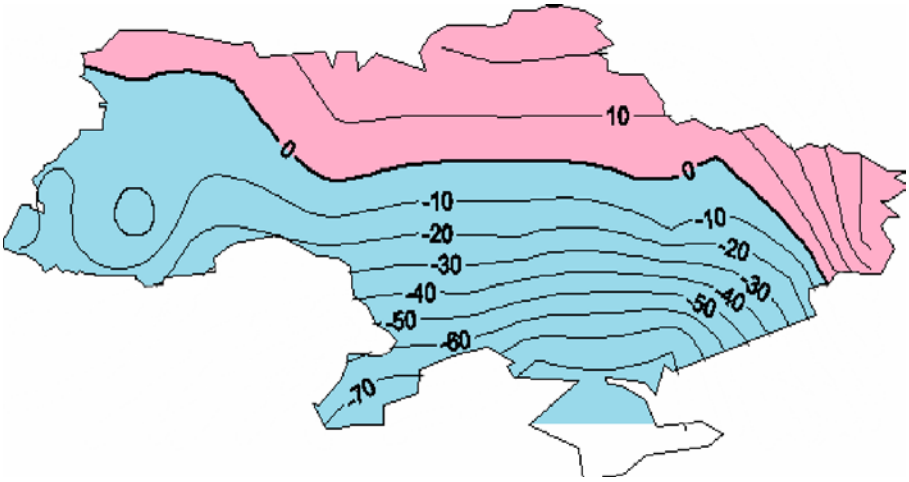


Figure 4.1. **The** ***spatial distribution of relative deviations (%) of the annual climate runoff of the 75th percentile in the period 2031-2050 compared to 2011-2030 (scenario A2)*** (Source: Boshok, 2015).

The decreasing of the value of the 95th percentile of the water runoff in the period 2031-2050 will reach 10% in the south part of Ukraine compared to 2011-2030 (scenario A2). (See Figure 4.2. for details).

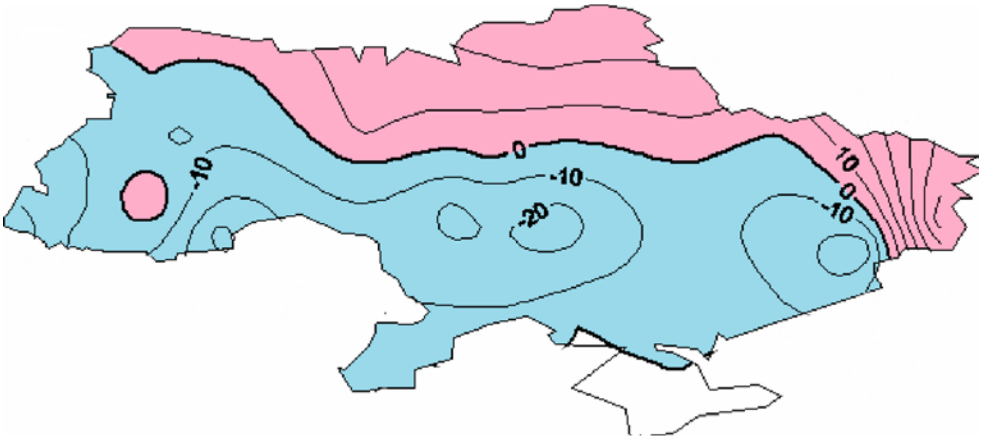


Figure 4.2. **The** ***spatial distribution of relative deviations(%) of the annual climate runoff of the 95th percentile in the period 2031-2050 compared to 2011-2030 (scenario A2).*** (Source: Boshok, 2015).

Projections of the average annual runoff of rivers of Ukraine in the middle of the XXI century relative to the 1991-2010 reference year, obtained by RCM data for (A1B) socio-economic development scenario show (see Figure 4.3. for details) that the most likely expected changes in the average annual flow will be within the limits of natural fluctuations (± 15%) of the long-term river runoff norm.

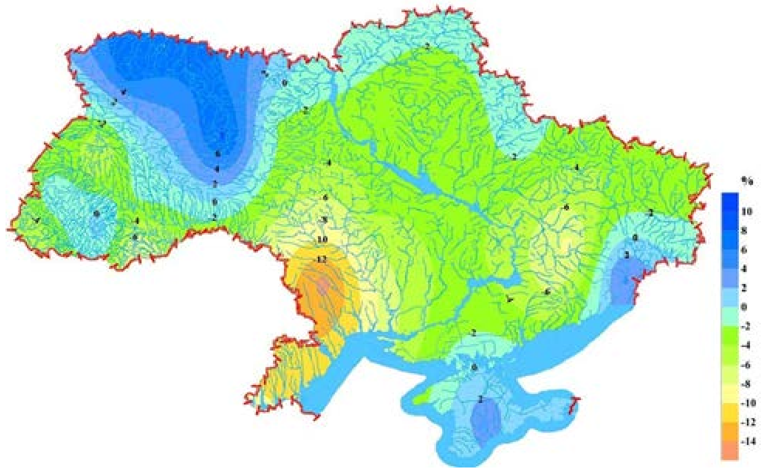


Figure 4.3. The projections of changes in the average annual river runoff (%) in Ukraine for the period 2031-2050 in relation to the reference period of 1991-2010 according to RCM, A1B scenario*(Source: Gorbachova,2017)*

The water balance assessment of changes in the local water resources (climatic flow) on the base of climatic projection from A1B scenario, which depends on the ratio of the main elements of the water balance of precipitation and evaporation, shows (Snizhko at al., 2011), that since 2040 the cease of the surface low-water runoff in the dry years in Kherson, Odesa, Mykolayiv, Dnipropetrovsk and Zaporizhzhya regions is possible.

One should bear in mind that this refers to zonal water resources of local drainage, which are sensitive to the warming of the climate and, even in the current climate, periodically dry up in arid years.

The water supply of these regions does not depend directly on the water resources of the local drain, but the general warming trends that will be accompanied by rising air temperature, the amount of evaporation, and the reduction of precipitation are threatening the sources of water supply, irrigation (reservoirs, rates) and linear water management infrastructure (canals, water pipes). There may be significant losses of water resources during storage and transportation, and additional energy costs will be incurred for the operation of water facilities.

In subsequent years, this situation will deteriorate: local surface runoff will decrease, and the zone of a possible complete cessation of runoff will expand.

In 2041-2060, in the years of average water flow, it will cover the territories of the Kherson, Odesa, Mykolaiv and Zaporizhzhia regions. In 2061-2080 it will expand to Dnipropetrovsk, Zaporozhye, Kirovograd regions and the Crimea (See Figure 4.4. for details).

Figure 4.4. Distribution of projected local water resources (climatic flow) for period 2061-2080 between the administrative regions of Ukraine (average runoff layer for a long-term period, mm), scenario A1B *(Source: Snizhko at al.,2011)*

The results of forecasting still suggest the presence of surface runoff in abundant water years before 2080 in most of the territory of Ukraine, except for Kherson and Odesa regions.

Within last years, more precise assessments of water runoff under impact of climate have emerged. One of the latest studies using the SWIM ecological and hydrological model (Krysanova,2000) and regional climate scenarios from the European interdisciplinary project IMPRESSIONS and 7 climate projections from RCP 4.5 and RCP 8.5 are joint Ukrainian-German studies carried out in recent years by the Kyiv National Taras Shevchenko University, Potsdam University and Potsdam Institute of Climate Studies (Didovets at al.,2017), (Didovets at al., 2019). Possible changes in water resources in various regions of Ukraine based on five indicator basins (the river Teterev, the Samara River, the Western Bug, the Tisza River and the Prut River) were assessed (See Figure 4.5. for details).

In the Teterev River basin, an increase of runoff is expected in the winter months and early spring, reaching a peak in March-April. In summer months, changes in drainage are not expected in the near future (until 2040), but in 2041-2070 and in 2071-2100, a slight decrease in drainage is expected (up to 17%). There is a probability of stopping the drain during the summer period for all forecasted periods. Autumn's months are characterized by a steady increase in drainage. In the basin of the Western Bug, an increase in drainage is expected compared to a control period for all seasons with a slight sporadic decrease in the spring months in the near and far future according to all scenarios.

The increase in river runoff in the summer and autumn, even in the case of a decrease in the amount of precipitation in these months, can be attributed to the delay in drainage due to the high level of groundwater accumulated in the earlier period of time.
The results obtained for the Samara River Basin under "high-end" scenarios show an increase in drainage in almost all months. In April, all scenarios show a decrease in drainage. However, the

obtained assessments of water runoff for this basin have the highest uncertainty due to changed hydrological regime of this river, located in the area of insufficient hydration.

Model runs "low-end" scenarios show a decrease in drainage from April to September, especially in the middle and far forecast periods. However, the results obtained for "high-end" and "intermediate" scenarios have a wide range of uncertainties.

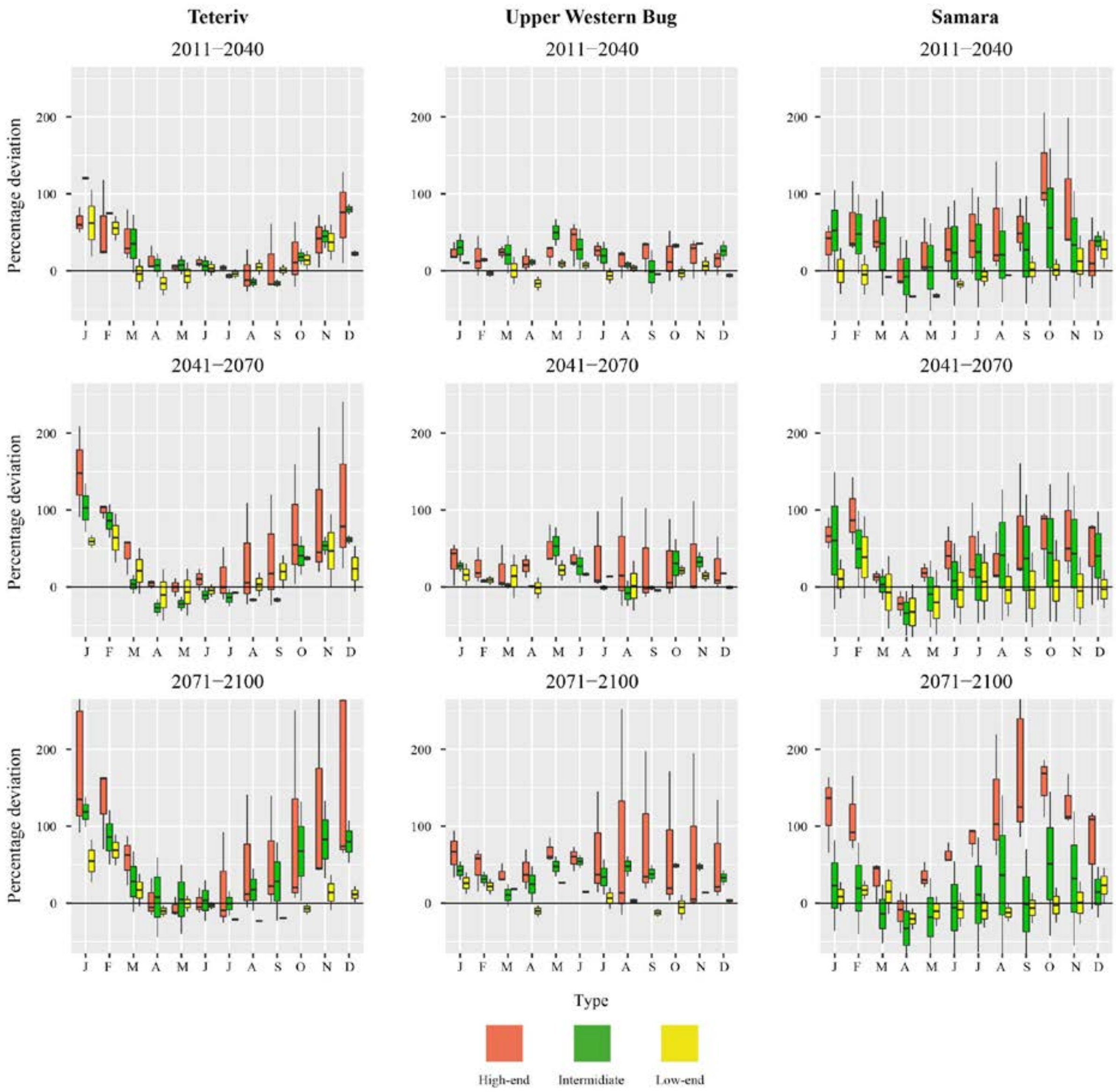


Figure 4.5. The projected future changes in areal catchment mean of river discharge in the basins under consideration for three scenarios and three future periods compared to the reference period shown as boxplots, where the boxes show ranges between the 25th and 75th percentiles, and thick black lines show the median values. *(Source:Didovets at al.,2017)*

Climate change is manifested not only in reducing the water flow in the future, but also in a significant change in the hydrological regime of water bodies. The most dangerous manifestations of the change in the hydrological regime are catastrophic floods and flash floods. The regional manifestation of these phenomena is wide enough. This is primarily the Carpathian region: Transcarpathia (Transcarpathian region), Prykarpattya (Lviv, Ivano-Frankivsk and Chernivtsi regions). The territory of the Carpathians (Tyzsa, Dniester and Prut basins) is one of the most flood-prone regions in Europe. Floods in the Carpathians are natural phenomena common to this territory. They are determined here by the frequency, intensity of development and simultaneous spread on a large area (up to 10-30 thousand km2), often with significant destructive consequences.

There were several destructive floods in recent decades (in 1998, 2001 and 2008) in Ukraine (Kovalets at al.,2014). One of the biggest and destructive floods occurred in the Carpathian region and surrounding areas within Ukraine, Moldova and Romania at the end of July 2008, causing 47 fatalities and evacuation of about 40 000 people (WHO, 2017). Over 40.000 houses and 33.000 ha of farmland were flooded in Ukraine (International Commission, 2009).

In the Carpathian rivers, rain and snow-rain flood of different heights are repeated 3-8 times a year. But they are particularly threatening in periods of high-water availability due to global atmospheric circulation. Studies have revealed the alternation of periods of high water in the rivers of the Western region of Ukraine and cyclic components in the structure of long-run fluctuations of the river runoff of the Carpathian region and the Right Bank of the Pripyat. During these periods, dangerous rain flood occurred with the appearance of cycles in 3-4 and 6-8 years.

The newest study (Didovets at al.,2019) for rivers of the Carpathian region of Ukraine (Tisza and Prut), reported investigates climate change impacts on flood risk in the region, and uncertainty related to hydrological modelling, downscaling techniques and climate projections. The climate projections used in the study were derived from five GCMs, downscaled either dynamically with RCMs or with the statistical downscaling model XDS. The resulting climate change scenarios were applied to drive the eco-hydrological model SWIM, which was calibrated and validated for the catchments in advance using observed climate and hydrological data. The changes in the 30-year flood hazards and 98 and 95 percentiles of discharge were evaluated for the far future period (2071–2100) in comparison with the reference period (1981–2010).

The majority of model outputs under RCP 4.5 show a small to strong increase of the 30-year flood level in the Tisza ranging from 4.5% to 62% (See Figure 4.6. for details), and moderate increase in the Prut ranging from 11% to 22% (See Figure 4.7. for details)

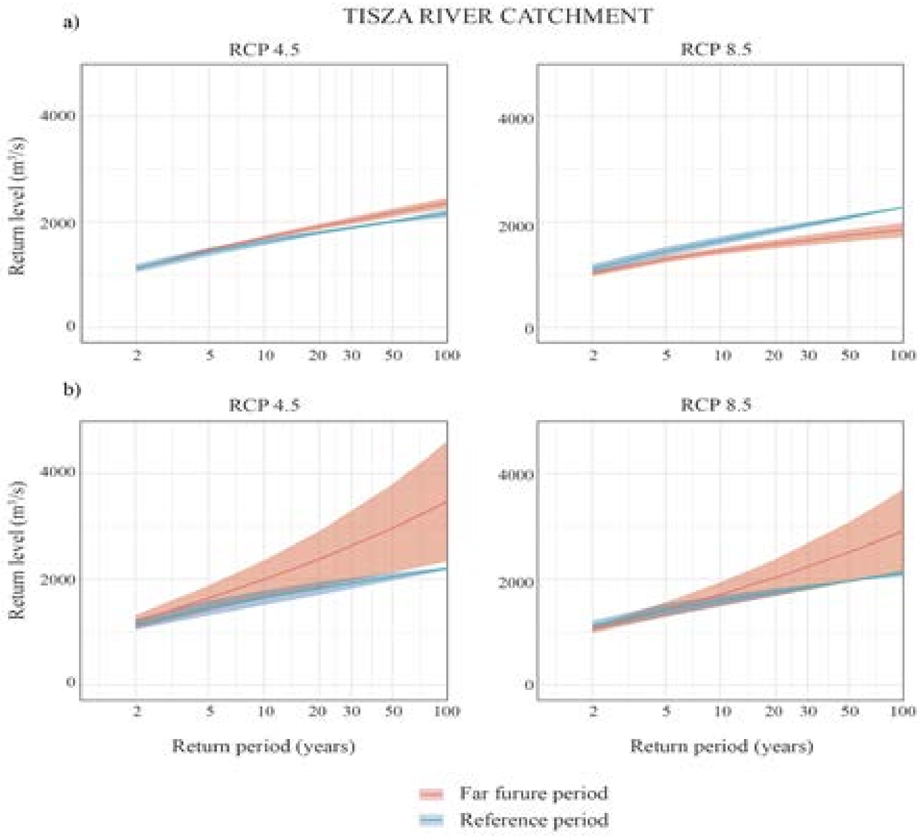


Figure 4.6. Flood frequency curves of simulated discharge rates for a) GCM-XDS and b) GCM-RCM projections, based on the GEV distribution fit to the annual maxima in the reference and far future periods for the Tisza catchment *(Source:Didovets at al.,2019)*

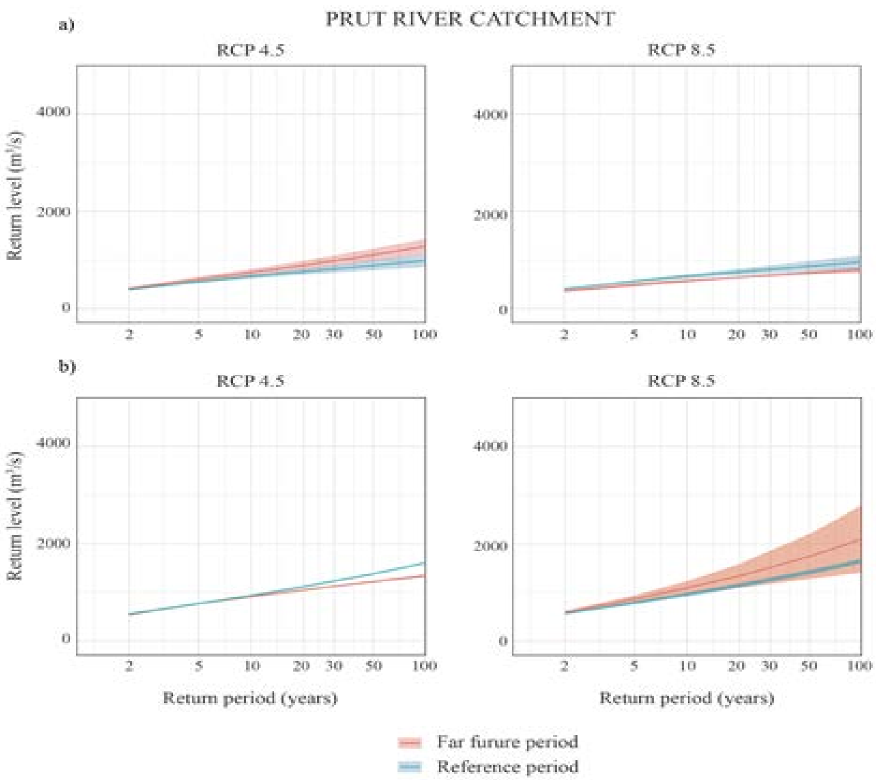


Figure 4.7. Flood frequency curves of simulated discharge rates for a) GCM-XDS and b) GCM-RCM projections, based on the GEV distribution fit to the annual maxima in the reference and far future periods for the Prut catchment *(Source:Didovets at al.,2019)*

The impact results under RCP 8.5 are more uncertain with changes in both directions due to high uncertainties in GCM-RCM climate projections, downscaling methods and the low density of available climate stations. The largest increase in flood during a thirty-year period of more than 40% was modeled on the basis of HadGEM2-RCA4 for the Tisza (both RTC) and the Prut (RTC 8.5).

We may conclude that most of Ukraine's territory currently has low level of water resources and a high vulnerability to climate change. Water resources of Ukraine depend on the river flow of water from the territories of adjoining countries (76.6%), and only about their fourth part is formed within the country (23.4%). Among the 20 European countries, Ukraine is ranked the 17th in terms of water resources availability. A significant part of the country's territory has low and very low water availability (1.98 - 0.12 thousand m3 per capita).

Taking into account the available modeling results, one should expect an increase in the deficit of water resources in the zone of unsustainable agriculture - in the southern regions of Ukraine as early as by the middle of the XXI century. At the same time, water sector of Ukraine will face the problem of devastating water effects in connection with the strengthening of the river's float regime.

Thus, the key technologies of adaptation of the water sector of Ukraine should take into account these two trends climate change vulnerabilities in the water sector to ensure sustainable socio-economic development of the country in the future.

4.2 Decision context

Ukraine belongs to the list of countries that have signed and ratified the United Nations Framework Convention on Climate Change and its Kyoto Protocol and committed themselves not only to protect the climate system for the benefit of the present and future generations of mankind, but also to fulfill their individual obligations as Parties to the Convention and Protocol. In particular, Ukraine has committed to implement policies and measures aimed at combating the climate change, taking into consideration the real socio-economic conditions of the country, to cover all sources and sinks of greenhouse gases as well as related economy sectors (VI National Communication, 2012) In Ukraine, activities on adaptation to climate change in 2010-2013 have significantly increased. In December 2010, under the Presidential Decree No.1119 “On the decision of the National Security and Defense Council of Ukraine of 17 November 2010 “On the challenges and threats to national security of Ukraine in 2011” the State Environmental Investment Agency of Ukraine together with the relevant central and local executive authorities, the National Academy of Sciences was requested to develop a National Plan of adaptation to climate change by identifying sources of funding the measures.

On the basis of analysis of the current work on adaptation to climate change, it can be noted that the activities related to adaptation in the context of climate change are already being implemented in the framework of national and state programs, national and regional programs and plans. The State Environmental Investment Agency of Ukraine developed and implemented the Plan of priority measures on adaptation to climate change in 2012 -2013 in order to ensure the continuity of activities on adaptation to climate change.

The indicated Plan included:

- The functioning of the Interdepartmental Working Group on Climate Change Adaptation at the
- Interdepartmental Commission on enforcement of the UN Framework Convention on Climate Change.

- conducting public awareness efforts on potential and existing risks and threats caused by climate change and actions to prevent them;
- holding roundtables and seminars to educate the public on the state of implementation of the state policy in the field of climate change adaptation;
- development of scenarios of climate change in Ukraine for the medium and long term using the data of global and regional models;
- development of detailed maps of future climatic conditions of the territory of Ukraine for different scenarios of climate change using geographic information systems;
- conducting the spatial analysis of trends in the frequency and intensity change of extreme
- meteorological events in Ukraine due to climate change;
- conducting the spatial assessment of the degree of profitableness of future climate conditions for the productivity of major crops and forest plantations;
- conducting the spatial analysis of changes in the water regime of pools of surface water bodies in the territory of Ukraine as a result of climate change;
- development of guidelines on risk assessment for human health, the environment, economic sectors due to the increased number and intensity of extreme meteorological events due to climate change;
- the development of guidelines for central and local executive authorities for the selection of measures on adaptation to climate change;
- conducting seminars with representatives of the executive authorities, business entities and science, on the definition of industry (sectoral) and regional measures to adapt to climate change;
- providing the consulting and methodological support to representatives of central and local executive bodies to develop and implement the industry (sectoral) and regional measures to adapt to climate change.

The scope of Ukrainian environmental legislation is quite broad and comprehensive (more than 300 legal acts). Ukraine’s legislation provides for the use of a wide spectrum of direct and indirect environmental policy instruments. However, implementation requires strengthening to ensure that they are in line with international good practices.

The Government of Ukraine approved the National Environment Strategy – 2020 (NES), as well as other strategic government both cross sectoral and sector specific.

NES include next key sectoral strategies and programs:
• Sustainable Development Strategy – 2020 (2015)
• National Action Plan on Renewable Energy – 2020 (2014)
• National Strategy for Regional Development – 2020 (2014)
• Concept of National Targeted Economic Program of the Industrial Development up to 2020 (2013)
• Energy Strategy – 2030 (2013)
• Agriculture Sector Development Strategy – 2020 (2013)
• National Program of Domestic Production (2011)
• Transport Strategy – 2020 (2010)
• National Action Plan on Settlements’ Improvement and their Adjacent Territories for 2010–2015(2009)
• State Targeted Program on the Development of the Ukrainian Village up to 2015 (2007)
• National Security Strategy (2007)
• Main Provisions of State Agrarian Policy – 2015 (2005)
• National Program for Reform and Development of Housing and Utility Services for 2009–2014 (2004)

• Ukraine Economic and Social Development Strategy by a Way of European Integration for 2004–2015 (2004)
The Ministry of Ecology and Natural Resources (MENR) is the main state authority tasked with the key role of developing and ensuring the implementation of environmental policy at the central government level. The ministry coordinates several agencies, including the State Ecological Inspectorate, the State Agency of Water Resources, the State Service of Geology and Mineral Resources, and the State Agency of Ukraine on Exclusion Zone Management. MENR also supervises three research institutes and nine state enterprises.

Water affairs are regulated in Ukraine by Water Code (Water Code,1995), the Law of Ukraine "On Nature Environment Protection" and other legislative acts. The last edition from 28 December 2014 together with the amendments passed on 4 October 2016 has completed the harmonization with the EU Water Framework Directive (WFD)
.
The current legal framework for EU-Ukraine relations is provided by the Association Agreement (AA), which replaced Partnership and Co-operation Agreement (PCA) in 2014. The signing of the political part of the agreement on 21 March 2014 made step forward implementation of the results of 10 years work of Ukraine on harmonization / approximation of environmental legislation to the EU legislation, including EU water legislation, particularly the EU Water Framework Directive.

Under this AA, Ukraine began the implementation of next directives:

- Water Framework Directive 2000/60/EC;
- Floods Directive 2007/60/EC;
- Marine Strategy Framework Directive 2008/56/EC;
- Urban Waste Water Directive 91/271/EEC;
- Drinking Water Directive 98/83/EC;
- •Nitrates Directive 91/676/EEC.

The Law of Ukraine adopting the State Targeted Programme on development of water economy and ecological sanitation of the Dnieper river basin by 2021 (2012). This addresses climate change adaptation issues, and the implementation of river basin management principles. The main directions of the National Water Programme are:

- The development of water management and land-melioration by improving ecological status of drained and irrigated areas;
- Providing rural population with centralized water-supply;
- Protection rural settlements and agricultural land from negative water influence;
- Integrated flood control and protection areas within the Tisza, Dniester, Prut and Siret river basins;
- Ecological enhancement of the Dnipro river basin and drinking water quality improvement;
- Implementation of integrated river basin approach in water management.

A wide range of other state documents - resolutions of the Cabinet of Ministers, Parliament, MENR are provided regulations of water use, protection, conservation and adaptation to climate change.

Among them the following should be called:

- Decree of the Cabinet of Ministers of Ukraine (CMU) dated May 18, 2017, No. 336 "On Approving the Procedure for the Development of the River Basin Management Plan";
- The Law “On drinking water and drinking water supply” from January 10, 2002 of No 2918-III (last edition from 22/07/2014) determines the legal, economic and organizational

basis of functioning of system of the drinking water supply, the populations directed on secured provision high-quality and safe for health of the person drinking water;

- Law on “Environmental Impact Assessment” No. 2059-VIII entered in force on December 18, 2017,
- The Draft Resolution of the Cabinet of Ministers of Ukraine “Procedure for Implementation of State Water Monitoring” (in process of approval);
- The Draft Order of the MENR “On the approval of the methodology of identification of surface and groundwater bodies” (in process) ;
- Law on “Approval of State-Targeted Program of Development of Water Industry and Ecological Sanitation of Dnipro River’s Basin up to 2021”;
- Parliament Resolution on “State Program ‘Drinking Water of Ukraine’ for 2011–2020”;
- CMU Decree “Procedure for Implementation of State Water Monitoring”;
- CMU Decree “Procedure for Approval and Obtaining Permits for Special Water Use”;
- CMU Decree “On Approval of the Rules of the Protection of Surface Waters from Pollution by the Return Waters”;
- CMU Decree “Procedure of Development and Approval of Pollution Discharge Limits and the List of Polluting Substances, for which the Discharge Limits are Set”;
- Order of the Ministry of Environment and Nuclear Safety of Ukraine “Guidance on the Procedure for Developing and Setting the Discharge Limit Values for Polluting Substances Released into Surface Waters with Effluent Discharges”.

Thus, Ukraine’s legislation provides for the use of a wide spectrum of direct and indirect environmental policy instruments to reduce the climate change vulnerabilities.

In recent years, Ukraine has started to integrate into the European Union. To comply with the EU legislation requirements, the harmonization of Ukrainian national standards to European ones in economic, social, and environmental fields has to take place. In this respect, there have been initial steps made in water resource management, planning, and policy. One of the main priorities, but also a concern, is the adoption and implementation of the Water Framework Directive (WFD) (EC, 2000) goals and standards in water resource management. It requires an improvement in water quality and complex assessment of the state of riparian ecosystems.

Ukraine has made some progresses in the implementation of the Integrated River Basin Management approach, promoted by WFD, especially for its transboundary catchments. As cited in the WFD, water dynamics and quantity play critical roles in the functioning of aquatic systems and for reaching environment goals (European Commission, 2012).

Therefore, climate change as a driver of potential future changes in water resources is important and has to be studied. The assessment of climate change impacts on water resources and development of the adaptation measures should be done as a part of strategy for achieving the environmental objectives.

4.3 Overview of Existing Technologies in Water Sector

The level of water availability in Ukraine is insufficient and is determined by the formation of river runoff, the presence of underground and sea waters. Potential resources of the river runoff are estimated at 209.8 km^3, of which the local runoff in Ukraine is an average of 52.4 km^3. km, inflow - 157.4 km^3 (SAWR of Ukraine, 2017).

Reservoirs of groundwater, not related to the surface runoff, are 7 km^3. In addition, up to 1.0 km^3 of sea water is used in the Ukrainian economy. In terms of per capita, local surface runoff is about 1045 m^3. The highest level of water supply for the inhabitants is in the western and northern regions of Ukraine.

According to the international classification, only the Transcarpathian region belongs to the category of average provision with local runoff (6.3 thousand m^3 per person). Low availability of water is in Chernihiv, Zhytomyr, Volyn and Ivano-Frankivsk regions (3.3-2.0 thousand m3) in other regions of Ukraine - low and very low water availability (1.98 - 0.12 thousand m^3 per person). Fig 4.8. below provides an overview of the water withdrawal from the natural water, raw water use and wastewater discharges.

Over the past 27 years, the population of Ukraine and the production of goods and services have dropped significantly, which led to a significant decrease in water consumption (from 30 bn m^3 in 1990 to <6.9 bn m^3 in 2017) and wastewater discharge in various sectors of the economy (from 20 bn m^3 in the 1990s to 4,9 bn m^3 in 2017).

However, there is no corresponding improvement in the quality of water resources, on the contrary, there are negative trends in the increase of the water deficit due to pollution and depletion of water resources, degradation of water ecosystems and the background of the negative effects of climate change.

Problems are increasing with regard to ensure an access of the population to water objects and safe drinking water. One of the key reasons for the current situation is the ineffective management system in the field of water conservation and reproduction, rational use of water resources and the development of water management and land reclamation.

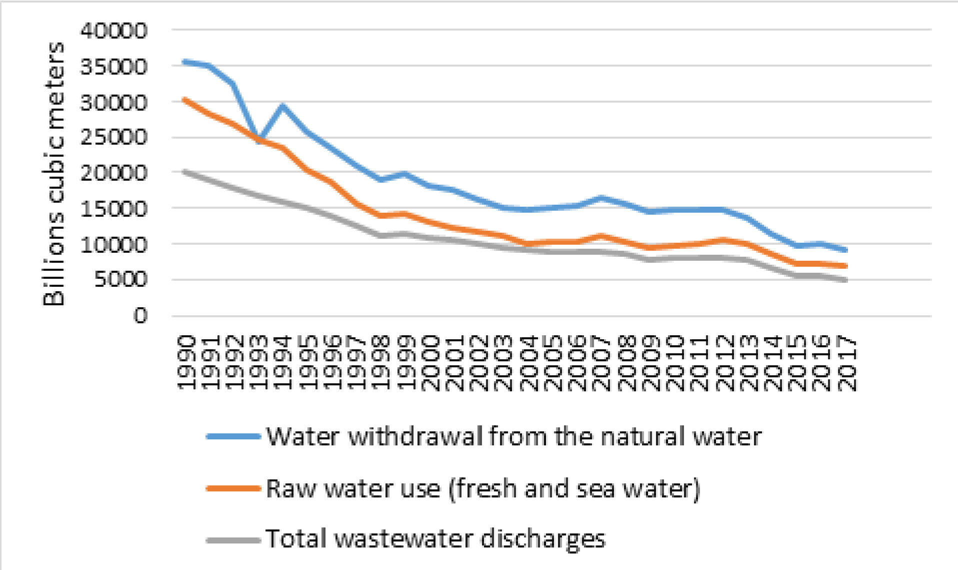


Figure 4.8. Water withdrawal from the natural water, raw water use and wastewater discharges after the data of the State Agency of Water Resources of Ukraine

Data exclude the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and a part of temporarily occupied territories in the Donetsk and Luhansk regions.

The structure of water resources use in Ukraine is as follows: 57% - industry, 22.6% - agriculture (irrigation), 17% - utilities (SAWR of Ukraine, 2017).

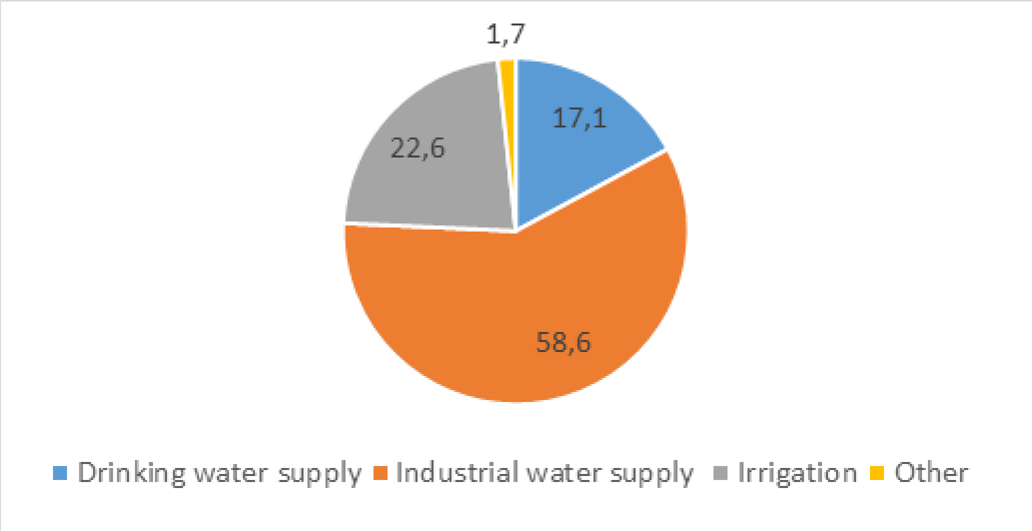


Figure 4.9. Structure of water consumption in Ukraine
(SAWR of Ukraine, 2017)

Water supply and sewage water treatment

Potable and industrial water supply. In Ukraine, sources of water are surface water bodies (rivers, lakes, reservoirs) for centralized water supply systems and groundwater.

In 2017, 9224 million m3 of water was withdrawn from natural resources (fresh water - 8635 million m3), of which 1178 million m3 came from underground water sources, including 315.9 million m3 of mining and quarry water. The largest amount of water was taken in Dnipropetrovsk (1033 million m3), Donetsk (1458 million m3), Zaporizhzhya (1218 million m3), Kherson (1727 million m3), Odesa (666.4 million m3) regions and in city of Kyiv (542.5 million m3), which account for 72% of the total volume of water withdrawal.

As for basins, the largest amount of water was withdrawn in the Dnipro basin - 6049 million m3, the Siversky Donets - 975.3 million m3, the Southern Bug - 287.3 million m3 and the Dniester - 463.4 million m3.

As for sectoral section in 2017, the main consumers are industrial enterprises, which withdraw 3577 million m3 of water, or 38.78% of water from the total withdrawal in the country (including the largest of them: thermal power plants, nuclear power plants, enterprises of ferrous metallurgy and coal industry), agriculture - 3206 million m3 (34.76%) and municipal services - 2397 million m3 (25.99%).

In general, the use of fresh water in 2017 for various needs amounted to 6284 million m3, of which drinking water reached 1642 million m3; technical water - 4642 million m3. About 430.9 million m3 water of drinking quality was used for production needs, of which 139.1 million m3 came from communal water pipes (i.e., it was water specially prepared for drinking quality) (National Report, 2018).

About 80% of the water demand is covered by surface water. About 35 million people (74% of the population) use the water resources of the Dnipro (ÖGUT, 2006). In small towns and rural areas private wells and springs are used as local drinking water reserves, often with unknown or lacking quality. The spatial distribution the water reserves does not necessarily correspond to the needs, in particular in the southeastern regions, therefore, there are regularly shortages (Modernisierungsstrategie, 2013).

The quality for the sources of underground water supply has significantly deteriorated during their exploitation period (mostly 35-40 years), and today only 57% of them meet the requirements of sources of the first class in accordance with All-Union State Standard 2761-84 "Sources of centralized domestic drinking water supply", 36% meet the requirements of the 2nd grade, and the remainder 7% - of the 3rd class. The situation with the superficial sources of water supply looks worse: none of them meets the requirements of the 1st class today.

All underground sources and the vast majority of surface sources during design and construction belonged to the 1st class and were designed for one type of water treatment in order to bring the water quality to the requirements of All-Union State Standard 2874-82 “Drinking Water”. Now, when the quality of water supply sources (especially of the surface ones) has deteriorated significantly, in order to bring water to the requirements of the standard, appropriate additional measures need to be implemented, namely either to change the technology of water purification or to use new reagents. All this requires require significant additional efforts and additional investment (Gipp, 2016).

Practically all surface and ground water resources are polluted. Key pollutants include nitrogen and phosphorus, organic substances, which are exposed to light oxidation, pesticides, oil products, heavy metals, and phenols. The main causes of surface water pollution are the discharge of contaminated municipal and industrial waste water directly into the water body or through the sewage system; polluted runoff water from built up areas and farmland; and soil erosion in water recharge areas. Donetsk, Dnipropetrovsk, Luhansk, and Odesa regions account for approximately 75% of all discharges into surface waters. Key sectors contributing to discharge of polluted waters are industrial enterprises (894 million cubic meters), followed by housing and the communal sector (538 million cubic meters), and the agricultural sector (71 million cubic meters). Due to the low quality of wastewater treatment, wastewater flow of contaminated surface reservoirs is not reduced (Modernisierungsstrategie,2013).

The treatment of the drinking water is predominantly by mechanical processes (Sedimentation, sand filter) followed by chlorination. The pipeline network is outdated, high turbidity levels are a common phenomenon, as well quality fluctuations during the day.

Depending on the quality of water supply sources, in 2017, before supplying to consumers, water was subjected to 100% disinfection in 3 regions (Lviv, Ivano-Frankivsk, Chernivtsi) and in the city of Kiev; in 7 regions disinfection was in the range from 90 to 98%; in 7 regions it was from 70 to 85%; in 5 regions from 43 to 70%; in 2 regions (Sumy and Chernihiv) water was not disinfected (National report, 2018).

For transportation of water, transportation and distribution systems are used. They include pumping stations, water pipes and distribution networks.

In 2017, centralized water supply provided 93,3% of urban water needs and 30% of rural water needs. A considerable part of settlements, especially in the arid steppe zone, is provided with water for drinking purposes by means of delivery by automobile transport. In this way, water supply is carried out in 10 oblasts: in Zaporizhzhya 21.4% of settlements and 2.6% of the population; Dnipropetrovsk - 20 and 1.8%; Mykolayivska - 17 and 5.6%, Odesa - 11.9 and 1.8%; Lviv - 3 and 0.5%; Kirovogradska - 2,2% and 5,3%; Donetsk - 2.1 and 0.6%; Poltava - 0.4 and 0.1%; Kherson - by 0.3%; Ivano-Frankivsk - 0.25 and 0.08%, respectively.
180 000 km of pipelines are used for water supply. Water supply system is up to 70% the total value of water supply assets. 30% of pipelines, especially street pipelines, are in an emergency. The overwhelming majority (47%) are cast-iron pipes, almost the same (41%) is the share of networks of steel pipes. Water pipes are made of asbestos cement (5% of the total length of networks), polyvinyl chloride and polyethylene (3%) and reinforced concrete pipes (2%) (Gipp, 2016). In this case, 24% of all networks have served their lifetime, since they have been operating for more than 30 years. This is primarily water pipes made of steel and asbestos cement pipes. The deteriorated

condition of steel pipelines is evidenced by the indicators of their high accident rate. With an average accident rate of water pipelines in 116 accidents per 100 km per year, the accident rate of steel water pipes is more than three times higher than this figure (367 accidents per 100 km per year).

The largest share of outdated and emergency water supply networks in 2017 was in Donetsk and Luhansk regions - 72.3 and 60.5%, respectively. In the Lviv region, this figure was 49.9%, Kirovohrad - 49.5%, Volyn - 47%; Kharkiv region - 44.3%, Dnipro city - 43.7%, Kyiv city - 43.5%. (National Report, 2018). Morgner (Morgner,2010) estimates that 31.5% of the entire water supply network, which corresponds to approximately 67.4 thousand km in Ukraine should be replaced.

In the last 15 years, there has been a steady trend towards a decrease in water consumption (by 35%) and an increase in water losses (from 16% to 45%, and sometimes even more).

Water losses in water supply systems providing drinking and household needs of the population amounted to 748.05 million cubic meters of water or 35.78% in 2017 from the total water withdrawal.

From the pumping capacity of the first level, 25-40% of assets are required to be repaired, and out of all current water treatment capacity, 40% of assets need to be repaired. The number of annual failures of the pipeline network of water supply is 1-4 breakdowns per kilometer, which is more than 5 times higher than in Western Europe. The average leakage and technical use of water is 30%, and in some networks, it reaches 50%.

Loss of water in urban networks is very high - about 10-70 m3 / km / day, in comparison with 2-10 m3 / km / day in Western Europe. The number of accidents in sewer pipelines is 1.4 per kilometer annually, the level of infiltration is 20%. Losses consist of leaks from water pipes, distribution and intra-city networks and unaccounted water consumption. The leaks from the water pipes and distribution networks make up to 20% (from total losses) on average, and the remaining water losses are due to leakage from the interior systems (plumbing devices and pipelines) and the lack of water supply accounting by individual appliances.

Household water consumption is significantly higher in Ukraine than in others EU countries. Sample surveys yielded an average of 27 cities Water consumption (average) of 275 l per person per day, standard deviation - 64, maximum consumption - 422 l, minimum consumption -173 l) In the EU states the consumption values are between approx. 100 - 200 l per person per day (Poland: 100 l, Germany 122 l, France 164 l per person and day (Dreberis,2008).

All water supply systems of cities have rather high indicators of specific energy consumption and low efficiency of pump units.
Significant parts of pumping units that have been operating for 25-30 years, due to wear and mismatch with the actual needs of the system, operate with an efficiency of 25-45%, which results in excess energy consumption. Energy consumption is 20-50% more than planned. The share of highly efficient pumping units with a efficiency of 84-88%, is not more than 10% of their total (Gipp, 2016).

Waste water treatment and transportation. According to the data of the state registration of water use in 2017, surface water objects have been thrown to 4715 million m3 of sewage, including: 2785 million m3 by enterprises of industry, 1510 mln m3 by housing and communal sector 355.5 mln m3 by enterprises of agriculture (See figure 1 for details). Out of the total amount of wastewater discharged to the water bodies, the contaminated water reached 997.3 million m3

(21,15%), the regulatory cleared - 1023 million m3 (21.7%), standard clean without clearing - 2550 million m3 (54.08%) and mining and quarry water - 144.7 million m3 (3%) (National Report, 2018).

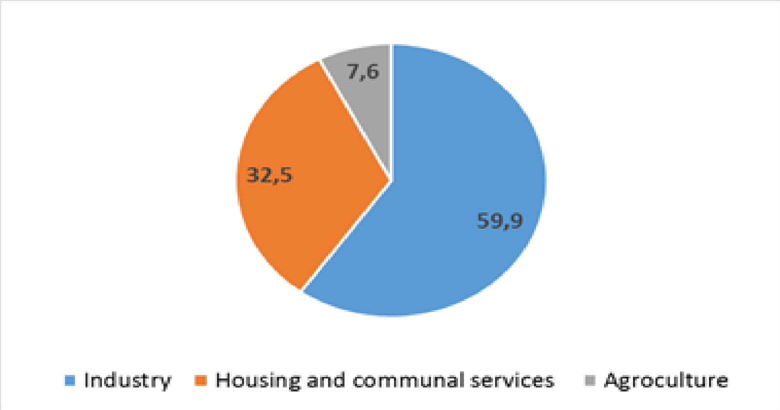


Figure 4.10. Structure of waste water discharged to a receiving water body in Ukraine

Territory wise, the most polluted wastewater is disposed off in Dnipropetrovsk region (230.3 million m3, which is 37.3% of the total volume of discharges in the region), Donetsk region (199.4 million m3, which is 24, 9% of the total volume of discharges in the region), Zaporizhzhya region (64.17 million m3, which is 6.7% of the total volume of discharges in the region), Lviv region (70.81 million cubic meters, which is 42.25% of the total volume of discharges in the region) and in the city of Kyiv (284.3 million m3, which is 52.4% of the total amount of discharges in the city).

In 2017, the largest polluters were enterprises of the housing and communal sector, which dumped 607.5 million m3 of contaminated wastewater.

Industrial enterprises dumped 311.1 million m3 of contaminated wastewater, of which the largest pollutants are ferrous metallurgy enterprises (278.3 million m3) and the chemical industry (12.77 million m3), and agricultural enterprises dumped 28.9 million m3 of contaminated wastewater.

In terms of basins, the volume of discharges of polluted waste water is distributed in the following order: in the Dnipro basin - 628.6 million m3, in the Western Bug - 64,0 million m3, in Siversky Donets - 41.9 million m3, in the Danube - 24.7 million m3, in Dniester - 20.1 million m3, in Southern Bug - 4.2 million m3. (National Report, 2018).

The discharge of polluted municipal and industrial waste water directly into water bodies and through the system of city sewage, as well as access to water bodies of pollutants in the process of surface runoff of water from built-up areas and agricultural lands is the main cause of pollution of surface water.

The quality of surface water is negatively affected by the discharges of mine and quarry waters, which, being without purification, are discharged into surface water bodies in the volume of 228.2 million m^3. (National Report, 2018). Mining covers about 22,500 ha of land of Ukraine (Modernisierungsstrategie, 2013).

This often changes the hydrology of the area associated with local drinking water and environmental problems.

Many mine closures are another problem. Responsibilities are not sufficiently clarified for resulting environmental damage such the contamination of drinking water or surface water. Funds generated by the government for the rehabilitation of such mines and mine effluents are usually sufficient only for a first initial rehabilitation during the decommissioning of the mine. Currently, due to improper water treatments more than 1 million tonnes of mineral salts entered into rivers, only half of the used mine water is prepared for reuse.

Extrapolations of the Ukrainian government for improvement measures the mine effluents have a financial requirement of 46 to $ 48 million a year (OECD, 2006). For the transport of sewage, centralized sewage systems are used, which consist of street networks, main collectors, pumping stations and pressure pipelines. The bulk of the existing drainage systems of cities was built 30-40 years ago.

The accident rate for sewage networks in Ukraine is an average of 300 accidents per 100 km per year (Gipp, 2016).More than 90% of obsolete pumping equipment needs to be replaced today. Its efficiency is low, caving capacity often 2-3 times, and sometimes 5-6 times higher than the needs, the use of electricity is 20-50% higher than the optimal use.

Waste Water Treatment Plants (WWTP) were built mainly in the 1960's and 1980's. Technologies of purification include mechanical and biological treatment of wastewater and treatment of sediment at the sludge sites, partly applied technologies of biological treatment of wastewater in the natural environment, on the fields of filtration. The main indicator of the quality of wastewater treatment is BOC20 (biological oxygen consumption). The efficacy of sewage treatment on the WWTP in BOC20 is not high enough and often does not meet the acting requirements in Ukraine ("Regulations on sewage acceptance of enterprises and departmental sewage systems of settlements of Ukraine", approved by the Order of the State Building Committee of Ukraine, №37, dated 19.02.2002).

In 2017, 20.84 thousand tons of suspended solids, 259.1 tons of oil products, 5.98 tons of ammonia nitrogen, 46.98 thousand tons of nitrates, 1.65 thousand tons of waste water tons of nitrites, 195.0 tons of spar, 422.4 tons of iron, 4552.0 tons of phosphates were disposed off in surface water bodies of Ukraine. (National report, 2018).

One of the most powerful WWTP in Ukraine is Bortnychi Waste Water Treatment Plant (see Fig 4.11.), which provides wastewater treatment for Kiev and 15 satellite towns and villages in the Kiev region. Every day at Bortnychi station there are almost 1 million tons of sewage, about 10 tons of garbage are collected, which after processing turns into 3 thousand tons of crude sediment. The current sewage treatment process involves the transportation of sediment for storage on silt fields that occupy an area of over 272 hectares. The sediment has been accumulated there for decades, the capacity of the fields has already been tripled. In addition, it is a constant emitter of greenhouse gases, in particular, CO_2 and CH_4 to the atmosphere.

Figure 4.11. View of Bortnychi Waste Water Treatment Plant

Wastewater treatment accounts for 43% of Ukraine's current environmental expenditures during 2010-2013, which puts it at highest category of expenditure. This is in addition to the 6% expenditure for the protection and rehabilitation of soil, and of ground and surface waters. However, it should be noted that a large proportion (65% nationally) covers operational costs, which may indicate under-investment in key wastewater collection and treatment infrastructure. (Ukraine Country Environmental Analysis, 2016).

Main reasons for the unsatisfactory state of wastewater transportation systems are:

- The significant reduction of wastewater (and primarily due to reduction of water consumption by industrial enterprises), which requires revision of drainage schemes and pumping equipment capacities;
- the overwhelming number of sewage accidents (80-95%) are congestions, caused by a decrease in the amount of wastewater entering the gravity collectors, which leads to a decrease in the flow rate of drains and causes silting of the networks;
- the restoration of collector throughput requires modern machines and mechanisms for the maintenance of sewage networks (See figure 4.12.);
- lack of funds for the timely replacement of worn pumping equipment and bringing it in line with the hydraulic needs of the system;
- a significant share of sewage networks is made from the steel low quality pipes without internal insulation and asbestos cement pipes;
- wear of a large part of sewer networks.
- The drainage of sewage networks makes Ukrainian cities vulnerable to climatic changes, as the number of storm rainfall has increased in recent years, leading to city emergencies and large economic losses (See Figure 4.13.).

Figure 4.12. Manual cleaning of collectors of municipal drainage rainwater system during flash flood after heavy rainfall in Kyiv,18 August 2018. Photo by Vladimir Bugaenko.

Figure 4.13. Flash flood after heavy rainfall in Kyiv,18 August 2018.
Photo by Vladimir Bugaenko.

In order to improve existing water supply and waste water technologies in Ukraine, it is necessary to review the water supply schemes, to determine the real demand for water, the necessary capacity of the pumping equipment, to distribute water flows and optimize the pressure in the distribution network. Implementation of this measure will enable, first of all, to reduce water losses in the system, reduce the actual volumes of its supply, and, consequently, pumping, and reduce leakage from internal systems of buildings.

An important priority is to replace the outdated and physically worn pumping equipment with modern (with high efficiency), according to the needs of the system. This will make it possible to optimize the pressure in the distribution network, reduce water consumption and leakage from internal systems of buildings, reduce the network accidents, and this together will reduce the energy consumption of the water supply system.

An important priority is the improvement of the quality of drinking water through the reconstruction of water treatment plants with the introduction of the latest technologies that will ensure the bringing of raw water to the requirements of All-Utilities State Standard 2874-82 "Drinking Water"; introduction of strict control over zones of sanitary protection of water intakes; replacement of emergency pipelines, which will reduce the secondary pollution of water.

To reduce the negative impact of WWTP on the environment (discharges of undertreated wastewater into surface water bodies, infiltration of toxic substances in groundwater in places where sludge sites are located, excess greenhouse gas emissions, etc.), replacement of old aeration systems with new modern systems, equipment enterprises by modern machines and mechanisms. This will make it possible to reduce the amount of congestion on the gravity collectors, reduce the time for the elimination of accidents, improve the state of the environment. Improvement of the processes of wastewater treatment and treatment of sediment, the restoration of equipment, separate technological facilities and complexes, the installation of appropriate control equipment will contribute to reducing the negative impact on the environment due to the improvement of the quality of wastewater after the WWTP and the reduction of areas under the mud grounds (which is currently a very acute the problem).

To a large extent, to solve this issue, the Directive 91/271/EEC dated the 25 May 1991 "On urban wastewater treatment" will be implemented. In order to comply with the requirements of EU legislation in the field of drainage, the Ministry of Regional Development developed a draft Law of Ukraine "On wastewater and wastewater treatment of settlements" (2017-2018).

Flood hazards. Flood-prone regions of Ukraine are located in a. in the environment of different Carpathian inflows in the Dniester, in the area of some Danube tributaries as well Tributaries of the Prypyat (Dnipro) in the northwest of the country (ICPDR,2005; ICPDR,2011).

Within the last 20 years, in Ukraine, significant floods that have led to emergencies have been observed in 1995, 1998, 2001, 2008, 2010. Annual average flood losses in 1995-1998 amounted to more than UAH 900 million, in 1999-2007 more than UAH 1.5 billion, in 2008-2010 - about UAH 6 billion.

Within the scope of various transnational cooperations were for some flood-prone river basins already started, strategies for a cost-efficient flood protection and forecasts as well as early warning systems to work out. This concerns partial catchment areas of the Danube (Tizsa, Tysa, Siret and Prut) or tributaries of the Dnister (ICPDR, (2011).

To reduce flood damage, various technologies for managing water resources are used to reduce surface runoff (use of watertight road coverings, forest plantations, use of water storage basins, wetlands, reservoirs); to increase the transport capacity of rivers (construction of bypass channels, deepening or expansion of the river bed), to strengthen dams.

Significant role is played by flood monitoring, flood forecasting, early warning of flood situation development. In the Transcarpathian region there is an automated information and measurement system for flood forecasting and water resources management in the Tisza River Basin (AIVS-Tisza), which was created jointly by the Ukrainian-Hungarian parties and started operation in 2000.
To date, the construction of a complex of three flood water reservoirs in the upper reaches of the Dniester (Lviv region) is completed, totaling about 160 million m3. Such an anti-flood complex will allow during periods of high floods, repeat once every 100 years, to reduce maximum volumes of water, due to redistribution of runoff by its accumulation in flood reservoirs and polder systems. Water level of the Dniester River at high floods will be reduced by two meters.

To implementat the Association Agreement between Ukraine on the one hand and the European Union on the other hand, one of the priorities of the environmental policy of Ukraine is the harmonization of the water legislation of Ukraine with the EU legislation, in particular, with Directive No. 2000/60 / EC "On the establishment of the Community framework for activities in the field of water policy "(Water Framework Directive, WFD) and Directive 2007/60 / EC" On Flood Assessment and Management "(Flood Directive), the main principles of which are the implementation of an integrated basin water management model and flood management.

Hydrological drought and irrigation. Due to the favorable combination of temperate climate and fertile soils, Ukraine is one of the main agricultural regions of Eastern Europe. However, its territory is under the influence of large-scale circulatory systems, which leads to long periods with a shortage of precipitation, resulting in droughts. Increased air temperature and uneven distribution of storm precipitation, and localized heavy rainfall in the warm season, which does not provide an effective accumulation of moisture in the soil can cause the increased incidence and intensity of droughts (Balabukh,2016).

Drought is a complex phenomenon caused by a lengthy and significant deficit of precipitation accompanied by elevated air temperatures during the warm period of the year resulting in the depletion of water stock through evaporation and transpiration. Accordingly, long-term droughts reduce flow of rivers (hydrological droughts) and surface water supply.

In the last decade, the repetition and the duration of hot weather periods in Ukraine increased significantly. They have name “heat waves”(HW) and are generally associated with quasi-stationary anticyclonic circulation anomalies, which produce subsidence, clear skies, warm-air advection and prolonged hot conditions in the near-surface atmosphere. HW have significant impacts on well-being, efficiency and health of humans, which can lead to marked short-term increases of morbidity and mortality, particularly in cities, where most humans are living. The total impact of a HW does leads to losses in economic sectors like agriculture, water or forestry and health sector Shevchenko,2013).
The efficiency of agricultural production in Ukraine depends on the level of use of land and water resources. The area of irrigated land is 2.2 million hectares. The main part of them is located in the Steppe zone - 2.1 million hectares (80%); in the zone of Forest-steppe 356 thousand hectares are irrigated, in Polissya - 11 thousand hectares.

Since 1991, the area of dry and very dry zone has increased by 7%. Today it covers almost one third of the territory, including 11.6 million hectares of arable land. At the same time, the area with excessive and sufficient atmospheric humidification has decreased by 10%, occupying only 7.6 million hectares of arable land. Permanent irrigation is required almost at 19 million hectares of arable land, and water management at 4.8 million hectares.

According to forecasts, further climate change will worsen the conditions of natural moisture supply. As a result, the role of irrigation and drainage in the production of agricultural products will only increase. In order to improve water supply in Ukraine, more than 1160 reservoirs with a total volume of about 55 km^3 have been created, as well as the network of main canals (more than 1000 km) and water conduits (more than 2000 km). This allows redistribution of 3 km3 and 12 km3 of water per year accordingly.
Every year, about 11 km3 of water is supplied for the needs of the households and sectors of the economy, including about 2 km3 for agriculture. Such a volume of water intake is only one third of the level of maximum water intake, which was in Soviet times (35 km3 in 1990).

Climate change has a significant effect on the dynamics of agrarian production in Ukraine, because neither modern technologies nor the latest hybrids provide efficient crop production when there is lack of water.

At present, the state of reclamation agriculture judging by the level of utilization of the available capacity of the engineering infrastructure of irrigation and drainage is estimated as a crisis one, with the subsequent threat of deterioration. The payments for irrigation and water management services are not sufficient for the proper operation of the inter-farm network of irrigation and drainage systems. Due to the lack of funds, the state is unable to provide adequate funding. As a result, there is a progressive deterioration of the technical state of the inter-enterprise network, which creates a real threat of its destruction. The only way out of this situation is to use a powerful water-reclamation complex, which was built in Soviet times. Previously, it provided irrigation on the area of 2.65 million hectares and drainage on an area of 3.3 million hectares, and today it is no longer capable of playing its role.

The unsatisfactory use of the existing potential for irrigation and drainage was due to a number of problems: incomplete reform of economic relations, privatization, loss of agricultural products markets, imperfect state support mechanisms, inconsistencies of the existing management system and water use management with new conditions.

The total budget of the State Agency of Water Resources of Ukraine is about UAH 2 billion annually, of which 80% is attributed to irrigation and drainage. Half of these costs are financed by the state, the rest is financed by water users. At the same time, the share of expenditures from the state budget essentially depends on the state of use of the existing engineering infrastructure: it ranges from UAH 438/ha in Kherson region (where almost 69% of the irrigated area is watered) to UAH 2594/ha in Odesa region (where watering is carried out only on 17.8% of the area of irrigated land) (Pavlenko, 2016).

4.4 Adaptation Technology Options for Water Sector and Their Main Adaptation benefits

Based on consultants' expertise, the following technologies were selected as those helping to adapt water sector of Ukraine to climate change:

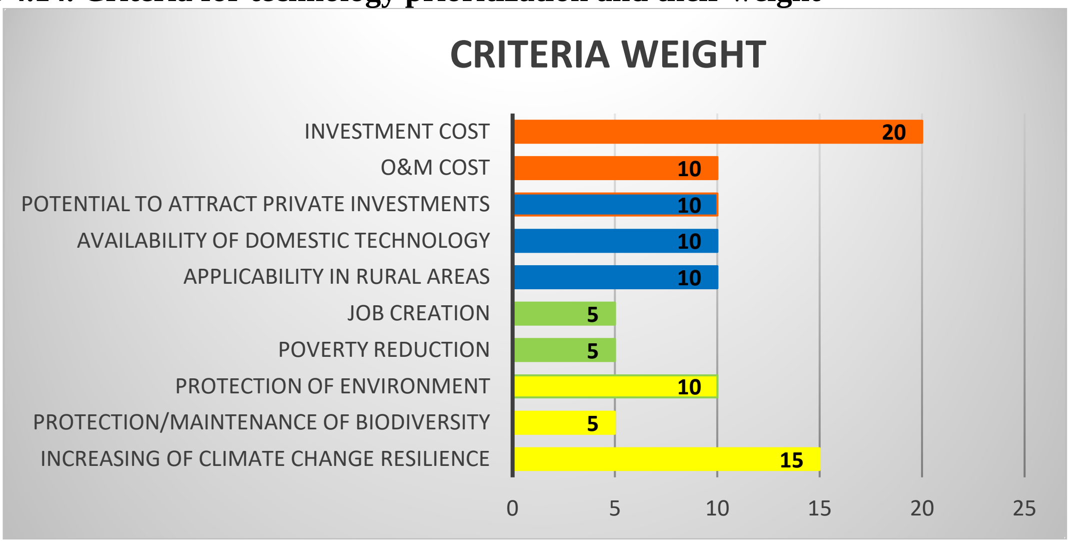
1) Drought risk assessment and mapping;
2) Flood hazard assessment and mapping;
3) Urban green spaces;
4) Source water protection;
5) Efficient irrigation;
6) Reducing system water loss and leakages;
7) Public water conservation campaigns;
8) Ecological river restoration;
9) Precision agriculture;
10) Climate-smart irrigation;
11) Advanced sewage wastewater treatment.

Technologies 9 and 10 are included in the list of technologies of adaptation in water sector, because they are very relevant to the water sector: the more precisely the nutrients are used, the less amount of those come to water bodies. The same applies to climate-smart irrigation, as it helps more justified use of water and water withdrawal.
Experts were familiarized not only with this list of technologies, but also with description of each technology based on developed TFS.

4.5 Criteria and process of technology prioritization

Criteria for technology prioritization include costs, economic, social, environmental and climate related. The detailed division of criteria is presented in Figure 4.14.

Figure 4.14. Criteria for technology prioritization and their weight



The criterion of climate relation, in particular enabling climate change resilience has been considered especially important, receiving 15% of weight within its category, as it helps to reduce vulnerability to climate change and this criteria corresponds to the main objective of the study. None of the technologies mentioned above presume adverse impact, i.e. they bring social, economic and environmental benefits.

Criteria “Investment cost” and “O&M cost” represent the cost parameters of technologies. The preliminary weighting of criteria has been conducted by consultants and project Coordinator. The weights criteria assessment will be carried out by stakeholders (having examined the technologies description). The obtained weights will used to conduct sensitivity analysis.

The highest weights were assigned to the cost and climate-related characteristics of technologies. “Potential to attract private investments”, “Availability of domestic technologies”, “Applicability in rural areas”, “Protection of environment” each obtained 10% of weight. “Job creation”, “poverty reduction” and “maintenance of biodiversity” follow.

The technology’s description, as well as additional information, have been sent to experts to conduct their evaluation. 10 experts have evaluated the presented 11 technologies based on their expertise, knowledge of the assessed technologies and provided supplementary material.

4.6 Results of technology prioritisation

The result of technology prioritisation is provided in Tables 4.2 and 4.3, so that “winning” technologies are “climate-smart irrigation”, “drought risk assessment and mapping” and “flood hazard assessment and mapping”.

Table 4.2. Ranking of water sector technologies

Rank	Technology option	Score
1	Climate-smart irrigation	66280
2	Drought risk assessment and mapping	65540
3	Flood hazard assessment and mapping	62120
4	Precision agriculture	61515
5	Public water conservation campaigns	60720
6	Efficient irrigation	59935
7	Ecological river restoration	58045
8	Source water protection	54410
9	Urban green spaces	52620
10	Reducing system water loss and leakages	49525
11	Advanced sewage wastewater treatment	46035

Table 4.3 Short list of prioritized technologies

Rank	Technology option

1	Climate-smart irrigation
2	Drought risk assessment and mapping
3	Flood hazard assessment and mapping

The technologies mentioned in Table 4.3 will be further analyzed, in particular, barriers for their commercialization will be defined. The short description of all selected technologies represented in the Technological Fact Sheets, Annex II.

Chapter 5 Summary and Conclusions

Ukraine is an important player on the world food market due to its vast farmland. Based on the the historical climate data, it is obvious that Ukraine is already experiencing the rise in temperature , and climate forecasts suggest further warming, especially in southern Ukraine.

Further crop production is threatened by climate change, which leads to changes in temperature, changes in rainfall patterns and more frequent extreme weather events. Drought and flood will often occur and will become more intense in nature. It is therefore urgent to understand the agriculture technological potential of adaptation to climate change.

Under the first stage conducting a TNA in Ukraine, the technologies were prioritized for agriculture adaptation to climate change.

The leading three technologies ("Drip irrigation in combination with conservation agriculture practices", "Agroforestry practices (shelterbelt reconstruction)","Integrated Pest and Disease Management") do not have a significant break with the fourth one (agrometeorological early warning system) and may be recommended for further assessment.

It is crucial to notice that the first three technologies are enough represented on the local market and recent highly demanded while fourth technology (development of AEWS) requires to be developed. However, the Ukrainian customers (market) already open to the implementation of the AEWS technology. Which makes it most promising for the nearest future.

The technologies placed on the 5,6,7 and 8 positions ("Interactive Integrated Land Management Maps", " Agricultural Credit Unions Net", "Seed Bank", and " Improving agricultural production sustainability on complex landscapes") do not have a significant gap in scoring. The main characteristic of this group is three technologies almost do not represent in Ukraine and do not have the appropriate legislation environment for implementation.

Thus, implementation of these technologies would require to strengthen the policy framework through the development of supporting strategies, laws, regulations, other documents to speed up the deployment of these technologies. As the further, the development of TAPs will be focused on on the implementation of strengthing their capacity. Otherwise, if these technologies have no political -regulatory framework, they will contravene to country’s laws that will impede their deployment.

Ukraine has committed to implement policies and measures aimed at combating the climate change. Activities related to adaptation in the context of climate change are already being implemented in the framework of national and state programs, national and regional programs and plans.

Despite the fact that in the past 27 years, the population of Ukraine and the production of goods and services have dropped significantly, which led to a significant decrease in water consumption and wastewater discharge in various sectors of the economy, there is no corresponding improvement in the quality of water resources, on the contrary, there are negative trends in the increase of the water deficit due to pollution and depletion of water resources, degradation of water ecosystems and the background of the negative effects of climate change.

There are technologies in water sector that are already in use. The most common technologies includes water extraction, waste water treatment, transportation by pipelines and distribution. Less common ones include formation of flood protection areas and forecasts and irrigation (as a measure to fight drought).

Eleven technologies were selected as those helping to adapt water sector of Ukraine to climate change. Criteria for technology prioritisation include costs (investment cost and O&M cost), economic (potential to attract private investments and availability of domestic technologies), social (applicability in rural areas, job creation, poverty reduction), environmental (protection of environment, maintenance of biodiversity) and climate related (enabling climate change resilience).

As a result of technology prioritization, the “winning” technologies are “climate-smart irrigation”, “drought risk assessment and mapping” and “flood hazard assessment and mapping”.

List of References

Adamenko T. I., Demydenko A. O., Romashchenko M. I., Tsvietkova A. M., Shevchenko A. M., Yatsyuk M. V. Rethinking of Water Security for Ukraine based on results of National Policy Dialogue. Global Water Partnership. Kyiv.2016. – 20 p. Avalible online at: https://www.gwp.org/globalassets/global/gwp-cee_files/regional/rethinking-water-security-ukraine-2016.pdf

Alcamo J., Moreno J.M., Nováky B., Bindi M., Corobov R., Devoy R.J.N., Giannakopoulos C., Martin E., Olesen J.E., Shvidenko A., 2007: Europe. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 541-580.

AQUASTAT—FAO's Information System on Water and Agriculture. Available online: http://www.fao.org/ nr/water/aquastat/countries_regions/UKR/index.stm (accessed on 3 September 2016).

Balabukh, V. 2016 Зміна інтенсивності конвекції вУкраїні: причини та наслідки. [Electronic resource]. Available from:http://meteo. gov.ua/files/content/docs/Vinnitsa/UkrGMI.pdf

Baluk S.A. Ukraine's soil resources: the state and measures to improve them. Bulletin of Agrarian Science.2010. http://agrovisnyk.com/oldpdf/visnyk_05_2013.pdf

Bär, R.; Rouholahnejad, E.; Rahman, K.; Abbaspour, K.C.; Lehmann, A. Climate change and agricultural water resources: A vulnerability assessment of the Black Sea catchment. Environ. Sci. Policy 2015, 46, 57–69.

Bates, B.C.; Kundzewicz, Z.W.; Wu, S.; Palutikof, J.P. Climate Change and Water; Technical Paper of the Intergovernmental Panel on Climate Change; IPCC Secretariat: Geneva, Switzerland, 2008.Water 2017, 9, 204.

Boshok, Y. V. Річний та меженний стік річок північно-західного Причорномор'я в умовах змін клімату. Дисертація на здобуття наук ступеня к. геогр. н. Одеса: 2015. - 300 с.

Buksha, I.; Gozhik, P.; Iemekianova, Z.; Trifimova, I.; Shereshevskiy, A. Ukraine and Global Greenhouse Effect. Book 2. Vulnerability and Adaptation Ecological and Economical Systems to Climate Change; Agency for Rational Energy and Ecology Use: Kyiv, Ukraine, 1998. (In Ukrainian)

Cisneros, J.; Oki, T.; Arnell, N.W.; Benito, G.; Cogley, J.G.; Döll, P.; Jiang, T.; Mwakalila, S.S. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge Univ. Press: Cambridge, UK, 2014; pp. 229–269.

Climate Change Post. Climate Adaptation. Available online at: http://www.climatechnagepost.com.

Concept of scientific, technological and innovative development of Ukraine. 1999. https://zakon.rada.gov.ua/laws/show/916-14

De Groot, J. Guidance for a gender-responsive Technology Needs Assessment. 2018. Available from: https://www.ctc-n.org/sites/www.ctc-n.org/files/resources/web_tna_gender_guidebook-01.pdf ISBN: 978-87 93458-39-0

Decree of the Cabinet of Ministers of Ukraine. "On Approval of the Concept for the Implementation of the State Policy in the Field of Climate Change for the Period until 2030".No. 932-r. December 7, 2016.

Didovets I., Krysanova V., Burger G., Snizhko S., Balabukh V., Bronstert A. Climate change impact on regional floods in the Carpathian region. Journal of Hydrology: Regional Studies 22 (2019). 100590

Didovets I., Lobanova A., Bronstert A., Snizhko S, Fox Maule C, Krysanova V. 2017.Assessment of Climate Change Impacts on Water Resources in Three Representative Ukrainian Catchments Using Eco-Hydrological Modelling. Water, 9, 204; doi:10.3390/w9030204

Dreberis:DBU Abschlussbericht, Bericht. 2008. Available from: http://www.dbu.de/OPAC/ab/DBU-abschlussbericht-AZ-24862.pdf.

EBRD, 2016. Ukraine Country Environmental Analysis. The International Bank for Reconstruction and Development. Report No: ACS16696

EC, 2000. European Commission The EU Water Framework Directive—Integrated River Basin Management for Europe. Available online: http://ec.europa.eu/environment/water/water-framework/index_en.html (accessed on 3 November 2016).

EC, 2012. Sustainable land use for the 21 century. DG for Environment, EC, May, 2012. - P. 81.

European fir is entitled to life in Polissya forests // The official site of the Chernihiv Regional Forestry and Hunting Management Department. – Available at: http://chernigivlis.gov.ua/yalina-yevropejska-maye-pravo-na-zhittya-v-poliskix-lisax/.

FAO, 2017. Tracking adaptation in agricultural sectors. Climate change adaptation indicators. Food and Agriculture Organization of the United Nations Rome, 2017http://www.fao.org/3/a-i8145e.pdf

FAO, EBRD, WB, 2014. Ukraine: Soil fertility to strengthen climate resilience: Preliminary assessment of the potential benefits of conservation agriculture: FAO / International Bank for Reconstruction and Development / The World Bank. Available online at: http://www.fao.org/3/a-i3905e.pdf.

Fischer, S.; Pluntke, T.; Pavlik, D.; Bernhofer, C. Hydrologic effects of climate change in a sub-basin of the Western Bug River, Western Ukraine. Environ. Earth Sci. 2014, 72, 4727–4744.

GGGI, Global Gender Gap Index.2017http://www3.weforum.org/docs/WEF_GGGR_2017.pdf

Gipp, T. Technical condition of systems of systems of centralized water supply and water drainage.2016. Available from:https://cleanwater.org.ua/tehnichnyj-stan-system-tsentralizovanoho-vodopostachannya-ta-vodovidvedennya/

Gorbachova, L. Hydrological and genetic analysis of spatio-temporal regularities of water flow of rivers in Ukraine: methodology, trends, forecast. Thesis for the degree of D.Geogr.Sc. K: 2017. - 400 p.

Hesse, C.; Stefanova, A.; Krysanova, V. Comparison of Water Flows in Four European Lagoon Catchments under a Set of Future Climate Scenarios. Water 2015, 7, 716–746. [CrossRef]

ICPDR, 2009. International Commission for the Protection of the Danube River. Flood Action Programme Prut-Siret Sub-basin. Vienna.

ICPDR: The Danube River Basin District. International Commission for the Protection of the Danube River (ICPDR) in cooperation with the countries of the Danube River Basin District. 2005. . Available from: http://www.icpdr.org).

ICPDR: Tisza River - the largest sub-basin of the Danube. 2011. Available from: http://www.icpdr.org/icpdr-pages/tisza_basin.htm.

II National Communication of Ukraine on Climate Change. Available online at: http://journal.esco.co.ua/2006_7/art064.pdf.

Impacts and Risks from High-End Scenarios: Strategies for Innovative Solutions. Available online: http://www.impressions-project.eu/

Kok, K.; Christensen,J.H.; Madsen,M.S.; Pedde,S.; Gramberger,M.; Jäger,J.; Carter,T. Evaluation of Existing Climate and Socio-Economic Scenarios Including a Detailed Description of the Final Selection. Available online: http://impressions-roject.eu/getatt.php?filename=attachme_12294.txt

Kovalets, I.V., Kivva, S., Udovenko, O.I., 2014. Usage of the WRF/DHSVM model chain for simulation of extreme floods in mountainous areas: a pilot study for the Uzh River Basin in the Ukrainian Carpathians. Nat. Hazard. https://doi.org/10.1007/s11069-014-1412-0.).

Kovats, R.S.; Valentini, R.; Bouwer, L.M.; Georgopoulou, E.; Jacob, D.; Martin, E.; Rounsevell, M.; Soussana, J.Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge Univ. Press:Cambridge, UK, 2014; pp. 1267–1326.

Krakovskaya S.V. at al., Report on research work on developing scenarios for changing the climatic conditions in Ukraine in the medium and long term period using global and regional models. UkrGMI 2013. -135 p. Access:https://uhmi.org.ua/project/rvndr/climate.pdf].

Krysanova, V.; Wechsung, F.; Arnold, J.; Ragavan, S.; Williams, J. 2000. SWIM (Soil and Water Integrated Model),User Manual; PIK Report Nr. 69: Potsdam, Germany.

Loboda, N.; Serbova, Z. Modelling of Climate Change Impact on the Rivers Flow of Ukraine. Impact Clim. Chang. Econ. Ukr. 2015, 1, 451–482. (In Ukrainian)
Medvedev V., Plisko I, Nakisko C., Titenko G.. World soil degradation: prevention and combating expiriance. Kharkiv. Spilna typofraphia, 2018 – 168 p.Naukova dumka. 283 p. (In Ukrainian)
MENR: Ukraine's greenhouse gas inventory 1990-2015. Kyiv. 2017.- 518 p.
Methods for the improvement of Vulnerability Assessment in Europe. Availible online at: https://cordis.europa.eu/project/rcn/88645/reporting/en.
Modernisierungsstrategie für die deutsche Wasserwirtschaft. Maßnahmen zur Stärkung der Präsenz der deutschen Wasserwirtschaft auf internationalen Markten fur Wasserdienstleistungen. 2013. UBA Texte 37,317.
Morgner M. Reformbedarf. Kommunale Selbstverwaltung in der Ukraine. Osteuropa. 2010. 60(2-4): 163-174
National Report on the Quality of Drinking Water and the State of Drinking Water Supply in Ukraine in 2017. – K.: , 2018. – 383 p.
Natural meteorological phenomena on the territory of Ukraine during the last twenty years (1985-2005) - K .: Nika-Center, 2006. - 312 p.
OECD, 2006: Legal Issues with regard to business operations and investments in Ukraine. 2006. 65 S.http://www.oecd.org/dataoecd/57/59/34514482.pdf
ÖGUT: Umwelttechnikmärkte in Russland, der Ukraine und Georgien Umweltpolitik, -strategien und -programme der Länder Russland Ukraine Georgien. 2006. Available from:http://www.oegut.at/downloads/pdf/ee-up5-end.pdf
Orlenko, O., Zhalilo. Ya., Trofimova, I. Countering Global Climate Change in the Context of the Kyoto Agreements: Ukrainian Dimension. – Kyiv: National Institute for Strategic Research, 2010. – 48 p.
Osadchyy, V., Babichenko, V. 2013. Dynamics of natural meteorological phenomena in Ukraine. Available online at: http://ukrgeojournal.org.ua/sites/default/files/UGJ-2012-4-08.pdf.
Pavlenko, O. 2016. Полити засушливий південь і заробити. Доступ: https://www.epravda.com.ua/columns/2016/01/14/576505
Pluntke, T.; Barfus, K.; Myknovych, A.; Bernhofer, K. Hydrologic Effects of Climate Change in the Western Bug Basin. In Proceedings of the Global and Regional Climate Changes, Kyiv, Ukraine, 16–19 November 2010.
Ryabchenko, O. The impact of climate change on the conditions of life in the rural areas of Ukraine. Problems of Small Agricultural Holdings . 2013. - №2. - P – 97-105.
SAWR of Ukraine, 2017. Data set. Available from:https://data.gov.ua/dataset/2054e342-fd89-4419-b130-685a9d042990/resource/dc9b2e95-5e6c-4053-839b-38d03931d4a4
Schneider, C.; Laizé, C.L.R.; Acreman, M.C.; Flörke, M. How will climate change modify river flow regimes in Europe? Hydrol. Earth Syst. Sci 2013, 17, 325–339.
SDGU, 2017. National Baseline Report «Sustainable Development Goals: Ukraine»http://un.org.ua/ua/publikatsii-ta-zvity/un-in-ukraine-publications/4203-2017-natsionalna-dopovid-tsili-staloho-rozvytku-ukraina-iaka-vyznachaie-bazovi-pokaznyky-dlia-dosiahnennia-tsilei-staloho-rozvytku-tssr
Shevchenko O. National climate vulnerability assessment: Ukraine / O.G. Shevchenko, O.Y. Vlasyuk, I.I. Stavchuk, M.V. Vakolyuk, O.E. Illyash. – Kyiv: Myflaer, 2014. – 62 p.
Shevchenko O., Lee H., Snizhko S., Mayer H. Long-term analysis of heat waves in Ukraine // International Journal of Climatology. – 2013. – Vol. 33, Issue 15. – P. 104–115.
Shevchenko O., Snizhko S., Vitrenko A. Economic meteorology. Kyiv: Mayster knyh. 2019. -352 c.(In Ukrainian)
Sidenko, V., Veklych, O. et al. Ukraine and policy of counteraction to climate change: the economic aspect / Analytical report. – Kyiv: Zapovit, 2016. – 208 p.- p.35
Snishko S. Wasserwirtschaftliche und ökologische Situation in Dnipro-Einzugsgebiet. Hydrologie und Wasserbewirtschaftung.2001. №1, p.2-8.
Snizhko S., Kuprikov I., Shevchenko O. Development of scientific principles of adaptation of water economy of Ukraine to possible climate changes taking into account hydrological parameters of

main river basins. Research report № T-501. State Agency of Water resources of Ukraine. Kyiv. 2011.-119 p.

Snizhko S., Shevchenko O., Didovets I. Climate projections for Ukraine for XXI century on the base of RCP-scenarios. Ukrainian Geographical Journal, 2019. In print.

Snizhko S., Yatsyuk M., Kuprikov I., Shevchenko O., Strutinska V., Krakovskaya S. Palamarchuk L., Shedemenko I. Estimation of possible changes of water resources of local drainage in Ukraine in the XXI century. Water economy of Ukraine. - 2012. - No. 6 (102). - P. 8-16.

Snizhko, S.; Kuprikov, I.; Shevchenko, O.; Pavelchuk, E., Didovets Y. Use of Water-Balance Turk Model and Numerical Regional Model REMO for Assessment of Local Water Resources Runoff in Ukraine in the XXI Century; Bryansk State Univ. Her.: Bryansk, Russia, 2014; pp. 191–201. (In Russian).

State Agency of Ecological Investment. 2013. VI National Communication of Ukraine on climate change. 2013. -304 p.

State Statistical Servises of Ukraine. The main statistical characteristics of households in the rural area of Ukraine. 2017. http://www.ukrstat.gov.ua/

VI National Communication of Ukraine on Climate Change. Available online at: http://www.seia.gov.ua/seia/doccatalog/document?id=638134.

Vormoor, K.; Lawrence, D.; Heistermann, M.; Bronstert, A. Climate change impacts on the seasonality and generation processes of floods—Projections and uncertainties for catchments with mixed snowmelt/rainfall regimes. Hydrol. Earth Syst. Sci. 2015, 19, 913–931.

Water Code of Ukraine. Law of Ukraine dated June 6, 1995 # 213/95-VR.

Water Strategy of Ukraine until 2025 – Kyiv: 2015. – 46 pp. (in Ukrainian)

WBG. World Bank Group. Renewable Internal Freshwater Resources per Capita (Cubic Meters). Available online: http://data.worldbank.org/indicator/ER.H2O.INTR.PC.

WHO, 2017. World Health Organization. Floods in Moldova, Romania and Ukraine (summer 2008). Available online at: http://www. euro.who.int/en/health-topics/emergencies/disaster-preparedness-and-response/policy/response/floods-2008.).

Annex I. Technology Factsheets for selected adaptation technologies in Agriculture Sector

1AA Increasing efficiency of feed production from crops and crop residue	
Introduction	The type of technology is sustainable livestock management. This technology towards to use crop residues and improves feed production from the mix of crops, with reference to their relevance as the primary source of feed in crop/livestock production systems, priorities for their use, the availability of cereal straws in terms of quantity produced and uses, and opportunities for more intensive utilization as feeds. The availability of these feeds depends on the type of agroecosystem, cropping patterns and intensity, type and concentration of animal species, and prevailing animal production systems.
Technology characteristics	Main recommended technological processes are the construction of underground storage facilities for feed silage and pressing and polymeric packaging of roughage. Main requirements for technology implementation: - availability of presses and packaging machines; - availability of the land resource for silage and dry feed storage; - short distance to the end consumers; - developed patterns for feed mix and appropriate knowledge about feed nutrients.
Country specific applicability and potential	
Capacity	Technology implementation is very low and has space to be reinforced. Recommended for small and medium-sized farms
Scale of application	Entire country
Time horizon- Short /Medium/long term	Medium
Status of technology in country	
Availability of technology	Available in Ukraine
Climate change adaptation benefits	- GHG reduction through Improving the diet of animals; - the diversification of the risks of loss of food from extreme disasters; - Improved tillage and soil conservation through increasing access to crop diversification.
Benefits to economic / social and environmental development	- the prevention of losses through the volatility of the avoiding price of feed and feedstock; - better use of farm labor for higher productivity and increased income; - diverse and efficient resource use; - increasing efficiency

Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: UAN 300K - 810K hryvna	
	OC: about UAN 720 hryvna per ha	

2AA Climate Smart Construction of Livestock Premises	
Introduction	The type of technology is sustainable livestock management. This technology towards to increase the height of premises with optimal ventilation systems application. Animals are the subject of getting stress in the result of temperature extremes under the unpredictable and sharp climate change events such as heating waves. The result can be illness or death; or at the very least, a reduction in the efficiency: breeding, milk production or conversion of feed into meat.
Technology characteristics	The proposed technology pertains to ventilating systems for buildings specially adapted to house livestock. The system includes vents adapted to direct the airflow in a direction adapted to create turbulence designed to avoid direct drafts on the livestock.
Country specific applicability and potential	
Capacity	Not popular. Often, implemented in case of interest farmer to ISO certification.
Scale of application	Entire country; especially focused on the Steppe regions. Recommended for small and medium-sized farms.
Time horizon- Short /Medium/long term	Short/Medium
Status of technology in country	
Availability of technology	Partly available in Ukraine
Climate change adaptation benefits	- GHG reduction through Improving the digestion process; - resistance to temperature fluctuation, heating, and warm hits
Benefits to economic / social and environmental development	-the prevention of losses through the volatility of the avoiding price of feed and feedstock; - better use of farm labor for higher productivity and increased income; - diverse and efficient resource use; - increasing efficiency
	CC: UAN 300K - 1300K hryvna

Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	OC: low

3AA Agroforestry practices (shelterbelt reconstruction)	
Introduction	The type of technology is sustainable farming system. This technology towards to the sustainable design of protective shelterbelts, considering a range of economy efficient plant species and forest objects of agro-landscapes. Shelterbelts stands play an important role in the integrated system of protection activities contributing to agricultural productivity and preventing land destruction and degradation.
Technology characteristics	There are different types of agroforestry practices can be implemented: Dense, moderately open, Open, Open-air blowing, Thinly planted. Shelterbelts of different designs have different effects on crop yields. The most effective are thinly planted and open planted shelterbelts. Main technical requirements: available plots; species selection appropriate to the environment, climate and economy conditions; planting project development; soil analysis; appropriate equipment.
Country specific applicability and potential	
Capacity	Highly demanded by farmers and state.
Scale of application	Entire country. Recommended for medium and large sized farms
Time horizon- Short /Medium/long term	Long term
Status of technology in country	
Availability of technology	Available, but with some limitation. Presently, it is being implemented in few locations but need to be further reinforced.
Climate change adaptation benefits	- GHG reduction; - temperature stabilization; - keeping soil moisture; - dust storm protection and prevention; - soil erosion prevention; - remaining biodiversity
Benefits to economic / social and environmental development	- the prevention of losses through the soil erosion process; - diverse and efficient resource use; - increasing crop production; - conservation production efficiency through the generation of additional incomes from forest and NTFPs

Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: from USA $ 2000
	OC: 150-300 per one km

4AA Interactive Integrated Land Management Maps	
Introduction	The type of technology is Land use management. This technique towards to provide a adaptable tool for the implementation and evaluation of integrated and sustainable land use management for the farmers. The purpose of implementation is to suggest an efficient solution for an integrated decision support system that will permit planners to address the multi objective nature of the land use process.
Technology characteristics	This decision support system will consist of three distinct decision-making technologies: a geographical information system (GIS); a sustainable land management rule-based system (RBS); and a multi objective programming model (MPM). That will be linked together in the form of an integrated spatial information system (ISIS). The result is expected to be a powerful, flexible and interactive decision support system that will assist in the effective planning and management of land resources. Development of E-base of integrated natural resource management maps for each district / united territorial community, agriculture producers
Country specific applicability and potential	
Capacity	
Scale of application	End consumers - all agricultural producers, members of rural and united territorial communities, financial institutions, agriculture service providers
Time horizon- Short /Medium/long term	Medium/Long term
Status of technology in country	
Availability of technology	Partly developed with a high level of segregation of methods and tools applied.
Climate change adaptation benefits	- GHG reduction; - increasing resilience to natural disasters

Benefits to economic / social and environmental development	-the optimization of all available natural resource usage; - the prevention of losses in the result of natural disasters; - diverse and efficient resource use; - conservation production efficiency; - the base for decision making about the implementation of all other technologies.
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: from USA $ 20 000 per region, about USA $ 50 per ha
	OC: very low

5AA Agricultural Credit Unions Net	
Introduction	The type of technology is Capacity building and stakeholder's organization. Credit unions are not for profit cooperative financial institutions which provide financial services to a membership defined on the basis of a common bond. They may be used as a tool of microfinance support for most vulnerable populations and agro-producer adapt to climate change with a means of accumulating and managing the assets and capabilities needed to become less susceptible to shocks and stresses and/or cope with their impacts
Technology characteristics	Requirements to technology implementation resource for registration of credit union; available types and mix of assets we are talking about can be understood in terms and ability to manage different types of assets – financial, physical, human, social and natural. Main activities are targeted loans for the installation of energy and water-saving technologies, reconstruction of premises, procurement of planting material for the planting of protective bands, etc.
Country specific applicability and potential	
Capacity	Lack of legislation and state support
Scale of application	Entire country . End consumers - all farms, cooperatives, village associations
Time horizon- Short /Medium/long term	Short term
Status of technology in country	
Availability of technology	Partly available.

Climate change adaptation benefits	- increasing resilience to natural disasters; - access to financial resource to develop and implement other adaptation technologies
Benefits to economic / social and environmental development	- The establishment or strengthening of social networks and exchange (i.e. through loan groups); - Establishment or strengthening of Informal safety nets ; - Diversification of assets; - Practice of sustainable soil and water management techniques as a loan condition (e.g. more favorable interest rates) - Capital for investing in sustainable natural resource management (SNRM) practices; - Reduced pressure on the natural resource base (as activities are improved or diversified); - Loans for equipment, infrastructure
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: initial investment from UAN 60 000 hryvnas
	OC: not given

6AA Development of an agrometrological early warning system	
Introduction	The type of technology is planning for climate change variability. agro metrological early warning systems means by which agro producers and people may systematically receive relevant and timely information before a natural disaster, temperature fluctuation, and other climate issues in order to make informed decisions and take action.
Technology characteristics	Meteorological early warning system with extensions to mobile services. Requirements for implementation: - Hazard type (climate and natural: hydro-meteorological, thermal, natural disasters, earthquake, landslides, etc.; human-caused: chemical pollutions; technological: infrastructure failures, etc.; biological: diseases, etc.) - Time scale (long-term, short-term and real-time), - Geographical scale (national, regional, or local, at least 10X10 km), - Dissemination (single-channel, multi-channel), - Audience (authorities, professionals, public, systems/telematics) - Provider/operator (a non-governmental, or private organization), - Structure of an EWS (task and functional view, process views, and architectural views).
Country specific applicability and potential	
Capacity	highly demanded
Scale of application	Entire country . End consumers - producers, authorities, professionals, public, systems/telematics)

Time horizon- Short /Medium/long term	Real time, short, medium and long terms
Status of technology in country	
Availability of technology	Presently not being implemented
Climate change adaptation benefits	- increasing resilience to natural disasters
Benefits to economic / social and environmental development	- The establishment or strengthening of social networks and exchange (i.e. through loan groups); - Establishment or strengthening of Informal safety nets ; - Diversification of assets; - Practice of sustainable soil and water management techniques as a loan condition (e.g. more favorable interest rates) - Capital for investing in sustainable natural resource management (SNRM) practices; - Reduced pressure on the natural resource base (as activities are improved or diversified); - Loans for equipment, infrastructure
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: initial investment from $ 1 500 mill
	OC: not given

7AA Seed Bank	
Introduction	Type of technology is sustainable crop management . Seed Bank is technology to collect and protect the genetic diversity of a portfolio of plants with the characteristics required for adapting the most critical food crops to climate change. The technology should make available this diversity in a form that plant breeders can readily use to produce varieties adapted to the new climatic conditions such as drought .
Technology characteristics	The seed bank should consist of two parts: gen bank and standard fields banks. Both of them have to be developed based on the FAO standards. http://www.fao.org/3/a-i3704r.pdf Standards of gene banks: the supply of germplasm, drying and storing seeds, viability control, germination recovery, description, evaluation, documentation, distribution, duplication to ensure reliable preservation; and safety/personnel.
Country specific applicability and potential	
Capacity	not applicable.
Scale of application	Each oblast of Ukraine. Lage agro-producers (agroholdings)

Time horizon- Short /Medium/long term	Long term
Status of technology in country	
Availability of technology	Lack of aviailability
Climate change adaptation benefits	- adaptation to drought, cold, and salinity improved ; - increasing plant resistance to biotic stresses;
Benefits to economic / social and environmental development	- increased yields and to quality traits of the crop; - conservation biodiversity; - developing of the labor market and rural areas strength capacity; - conservation productivity
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: not given
	OC: not given

8AA Drip irrigation in the combination with conservation agriculture practices	
Introduction	The type of technology is Sustainable farming system. It environmentally sound technologies of crop cultivation in condition of desertification in combination with drip irrigation practices. There is a way to ensure widespread implementation of environmentally balanced land use technologies, such as climate-smart agriculture and irrigation practice hat protect critical ecosystem services, meantime generating more short-term benefits for land users.
Technology characteristics	Key stages for technology implementation are: - compliance with biodiversity through rational crop rotation; - application of conservation agriculture techniques such as no-till (applicable for sunflower); - integrated pest management; - groundwater drip irrigation combined with an environmentally safe irrigation regime; - accumulation of moisture - snow removal, the use of fences, soil cracking, introduction of natural adsorbents, etc .
Country specific applicability and potential	
Capacity	The highly demanded and fast-growing market
Scale of application	Steppe and Forest Steppe zones (droughted areas). Medium size and large agro-producers (agroholdings)
Time horizon- Short /Medium/long term	Long term

Status of technology in country	
Availability of technology	Available
Climate change adaptation benefits	- additional humidification (precipitation); - avoiding wind and water erosion; - adjustment of temperature mode (ground);
Benefits to economic / social and environmental development	- increasing efficiency of land and water natural resource management; - prevention of losses in the result of droughts and other natural disasters; - diverse and efficient resource use; - conservation production efficiency; - increasing of yield
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: from $ 8K US per ha
	OC: about $ 50 – 150 US per ha

9AA Underground greenhouses	
Introduction	The underground greenhouse also is known as underground gardens or pit greenhouses. This is the technology which extends the growing season, as underground greenhouses are much warmer in winter and the surrounding soil keeps the structure comfortable for plants (and people) during the summer heat. The reduction of energy consumption is possible due to using landscape specific and relevant natural materials.
Technology characteristics	The inside can be cased in stone, mud-brick or any dense natural material able to absorb large amounts of heat. The glazing creates a “greenhouse effect.” During the day, the earth walls store heat. The walls are the battery that releases their heat at night. A properly-designed pit greenhouse is naturally warmed at night from five sides. In an above-ground greenhouse only one side, the floor, is heated during the day. The main restriction is the high water table. In this case, a waterproof barrier extending along the periphery and down the berms are necessary.
Country specific applicability and potential	
Capacity	the small farmers (33 000) and households (about 15 million) are potential end customers
Scale of application	Low demand, not popular and needs additional promotion

Time horizon- Short /Medium/long term	Short and medium term
Status of technology in country	
Availability of technology	Lack of appropriate technologies
Climate change adaptation benefits	- consistent Temperatures (ability to maintain a stable temperature all year) ; - keep moisturizing
Benefits to economic / social and environmental development	- prevention of losses in the result of droughts and temperature fluctations ; - reduction of energy resource using; - maintaining of livelihood and increasing rural living standards; - cost available
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: from $ 300 US per unit
	OC: not given

10AA Inclusive crops production	
Introduction	The type of technology is Soil management. Developing and producing of the inclusive and green food and feed value-chains strengthened (e.g. cereals, oilseeds, selected non-timber forest products). For agricultural land, the focus should be on crop and plants matching to climate change condition, highly adopted such as sorghum, tropical fruits and other. Increasing the of legumes and inclusive crops in crop rotation
Technology characteristics	The technology is foreseen developing solutions and identifying opportunities for certification, branding and marketing strategies, etc. in collaboration with agricultural cooperatives and village councils in order to develop models on inclusive crop productions with the initial focus on the legumes. The aim is to tackle with market failures and strengthen the private sector in a way that creates large-scale, lasting benefits for technology implementation.
Country specific applicability and potential	
Capacity	Growing demand
Scale of application	Entire country. Recommended for all types farm
Time horizon- Short /Medium/long term	Medium and long term
Status of technology in country	

Availability of technology	Available but should be reinforced
Climate change adaptation benefits	- Reduction GHG emission;
Benefits to economic / social and environmental development	- diverse and efficient resource use; - conservation production efficiency; - increasing of yield; - the enforcement labor market in the rural area;
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: from $1200 US per ha
	OC: not given

11AA Integrated Pest and Disease Management	
Introduction	Type of technology is Sustainable crop management . The application of integrated crop cultivation practices is based on the technical and biological protection (covering with agro fiber, sack, mulching, biopesticide, bioplastic, and bio-fertilizer usage)
Technology characteristics	In this particular case, Integrated Pest and Disease Management technology based on the application of biophysical methods for the adaptation of agriculture for climate change such as a bioplastic for growing and crop covering and bioplastic mulching. Solar heating of soils by mulching with transparent polyethylene during the hot season results in increased soil temperatures and the killing of certain pathogens. A plastic mulch does not discourage deep rooting of a shade crop variety, and mulched plants developed better.
Country specific applicability and potential	
Capacity	Highly Demanded
Scale of application	Forest and Forest Steppe zones. Recommended for all types farm
Time horizon- Short /Medium/long term	Short term
Status of technology in country	
Availability of technology	Lack of materials supply
Climate change adaptation benefits	- Reduction GHG emission; - thermal protection and thermoregulation

Benefits to economic / social and environmental development	- diverse and efficient resource use; - conservation production efficiency; - increasing of yield; - the enforcement labor market in the rural area;
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: from $300 US per ha
	OC: very low

12AA Improving agricultural production sustainability on complex landscapes	
Introduction	The type of technology is Land use management. Increasing of perennial grasses including medicinal plants, especially on slopes with steepness more than 3 degrees
Technology characteristics	Requirements for technology implementations: - seeds and equipment for perennial plantations arrangement on the slopes; - renting machinery for planting and harvesting
Country specific applicability and potential	
Capacity	Low demand, not popular and needs additional promotion
Scale of application	Entire country. All farms, cooperatives, village associations
Time horizon- Short /Medium/long term	Medium and Long term
Status of technology in country	
Availability of technology	Low level of availability
Climate change adaptation benefits	- reduction of water and wind erosion process; - water collection
Benefits to economic / social and environmental development	- conservation biodiversity; - conservation productivity; - increasing efficiency of land and water natural resource management;
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	CC: from $700 US per ha
	OC: US 50-120 $ ha

Annex II. Technology Factsheets for selected technologies in Water Sector

Drought risk assessment and mapping	
Introduction	This technology belongs to the category of Hazard and risk assessment. It promotes efficient allocation of water.
Technology characteristics	A key element of drought management as it helps to identify the areas most at risk of drought, allowing communities to plan, as well as prepare for and mitigate possible impacts. Drought risk is calculated as the probability of negative impact caused by interactions between hazard (probability of future drought events occurring based on past, current and projected drought conditions), exposure (scale of assets and population in the area) and vulnerability (probability of assets and population being affected by droughts in the area). Hydro-meteorological or hydrological indicators are commonly used to assess drought risks.
Country specific applicability and potential	
Capacity	Not applicable
Scale of application	Entire country
Time horizon- Short /Medium/long term	Medium term
Status of technology in country	
Availability of technology	available in Ukraine
Climate change adaptation benefits	Promotes more efficient allocation of water, by means of reduction vulnerability of climate during timely preparation of adaptation measures and mitigation of possible impacts
Benefits to economic / social and environmental development	Has a potential of decreasing losses caused by drought . Contributes to decrease of desertification and land degradation. Improves the efficiency of water use and related expenses. Creates preconditions for development of insurance business. Protection of vulnerable groups of population and of water-dependent companies (eg., in agriculture). Promotes water saving measures amongst all water users.
Financial Requirements and Costs (capital, costs (CC) operating costs (OC))	**According to “Climate Change Adaptation Technologies for Water:** A Practitioner’s Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017”, the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-4 OC: 1-3

	This assessment serves to give a notion of costs, that otherwise would be unknown in conditions of Ukraine.

Flood hazard assessment and mapping	
Introduction	This technology belongs to the category Hazard and risk assessment
Technology characteristics	Technology (-ies) is used to identify areas at risk of flooding, and consequently to improve flood risk management and disaster preparedness. Typically look at the expected extent and depth of flooding in a given location, based on various scenarios (e.g. 100-year events, 50-year events, etc.). Flood hazard assessments can be further expanded to assess specific risks, which take into consideration the socioeconomic characteristics (e.g. industrial activities, population density, land use) of the exposed areas.
Country specific applicability and potential	
Capacity	Not applicable
Scale of application	Entire country
Time horizon- Short /Medium/long term	Medium term
Status of technology in country	
Availability of technology	available in Ukraine
Climate change mitigation/adaptation benefits	Helps to increase readiness to floods. Reduces vulnerability of climate during timely preparation of adaptation measures and the mitigation of possible impacts
Benefits to economic / social and environmental development	Has a potential of decreasing losses and damage caused by flood . Helps to increase preparedness to floods, decreasing costs needed for dealing with their consequences. Creates preconditions for development of insurance business. Increased preparedness to floods leads to smaller negative environmental impact, which is especially important in case of availability of landfills, nuclear power plants etc. Protection of population and companies via improved planning and increased preparedness. Creation of visual product that helps to understand one of the display of climate change.
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted:

	1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-5 OC: 1-2 This assessment serves to give a notion of costs, that otherwise would be unknown in conditions of Ukraine.

Urban green spaces	
Introduction	Technology belongs to category Water augmentation, urban stromwater management
Technology characteristics	Green spaces are areas covered by vegetation (e.g. grass, bushes or trees). Particularly relevant in urban settings, where they help to uptake and infiltrate water, decreasing runoff rates, which also often contain excessive amounts of pollutants. This subsequently reduces the pressure on water drainage systems and treatment facilities. The high water retention capacity of vegetation makes them important for mitigating floods and managing urban stormwater, and in creating opportunities for groundwater recharge.
Country specific applicability and potential	
Capacity	Not applicable
Scale of application	large-scale, country-wide
Time horizon- Short /Medium/long term	short term
Status of technology in country	
Availability of technology	available in Ukraine
Climate change mitigation/adaptation benefits	Manages storm water, purifies water, saves moisture in the ground. Decreasing of vulnerability of urban spaces to extreme rainstormes and floods, they can destroy the cities economies, transport connections, energy, water, food supply and welfare of citizens.
Benefits to economic / social and environmental development	Helps to save water, to increase attractiveness and convenience of cities. Increases property cost. Creates shades, resulting in lower energy demand for cooling. Numerous environmental benefits (contributes to carbon sequestration, decreases soil erosion, maintains biodiversity in urban areas). Helps to filtrate and purify water. Recreational and health benefits for inhabitants and guests. Reduces heat island effect. Decreases temperature in summer time compared to concrete-glass constructions. Reduces noise level.

Financial Requirements and Costs (capital, operating costs)	**According to “Climate Change Adaptation Technologies for Water:** A Practitioner’s Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017”, the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 1-3 OC: 1-3 In Ukraine, the number of urban population is 29.371 million. Based on our estimates, relative availability of green areas in Ukraine is 57.45% (judging from availability of green areas in Kyiv, Kharkiv, Odesa and Uzhgorod). Average availability of urban areas is 29371000*57,45%=16 873 639, i.e. urban areas are available for 17 million people. Additionally, green urban areas have to be provided to 29371000-16873639=12 497 361 people. Assuming that the cost of urban green space is EUR 1.5/person, to provide urban green spaces in Ukraine, 12 497 361 people *EUR 1.5/person = EUR 18 746 042, or EUR 19 million are needed.

Source water protection	
Introduction	Technology belongs to category Water augmentation
Technology characteristics	Technology works by means of defining the watershed’s dynamics and identification of the community water source, as well as contamination sources. If over-extraction takes places, than restrictive water extraction measures are implemented. Technology entails measures that restrict overuse and pollution of water at its source, and may include regulations (e.g. water allocation quotas, water quality compliance regulations), compensation schemes (e.g. payments to industrial or agricultural users to reduce use of pollutants or extraction volumes, payments for ecosystem services schemes) or conservation measures in the upstream watershed. These include measures to maintain optimal water recharge and infiltration in upstream areas.
Country specific applicability and potential	
Capacity	Not applicable
Scale of application	Country-wide
Time horizon- Short /Medium/long term	Medium-term
Status of technology in country	
Availability of technology	available in Ukraine

Climate change mitigation/adaptation benefits	Helps to increase the amount of water that potentially could be of use
Benefits to economic / social and environmental development	Increases the availability of water that otherwise would need to be withdrawn elsewhere. Transition toward resource- water efficient production. Benefits deriving from cleaning of river beds. Benefits for water ecosystems. Reduces the velocity of storm water, decreasing flood risks and consequences. Recreational benefits, making areas more attractive for tourism. Supplies clean water, decreasing the costs of water treatment.
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 1-4 OC: 2-4 This assessment serves to give a notion of costs, that otherwise would be unknown in conditions of Ukraine.

Efficient irrigation	
Introduction	Technology belongs to the category of Water efficiency and demand management
Technology characteristics	Technology aims at minimizing water use within the agricultural sector while continuing to maintain optimal crop productivity rates. Technologies include more efficient irrigation systems where water release can be controlled so that crops receive only the amount needed (e.g. pressurized irrigation systems such as drip irrigation. The essence of the system of drip irrigation is as follows: water is dispensed by the system of pipelines and comes directly to the root system of plants through the droppers. This type of irrigation gives an opportunity to obtain optimum soil moisture (200-800 m^3 / ha)). Other modern irrigation systems are self-propelled and include wireless sensors and GPS technology to improve site-specific and volumetric precision of water applications to match the needs of the soil and crops. The use of GPS is intended to increase the quality and accuracy of irrigation, as well as help to solve problems with remote control of watering equipment. GPS helps to perfectly align the landing line and the irrigation line, which will help to effectively use the ground on the field and give optimal use of water. Irrigation efficiency can also be improved through altering farming practices, such as crop rotation (plant crops according to seasons and soil conditions) and conservation tillage (leaving a previous

	year's crop residue on the field to reduce soil erosion and runoff) that help improve soil moisture conservation.
Country specific applicability and potential	
Capacity	Capacity strongly depends on types of crops, location and moisture level of land
Scale of application	entire country, especially southern and south-eastern regions of the country
Time horizon- Short /Medium/long term	medium – term
Status of technology in country	
Availability of technology	available in Ukraine. Has high market potential due to high share of agricultural production in Ukraine
Climate change mitigation/adaptation benefits	Direct crossectoral adaptation measure in agriculture and water sector. Drip irrigation is particularly suitable for use with ground water from wells. It requires institutional arrangements and capacity building of water users to avoid an overuse of aquifer resources and potential conflicts. Drip irrigation technologies can be implemented through a water user association to improve economic benefits and reduce initial investment costs. Drip irrigation is a versatile technology suitable for application in a wide range of contexts. It can be implemented at small or large scales and with low-cost or more sophisticated components. This technology can be employed in conjunction with other adaptation measures such as the establishment of water user boards, multi-cropping and fertiliser management. Promoting drip irrigation contributes to efficient water use, reduces requirements for fertilisers and increases soil productivity. It is particularly suitable in areas with permanent or seasonal water scarcity, since crop varieties to plant can also be adaptable to these conditions.
Benefits to economic / social and environmental development	Increases the efficiency of water use. Contributes to increased productivity of crops. Declining costs of agricultural production. Declines costs of water piping and transportation. Environmental benefits deriving from decreased soil degradation and increased water retention in soils. Increases water availability during water scarcity.
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-4

	OC: 1-2. capital costs - USD 1100-2500/ha. operating costs - USD 60-190/ha (source of information: M.Shlapak)

Reducing system water loss and leakages	
Introduction	This technology belongs to category Water efficiency and demand management
Technology characteristics	Measures to improve efficiency in distribution systems and avoid unnecessary withdrawals. ‘Real’ water losses are defined as the amount of water lost between the supplier and the consumer, while ‘apparent’ losses are defined as those due to inaccurate consumption measurements by the consumer or utility. Implementing leak detection systems, pressure control, maintaining meters, and controlling against unauthorized use, are all measures that can help mitigate real and apparent water losses (also known as non-revenue water).
Country specific applicability and potential	
Capacity	Not applicable
Scale of application	Country wide
Time horizon- Short /Medium/long term	Long term
Status of technology in country	
Availability of technology	available in Ukraine
Climate change mitigation/adaptation benefits	promotes more efficient use of water
Benefits to economic / social and environmental development	Increases efficiency of water use. Helps to avoid unnecessary water transportation. Prevents unnecessary water withdrawal.
Financial Requirements and Costs (capital, operating costs)	**According to “Climate Change Adaptation Technologies for Water:** A Practitioner’s Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017”, the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 3-4 OC: 2-3 In Ukraine, in structure of tariff for centralized water supply the cost of reducing system water loss and leakages is UAH 0.26/m3

	or 4% (having the fare UAH 6.52/m3).
Public water conservation campaigns	
Introduction	Technology belongs to the category of Water efficiency and demand management
Technology characteristics	Aims to change citizen attitudes and behaviour to improve water use efficiency. Technology includes education and awareness campaigns on the socioeconomic and environmental benefits of water conservation and different conservation methods. Communication means include traditional and social media, as well as direct communication such as workshops, presentations, stakeholder dialogues, etc. Economic incentives can also be employed, for example, free installation of water meters.
Country specific applicability and potential	
Capacity	Not applicable
Scale of application	Country wide
Time horizon- Short /Medium/long term	Short term
Status of technology in country	
Availability of technology	Available
Climate change mitigation/adaptation benefits	measure aimed at conservation of available water
Benefits to economic / social and environmental development	Increases the efficiency of water use. Development of market of auxiliary services. Reduces water costs for end users. Less energy and chemicals are needed to treat and transport water
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-3 OC: 1-3 This assessment serves to give a notion of costs, that otherwise would be unknown in conditions of Ukraine.

Ecological river restoration

Introduction	Technology belongs to category Riverine flood protection
Technology characteristics	Involves ecological, spatial and physical management practices to return a river back (or close) to its natural state. Common restoration techniques include re-connecting rivers with floodplains, reestablishment of the river's meandering form with no barriers along its banks, and stabilizing surrounding soil to reduce sedimentation and erosion. Restored rivers have increased water retention capacity due to their ability to naturally expand their banks and flood onto floodplains, thus making them more effective for flood risk management. This technology is applicable to all rivers, however, from economic point of view, application to small rivers (with watershed area less than 2 thousand km^2) is the most reasonable, as they significantly suffer from anthropogenic impact.
Country specific applicability and potential	
Capacity	Not applicable
Scale of application	Country wide
Time horizon- Short /Medium/long term	Medium term
Status of technology in country	
Availability of technology	Available
Climate change mitigation/adaptation benefits	direct adaptation measure, aimed at returning river to its natural course and path. It is extremely important when floods occur. Maintains biodiversity, promotes recreational activities.
Benefits to economic / social and environmental development	reduces maintenance cost for man-built flood barriers. Recreational opportunities and increased tourism. Increased possibility of fishing.
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-4 OC: 1-2 In 2017, the average cost of restoring 1 ha of an European river was EUR 310 thousand (https://www.mdpi.com/2071-1050/10/1/129/pdf).

Precision agriculture

Introduction	Technology belongs to category Limiting nutrient leakage
Technology characteristics	The concept of precision agriculture is based on the notion of the existence of inhomogeneities within the same field. The latest technologies such as global positioning systems (GPS, GLONASS, Galileo), special sensors, aerial photographs and satellite imagery, as well as special programs for agri-management based on geographic information systems (GIS) are used to assess and detect these heterogeneities. The data collected are used to plan seeding, fertilizer and plant protection (CZD) calculations, more accurate prediction of yield and financial planning. This concept takes into account local soil features and climatic conditions. In some cases, it makes easier to determine the local causes of illness or seals. Agriproducers apply technologies of variable or differentiated introduction of fertilizers and water on areas of the field that are identified by GPS receivers and where the need for a certain rate of fertilizers is identified by the agronomist using agro-chemical research and yield maps. Therefore, in some areas of the field, the rate of application or spraying becomes less than average, there is a redistribution of fertilizers in favor of sites where the norm should be higher and, thus, optimizing the introduction of fertilizers. This technology helps to reduce the leakage of fertilizers, particularly of nitrogen and phosphorous, and the resulting nutrient pollution of waterways. Changes to more sustainable land use-practices aim to increase the ability of soils to retain nutrients, limit the amount of excess nutrients added to soils and minimize soil-loss from erosion. Improving farmer knowledge on soils and plants is also important for accurate dosage, timing and placement of nutrients to match the exact needs of the crop and avoid excess dosages, and therefore leakage.
Country specific applicability and potential	
Capacity	not applicable
Scale of application	entire country
Time horizon- Short /Medium/long term	medium term
Status of technology in country	
Availability of technology	available in Ukraine. Currently, only 20-30% of arable lands have some elements of precision agriculture (https://nachasi.com/2018/10/02/it-zemlerobstvo/?fbclid=IwAR3rd3KFfnyJC6BddC03ndcg_V_tVuvq8eD4OpcgLpZatUzX4ZmyYEpJNKM).

Climate change mitigation/adaptation benefits	Technology decreases chemical contamination of water and soils, increasing the quality of (scarce) water
Benefits to economic / social and environmental development	Direct environmental benefits derived from diminished use of nutrients. Reduces land degradation. Sediment control. Social benefits include improved health of population due to the decreased use of nutrients
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-3 OC: 1-3 This assessment serves to give a notion of costs, that otherwise would be unknown in conditions of Ukraine.

Climate-smart irrigation	
Introduction	Technology belongs to the category of Water efficiency and demand management
Technology characteristics	Climate smart irrigation is a key element of climate-smart agriculture. Includes not only water irrigation, but also air injection. Climate-smart irrigation, as well as drip irrigation, consists of several basic elements, such as tubes, emitters and connectors. Biological supplements can be applied in liquid form and introduced into the irrigation system or used in granular form. There is a biological compound that attracts water molecules from the atmosphere and from the soil, maintaining a significant amount of water used in a cost effective way. Hydraulic fertilizer systems and chemical injection systems are cost effective injection systems that do not require an additional power supply. Air injection has revolutionized drip irrigation under the surface. Such a system extracts nitrogen and oxygen from the atmosphere and mixes it with an irrigation system that provides critical air for the root zone[20]. Climate-smart irrigation presumes monitoring of external factors (such as sensor monitoring of soil moisture, or air availability (for eg., in clay soils)) together with monitoring of physiological parameters of the water regime of plants, based on which watering is carried out. Lower amount of nutrient use leads to minimized soil-loss from erosion. Improving farmer knowledge in regards to soils and plants is also important for

[20] http://climatesmartirrigation.com/technology/technology/drip-irrigation

	accurate dosage, timing and placement of nutrients to match the exact needs of the planted crops.
Country specific applicability and potential	
Capacity	not applicable
Scale of application	entire country
Time horizon- Short /Medium/long term	long-term
Status of technology in country	
Availability of technology	Not available in the country
Climate change mitigation/adaptation benefits	direct adaptation measure, helping to protect farmers and communities from adverse climatic conditions, to decrease CO_2 emissions and to improve water management at all levels, up to river basin scale.
Benefits to economic / social and environmental development	Decrease in the cost of tillage, nutrients. Reduced cost of water treatment. The reduction of land degradation and erosion. Increase of soil organic matter. Improvement of carbon sequestration. Improved health of population due to decreased use of nutrients and their contents in water.
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-3 OC: 1-3 This assessment serves to give a notion of costs, that otherwise would be unknown in conditions of Ukraine.

Advanced sewage wastewater treatment	
Introduction	Technology belongs to category Improved water treatment
Technology characteristics	Sewage wastewater treatment makes wastewater useful, saving the economic and environmental costs related to establishing new water supplies. The recycled sewage wastewater can be used for irrigation or industrial purposes if properly treated. Includes advanced technologies for large-scale water treatment, which means less energy and chemical inputs required, while improving water quality. Modern technologies include Phosphorus recycling (with further production of fertilizers), burning solid sludge and further use of ash for construction

	materials output etc. Treatment processes are necessary to remove nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals and dissolved solids. An adaptation of the activated sludge process is often used to remove nitrogen and phosphorus.
Country specific applicability and potential	
Capacity	Varies depending on size of site
Scale of application	Entire country
Time horizon- Short /Medium/long term	Medium term
Status of technology in country	
Availability of technology	not available in Ukraine
Climate change mitigation/adaptation benefits	technology improves quality of water and presumes prolific use of sediments.
Benefits to economic / social and environmental development	Higher level of water treatment. The additional source of Phosphorus fertilizers. Additional source of feedstock for construction materials output. Decreased amount of insufficiently treated water released to the environment. Lower CO2 emissions derived from decreased use of regular construction materials. Improved health of population due to higher level of water treatment.
Financial Requirements and Costs (capital, operating costs)	**According to "Climate Change Adaptation Technologies for Water:** A Practitioner's Guide to Adaptation Technologies for Increased Water Sector Resilience. DHI, CTCN, UNEP DTU. 2017", the following assessment and scale of cost was adopted: 1 – very low/no cost, to 5 – very high costs. For this particular technology, CC and OC were defined as follows: CC: 2-4 OC: 1-3 This assessment serves to give a notion of costs, that otherwise would be unknown in conditions of Ukraine.

Annex III. The List of Stakeholders

Sector	Organisation	Contacts
Government Bodies		
Agriculture	Ministry of Agrarian Policy and Food of Ukraine	http://minagro.gov.ua/
Water Agriculture	Ministry of Ecology and Natural Resources of Ukraine	https://menr.gov.ua/
Agriculture	State Agency on Energy Efficiency and Energy Saving of Ukraine	http://saee.gov.ua/
Water Agriculture	State Agency of Water Resources of Ukraine	https://www.davr.gov.ua/
Agriculture	State Forest Resources Agency of Ukraine	http://dklg.kmu.gov.ua/forest/control/uk/index
Agriculture	State service of Ukraine for food safety and consumer protection	http://www.consumer.gov.ua
Water Agriculture	Ukrainian Hydrometeorological Centre	https://www.meteo.gov.ua
Agriculture	State Farmers Support Fund of Ukraine	https://udf.gov.ua
Water	Regional Office of Water Resources in Dnipropetrivsk Region	vodhoz.dp.ua
Water	Danube Regional Office of Water Resources	dbuvr.od.ua
Water	Interregional Office of Defence Bodies of Dnipro Water Storage	mozmdv.gov.ua
Water	Regional Office of Water Resources in Kirovograd Region	vodnik.kr.ua
Water	Regional Office of Water Resources in Lugansk Region	rovrlg.gov.ua
Water	Regional Office of Water Resources in Poltava Region	poltavavodgosp.gov.ua
Water	Regional Office of Water Resources in Mykolayiv Region	mk-vodres.davr.gov.ua
Water	Regional Office of Water Resources in Rivne Region	rivnevodres.rv.ua
Water	Regional Office of Water Resources in Sumy Region	sumyvodres.davr.gov.ua
Water	Regional Office of Water Resources in Ternopil Region	vodgosp.te.ua
Water	Regional Office of Water Resources in Khmelnytsky Region	хмовр.укр
Water	Regional Office of Water Resources in Kharkiv Region	vodgosp.kharkov.ua

Water	Regional Office of Water Resources in Cherkasy Region	ckovr.gov.ua
Water	Regional Office of Water Resources in Volyn Region	vodres.gov.ua
Water	Regional Office of Water Resources of Ros River	buvrrosi.com.ua
Water	Bureau of Main Kakhovka Principal Channel	ugkmk.davr.gov.ua
Water	Bereau of Dnipro-Donbas Channel	ukdd.dp.ua
Water	Bureau of Ingulets River Channels	www.ukios.mk.ua
Water	Bureau of Nothern-Crimean Channel	upkk.com.ua
Water	Basin Bureau of Water Resources of Water Resources of Southern Bug River	buvr.vn.ua
Water	Basin Bureau of Water Resources of Western Bug and Syan Rivers	buvr.vn.ua
Water	Basin Bureau of Water Resources of Middle Dnipro River	buvrd.org.ua
Water	Basin Bureau of Water Reurces of Lower Dnipro River	www.buvr.kherson.ua
Water	Basin Bureau of Water Resources of Tysa River	buvrtysa.gov.ua
Water	Desna River Basin Bureau of Water Resources	desna-buvr.gov.ua
Water	Dnister River Basin Bureau of Water Resources	vodaif.gov.ua
Water	Basin Bureau of Water Resources of Prypyat RIver	buvrzt.gov.ua
Water	Siversko-Donetsk Basin Bureau of Water Resources	sdbuvr.gov.ua
Academic/Research Institutions		
Agriculture	The National Academy of Agrarian Sciences of Ukraine	http://naas.gov.ua
Agriculture	Institute bioenergy crops and sugar beet of the National Academy of Agrarian Sciences Ukraine	http://bio.gov.ua
Agriculture	Institute of Agriculture Economy	http://www.iae.org.ua
Agriculture	Institute of Plant Protection	http://www.ipp.gov.ua/uk
Agriculture	Institute of Water Problems and Land Reclamation NAAS	http://igim.org.ua
Agriculture	Ukrainian Scientific and Research Institute for Forecasting and Testing Machinery and Technologies for Agricultural Production named after L. Pogorilogo	http://www.ndipvt.com.ua/
Agriculture	National Scientific Centre "Institute of Agriculture of National Academy of Agrarian Science of Ukraine	http://zemlerobstvo.com/
Agriculture	Institute of Agricultural Microbiology and Agro-Industrial Production of National Academy of Agrarian Science of Ukraine	https://ismav.com.ua
Agriculture	Ukrainian Research Institute of Forestry and AgroForest Melioration named after G. M. Vysotsky	http://uriffm.org.ua

Agriculture	Institute of agroecology and natural resource management	https://agroeco.org.ua/
Agriculture	National University of Life and Environmental Sciences of Ukraine	https://nubip.edu.ua
Agriculture	Bila Tserkva National Agrarian University	http://btsau.edu.ua
Agriculture	Kharkiv National Agricalture University named after Dokuchaev	https://knau.kharkov.ua
Agriculture	Kherson State Agrarian University	www.ksau.kherson.ua
Agriculture	State Institution "Scientific and Methodological Center for Information and Analytical Support of Higher Educational Institutions Operation "Agroosvita""	http://agroosvita.com
NGOs		
Agriculture	Ukrainian Agribusiness Club	http://ucab.ua/ua
Agriculture	Bioenergy Association of Ukraine	http://www.uabio.org/
Agriculture	Non-governmental organization of Manufacturers of Organic Certified products	http://organicukraine.org.ua/
Agriculture	Ukrainian Nut Association	https://ukr-nuts.org/
Agriculture	Public Association "Community Of Pulse Producers And Customers Of Ukraine"	http://ukraine-pulse.org/
Agriculture	The Ukrainian Stock Breeders Association	https://usba.com.ua
Agriculture Water	NGO Eco-Action	https://ecoaction.org.ua/
Agriculture	Organic Federation of Ukraine	http://www.organic.com.ua
Agriculture	All-Ukrainian association of village councils and amalgamated communities	https://assogu.org.ua
Agriculture	Institute for rural development	http://www.icp.org.ua
Agriculture	NGO "National Association of Agricultural Advisory Services of Ukraine.	http://www.dorada.org.ua/pro-asotsiatsiyu/pro-nasdsu/naaasu.html
Private Sector		
Agriculture	Agro-Soyuz Holding	http://www.agrosoyuz.com.ua/
Agriculture	AgroGeneration	http://www.agrogeneration.com/ua
Agriculture	LLC SP Nibulon	http://nibulon.com/
Agriculture	Syngenta Ukraine	https://www.syngenta.ua/
Agriculture	Crops Care Institute	https://ukravit.ua/
International Organization		
Agriculture Water	WWF in Ukraine	http://wwf.panda.org/uk/
Agriculture	German-Ukrainian Agricultural Policy Dialogue	https://apd-ukraine.de/ua/pro-proekt
Agriculture Water	International Finance Corporation in Ukraine	https://www.ifc.org/
Agriculture Water	European Bank of Reconstruction and Development	https://www.ebrd.com/ukraine.html
Agriculture	Food and Agriculture Organization of the United Nations	http://www.fao.org/countryprofiles/index/ru/?iso3=ukr

Annex IV. List of Experts Participated in Adaptation Technologies Evaluation

List of Experts in Agriculture Sector		
Name	**Affiliation**	**Position**
Sergiy Demyanenko	Kyiv National Economic University named after Vadym Hetman	PhD in Economy, Professor, Head of Department of Agribusiness Economics and Management
Natalia Visotska	Research Institute of Forestry and Agroforestry named after G.N. Vysotsky	PhD in Forestry, Vice-Head
Raisa Vogegova	Institute of Irrigated Agriculture, National Academy of Scince of Ukraine	PhD in Agriculture, Professor, CEO
Oleksiy Tsuk	National University of Life and Environmental Science of Ukraine	PhD in Ecology, Professor of Department of Agriculture and Herbology
Sergiy Ruban	National University of Life and Environmental Science of Ukraine	PhD In Genetic, Head of Department Genetic, Breeding and Livestock Biotechnology
Vitaliy Zhemoida	National University of Life and Environmental Science of Ukraine	PhD in Agriculture, Head of Department of Genetics, Selection and Seedling
Volodimir Starodubtsev	National University of Life and Environmental Science of Ukraine	PhD in Biology, Professor of Environmental Security and Safety Department
Genadiy Golub	National University of Life and Environmental Science of Ukraine	PhD in Agriculture, Head of Department Machinary and Bio based energy systems
Yulia Danilenko	Institute of Water Problems and Land Reclamation	PhD in Technology Science , Head of Laboratory of Water Management
Roman Saydak	Institute of Water Problems and Land Reclamation	PhD in Agriculture, Leading Reseacher on agriculture potential development
Mihailo Yatsuk	Institute of Water Problems and Land Reclamation	PhD in Agriculture, Vice-Head on R&D
Tatyana Adamenko	Ukrainian Hydrometeorological Center	Head of AgroMeteo Department
Eugene Vainer	FAO UN	National Expert
Sergiy Kuzmenko	Ukrainian Industrial Association of Plant Protection	Head
Larisa Bondarenko	Agrosurveyor LLC	Director
Andrey Schedrininov	Privat Farm Telus Yug	Head/Owner
Leonid Tsentylo	Agrofirma Kolos, ltd	PhD in Agriculture, Head/Owner
Mikhail Draganchuk	No-Till Laboratoria Channal	Head/Owner
List of Experts in Water Sector		
Grebin Vasyl	Taras Shevchenko National University of Kyiv	DSc in Geography, professor
Ovcharuk Valeriya	Odesa State Ecological University	DSc in Geography, Professor
Boyko Viktoriya	Ukrainian Hydrometeorological Center	PhD in Geography, Head of Hydrological Forecast Department
Yuschenko Yuriy	Yuriy Fedkovych Chernivtsi National University	DSc in Geography, Professor, Head of Hydrometeorology and Water Resources Department

Shevchenko Olga	Taras Shevchenko National University of Kyiv	DSc in Geography, Associate Professor
Manivchuk Vasyl	Transcarpathian Regional Center of Hydrometeorology	MSc in Hydrology, Head
Gopchak Igor	National University of Water and Nature Management	DSc in Geography, Associate Professor
Sherstyuk Nataliya	Oles Honchar Dnipro National University	DSc in Geography, Professor, Dean of Faculty of Geology and Geography
Denyshchyk Olga	World Wild Fund Ukraine	MSc in Environmental Science and Management, Freshwater manager
Grychulevych Liliya	Black Sea Women's Club	MSc in ecology, MSc in State Administration, Project Leader

Annex V. List of participants of the Technology Needs Assessment (TNA) stakeholder workshop: an introduction and basic training in project methodology

(21 August 2018, Aarhus' center at the Ministry of Ecology and Natural resources of Ukraine)

#	Participant	Position	Contacts
1	Mr. Anatolii Shmurak	National TNA coordinator and NDE, The Senior Specialist of Climate Policy and Reporting Division of the Climate Change and Ozone Layer Protection Department of the MENR	a.shmurak@menr.gov.ua, shmurak@i.ua
2	Ms. Svitlana Grynchuk	The Director of the Climate Change and Ozone Layer Protection Department of the MENR, UNFCCC National Focal Point	grynchuk@menr.gov.ua, svitlana.iva@gmail.com
3	Mr. Mykhailo Chyzhenko	The Head of Climate Policy and Reporting Division of the Climate Change and Ozone Layer Protection Department of the MENR, UNFCCC National Focal Point	chyzhenko@menr.gov.ua, chyzhenko@gmail.com
4	Ms.Olesia Shapovalova	The Senior Specialist of Climate Policy and Reporting Division of the Climate Change and Ozone Layer Protection Department of the MENR	shapovalova@menr.gov.ua, alesia.shapovalova@gmail.com
5	Ms. Antonina Platonova	The Senior Specialist of Climate Policy and Reporting Division of the Climate Change and Ozone Layer Protection Department of the MENR	platonova@menr.gov.ua, platonovaantonina@gmail.com
6	Mr. Olexandr Tarasenko	The Head of International Projects Coordination Division of the Strategy and European Integration Department of the MENR	o.tarasenko@menr.gov.ua
7	Mr. Roman Filonenko	The Head of Environmental Security Division of the Environmental Security and Permitting-Licensing Activity Department of the MENR	frs@menr.gov.ua
8	Mr. Evgeniy Shmurak	The Senior Specialist of Waste Management Division of the Environmental Security and Permitting-Licensing Activity Department of the MENR	e.shmurak@menr.gov.ua
9	Mr. Sviatoslav Kurulenko	The Head of the Committee on Climate Change and Ozone Layer Protection of the Public Council at the MENR, Head of the Committee on Environmental Resources Management of the Chamber of Commerce of Ukraine	s_kurulenko@ukr.net

10	Ms. Oksana Moroz	The Senior Specialist of Research and Environmental Activities Coordination and Metrology, Certification and Accreditation The Division of the Fuel and Energy Complex Strategy Development and Investment Policy Department of the Ministry of Energy and Coal Industry of Ukraine	oksana.moroz@mev.energy.gov.ua, oksana.moroz@yahoo.com
11	Mr. Igor Onopchuk	The Head of Inventory and Monitoring Department of the Budget Institution “National Center for GHG Emissions Inventory”, Member of Technology Executive Committee, National expert on LULUCF	imo@nci.org.ua, igor.onopchuk@gmail.com
12	Mr. Olexander Tymoshchuk	The Deputy Head of Inventory and Monitoring Department of the Budget Institution “National Center for GHG Emissions Inventory”, National expert on agriculture	oat@nci.org.ua
13	Ms. Yulia Zakharchuk	The Senior Specialist of Inventory and Monitoring Department of the Budget Institution “National Center for GHG Emissions Inventory”, National expert on waste	yvz@nci.org.ua
14	Mr. Georgii Geletukha	The Head of Bioenergy Department of Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine, Director of “Scientific Engineering Center “Biomass” Ltd., Chairman of Public Union “Bioenergy Association of Ukraine”, Member of the Public Council at the State Agency for Energy Efficiency and Energy Conservation of Ukraine	geletukha@uabio.org
15	Mr. Yuri Matveev	The Senior Scientist of Bioenergy Department of Institute of Engineering Thermophysics of the National Academy of Sciences of Ukraine, Board Member of Public Union “Bioenergy Association of Ukraine”, Deputy Chairman of Public Organization “Renewable Energy Agency”	matveev@uabio.org
16	Mr. Oleksandr Diachuk	The Senior Researcher of the State Institution “Institute of Economics and Forecasting of the National Academy of Sciences of Ukraine”	oadyachuk@ukr.net

17	Mr. Dmytro Paderno	The Deputy Director of the Institute of Industrial Ecology	paderno@engecology.com
18	Mr. Sergii Shmarin	The Head specialist of the Development of the Transmission System Department of the State Enterprise “Ukrenergo”	sergeyshmarin1988@gmail.com
19	Mr. Mikhail Malkov	National Coordinator, FAO	mikhail.malkov@fao.org
20	Mr. Pavlo Masiukov	The Senior Project Coordinator of the GIZ project “Support to the establishment of an ETS in Ukraine”	pavlo.masiukov@giz.de
21	Ms. Nataliya Parasyuk	The Project Manager of the project “Preparedness for Market Readiness Project Ukraine”	climate.i5e@gmail.com
22	Ms. Ganna Korniyenko	Technical Coordinator for carbon tax and interaction with ETS/MRV of the project “Preparedness for Market Readiness Project Ukraine”	hannakornienko@gmail.com
23	Ms. Oleksandra Azarkhina	The Communication Specialist of the Reform Support Team	oleksandra.azarkhina@reforms.in.ua
24	Ms. Anastasiia Cherkashchenko	The Junior Sectoral Policy Fellow of the EU project “Association4U”	anastasiia.cherkashchenko@gmail.com
25	Ms. Sofia Sadogurska	The Board Member of Ukrainian Climate Change Network, Coordinator of Climate Change Campaigns of the Centre of Environmental Initiatives “Ecoaction”	sofia@ecoact.org.ua
26	Ms. Anna Ackermann	The Head of Climate Change Division of the Centre of Environmental Initiatives “Ecoaction”	aa@ecoact.org.ua
27	Ms. Kateryna Pasichnyk	National Expert, UNIDO	k.pasichnyk@unido.org
28	Ms. Kateryna Pernata	National Expert, UNIDO	kateryna.pernata@gmail.com, k.pernata@unido.org
29	Ms. Sara Laerke Meltofte Traerup	UNEP DTU Partnership, Global Project coordinator	slmt@dtu.dk
30	Ms. Alla Druta	TNA Project Consultant	drutaala@yahoo.com
31	Mr. Vladimir Hecl	UNFCCC, FTC, Technology sub-programme	vhecl@unfccc.int

Annex VI. TNA team contacts

Name	Affiliation	Position	Contacts
Mr. Anatolii Shmurak	Ministry of Ecology and Natural Resources of Ukraine	National TNA Coordinator, UNFCCC focal point in Ukraine	+380(97) 450 14 67 shmurak@i.ua; a.shmurak@menr.gov.ua
Ms. Yevheniia Anpilova	Institute of Telecommunications and Global Information Space of NAS of Ukraine	Assistant of TNA Coordinator	+380(44) 244 79 63 anpilova@ukr.net
Mr. Mykola Shlapak	Environmental Consultant	National Consultant Mitigation Agriculture	m.shlapak.ua@gmail.com
Mr. Yuriy Matveev	Institute of Engineering Thermophysics of NAS of Ukraine	National Consultant Mitigation Waste	+380(67)7907508 mtv@biomass.kiev.ua
Mr. Sergii Shmarin	Non-governmental organization "Bureau of integrated analysis and forecasting"	National Consultant Mitigation Waste	sergeyshmarin1988@gmail.com
Ms.Oksana Ryabchenko	National University of Life and of Environmental Sciences of Ukraine	National Consultant Adaptation Agriculture	riabchenko_oksana@nubip.edu.ua
Mr. Sergiy Snizhko	Kyiv National Taras Shevchenko University	National Consultant Adaptation Water	+ 380(67) 491 11 10 snizhkosi@gmail.com
Ms.Galyna Trypolska	Institute for Economics and Forecasting of NAS of Ukraine	National Consultant Adaptation Water	g.trypolska@gmail.com

Annex VI. Order of CM of Ukraine #583 of April 14, 1999

CABINET OF MINISTERS OF UKRAINE
Order of April 14, 1999 N 583
Kyiv
On the Interagency Commission on Implementation of United Nations Framework Convention on Climate Change,
{As amended according to the Resolution of the Cabinet of Ministers
N 1262 (1262-2000-p) of 11.08.2000
N 1227 (1227-2001-p) of September 26, 2001
N 635 (635-2003-p) of April 26, 2003
N 123 (123-2004-p) of 04.02.2004
by the Order of the Cabinet of Ministers
N 473-p (473-2005-p) of November 22, 2005
by the Order of the Cabinet of Ministers
N 1150 (1150-2005-p) of 07.12.2005
N 1208 (1208-2007-p) of 10.10.2007
No. 1137 (1137-2011-p) of 07.11.2011
N 616 (616-2015-p) of 12.08.2015}

In order to ensure the organization of the development and coordination of the implementation of the national strategy and the national action plan to fulfill Ukraine's commitments in accordance with the UN Framework Convention on Climate Change and the Kyoto Protocol thereto (995-801), the Cabinet of Ministers of Ukraine decides:

1. Create an Interagency Commission on Ensuring the Implementation of the UN Framework Convention on Climate Change (995_044).

(Clause 1 as amended according to the Resolution of the Cabinet of Ministers N 1150 (1150-2005-p) dated 12/7/2005)

2. To approve the Regulation on the Interagency Commission for the Enforcement of the UN Framework Convention on Climate Change (attached).

Prime Minister of Ukraine V.Pustovoitenko

The Composition of the Interagency Commission on Ensuring the Implementation of the UN Framework Convention on Climate Change is excluded on the basis of the Decree of the Cabinet of Ministers N 1150 (1150-2005-p) of 12.12.2005)

Approved by the Resolution of the

Cabinet of Ministers of Ukraine of April 14, 1999 N 583

Regulation on the Interagency Commission on Ensuring the Implementation of the UN Framework Convention on Climate Change

(In the text of the Provision, the word "Minekobezpeky" is replaced by the word "Minprirody" according to the Resolution of the Cabinet of Ministers N 1150 (1150-2005-p) dated 12/7/2005)

1. The Interagency Commission on Ensuring the Implementation of the UN Framework Convention on Climate Change (995_044) (hereinafter referred to as the Commission) is created to organize the development and coordination of the implementation of a national strategy and national action plan to fulfill Ukraine's obligations under the UN Framework Convention on Climate Change (hereinafter - UN Framework Convention) and its Kyoto Protocol.

2. The Commission is guided in its activities by the Constitution of Ukraine (254k / 96-BP) by the laws of Ukraine, acts of the President of Ukraine and the Cabinet of Ministers of Ukraine, as well as these Regulations, decisions of the Conference of the Parties to the UN Framework Convention on Climate Change.

3. The Commission interacts with the relevant committees of the Verkhovna Rada of Ukraine, ministries, other central and local executive bodies, enterprises, institutions and organizations.

4. The main tasks of the Commission are:

organizing the development of a national strategy and a national action plan for fulfilling Ukraine's obligations in accordance with the UN Framework Convention and its Kyoto Protocol;

the coordination of the activities of ministries, other central and local executive authorities, enterprises, institutions and organizations on the implementation of the national action plan to fulfill the obligations of Ukraine in accordance with the UN Framework Convention and its Kyoto Protocol;

the development of proposals for the implementation of commitments provided for by the Kyoto Protocol;

the organization of the preparation of national communications on the implementation of obligations under the UN Framework Convention;

the organization for the preparation of a national inventory of anthropogenic emissions from sources and adsorption through absorbers of all greenhouse gases not controlled by the Montreal Protocol on substances that deplete the ozone layer;

monitoring the implementation of a mitigation plan for climate change by addressing the problem of anthropogenic emissions from sources and adsorption by sinks of all greenhouse gases not controlled by the specified Montreal Protocol, and promoting adequate adaptation to climate change;

the consideration of the materials on the UN Framework Convention and the Kyoto Protocol thereto, which come from the governments of other countries, the Global Environment Facility, the World Bank, other international organizations and the preparation of relevant proposals based on them;

the consideration of reporting documents sent by the Secretariat of the UN Framework Convention on Climate Change (995_044) and draft directives to official government delegations and representatives of the Cabinet of Ministers of Ukraine for international events on climate change and reports on the results of participation in these events. {Clause 4 is supplemented by a paragraph according to the Resolution of the Cabinet of Ministers N 1208 (1208-2007-p) of 10.10.2007}

5. The Commission has the right to:

To submit proposals in accordance with the established procedure on matters within its competence;

To receive in accordance with the established procedure, from central and local executive authorities, enterprises, institutions and organizations the information necessary to carry out the tasks assigned to it;

To form in order to fulfill the tasks assigned to it, expert commissions and working groups, to involve in their work the employees of central and local executive bodies, as well as specialists from scientific and other institutions (by agreement of their leaders).

6. The Commission consists of the

Minister of Ecology and Natural Resources - the Chairman of the Commission,

the Deputy Minister of Ecology and Natural Resources - the First Deputy Chairman of the Commission,

the Deputy Minister of Economic Development and Trade - the Chief of Staff - the Deputy Chairman of the Commission,

the First Deputy Minister of Energy and Coal Industry - Deputy Chairman of the Commission,

Head of the structural unit of the Ministry of Ecology and Natural Resources, who is entrusted with the functions of ensuring the formation and implementation of state policy on meeting the requirements of the UN Framework Convention on Climate Change, - Commission Secretary,

Deputy Minister of Foreign Affairs - Chief of Staff,

Deputy Minister of Finance - Chief of Staff,

Deputy Minister of Agrarian Policy and Food - Chief of Staff,

Deputy Minister of Infrastructure - Chief of Staff,

Deputy Minister Education and Science, Youth and Sports - Head of Staff,

Deputy Minister of Regional Development, Construction and Housing and Communal Services

deputy secretary of the National Security and Defense Council of Ukraine (by agreement),

Deputy Chairman of the State Land Committee,

Deputy Chairman of the State Forest Agency,

Deputy Chairman of the State Statistics Committee, Chairman of the Committee of the Verkhovna Rada of Ukraine on environmental policy, environmental management and liquidation of the consequences of the Chernobyl disaster (by agreement),

representative of the Secretariat of the Cabinet of Ministers of Ukraine,

as well as by agreement

the representatives of state bodies, local municipality bodies, academic institutions, non-governmental organizations, people's deputies of Ukraine.

{The first paragraph of paragraph 6, as amended by the Decree of the Cabinet of Ministers N 1208 (1208-2007-p) of 10.10.2007; as amended by Resolution of the Cabinet of Ministers N 1137 (1137-2011-p) of 07.11.2011; as amended up to Resolution No. 616 of CM (616-2015-p) of August 12, 2015}

The personal composition of the Commission is approved by its chairman.

The Chairman of the Commission is responsible for ensuring the holding of its meetings, organizing the monitoring of the implementation of decisions taken, coordinating the activities of the Commission with the relevant executive structures of the UN Framework Convention (995_044) and the Kyoto Protocol (995_801) to it.

(Clause 6, as amended up to Resolution No. 1262 (1262-2000-p) of the Cabinet of Ministers on August 11, 2000, as amended by Resolution No. 1150 of the Cabinet of Ministers (1150-2005-n) of December 7, 2005)

7. The organizational and technical support for the Commission’s activities is provided by the Ministry of Environment.

8. The main form of work of the Commission is meetings, which are held quarterly in accordance with the work plan of the Commission, approved by the Chairman of the Commission or, if necessary. {The first paragraph of paragraph 8 as amended by the Decree of the Cabinet of Ministers N 1208 (1208-2007-p) of 10.10.2007}

A meeting of the Commission shall be deemed to be valid, if it is attended by at least half of its members.

The decision of the Commission is considered to be adopted, if more than half of the members of the Commission present at the meeting in order to vote for it.

The decision of the Commission shall be drawn up in a protocol and signed by the Chairman of the Commission and in case of his absence - by his first deputy. (The fourth paragraph of paragraph 8 as amended by the Decree of the Cabinet of Ministers N 1262 (1262-2000-p) of August 11, 2000)

Annex VIII. List of current scientific projects aimed to research influence of climate change to agriculture production in Ukraine

Project aim	Organization	Author
Perform Ukrainian zoning based on climate change and existing predictions.	National University of Life and Environmental Sciences (NUBIP),Al-Farabi Kazakh National University (KazGU or KazNU) Ukrainian Gidrometeorologichny Center	O.Skrynik, S. Snizhko,T. Adamenko and other
Evaluate the soil and climate zone changes in Ukraine due to climate change.	NUBIP	S. Bulygin, N. Makarenko and other
Evaluate the spatial heterogeneity of the soil cover and its changes due to climate change.	NUBIP	Starodubtsev V.M., Aniskevych L.V. Basarab R. M. and other
Analyze irrigated lands changes in Ukraine since 1991 and the prospects for their recovery in connection with climate change and xerotization of soils due to warming.	Institute of Water problem and Reclamation (IWPIM), Institute of irrigated agriculture NAAS	Igor Yatsuk,Iuliia Danylenko,R. Vozhegova and other
Assess changes in the timing of snowmelt in Ukraine and yield losses on the plains with defined microrelief.	NUBIP	Starodubtsev V.M., Skrynyk O.A., Golub B.L., Rosamaha Y.O., and others
Assess the risks of intensification of water erosion during climate change.	NUBIP	Bulygin S.Y. and other
Adjustment of introduction norms and technologies of organo-mineral fertilizers and ameliorants during climate change	NUBIP	A. Bykin and other
Introduction of new bacterial fertilizers to improve soil productivity (Extrakon, N-fixing and Microbial P biofertilizers).	NUBIP	M.Patyka and others
Estimate changes in the quantity and quality of water resources in Ukraine as a source of irrigation, water supply, energy, etc.	Institute of Water problem and Reclamation (IWPIM), Institute of irrigated agriculture NAAS	Igor Yatsuk,Iuliia Danylenko,R. Vozhegova and other
Introduction of new technologies and soil tillage systems in agricultural crop cultivation systems.	NUBIP	H. Holyb,Aniskevych L.V. Rosamaha Y.O., and others
Application of aerospace methods for the analysis of environmental changes and crop management	Institute of Geological Sciences, NAS Of Ukraine, State institution "Scientific Centre for Aerospace Research of the Earth"	Golub B. L., Kokhan S.S., Starodubtsev V. M., Basarab R.M., Popov M.O. and other
Implementation of new methods of fertilizer and chemicals application on the fields using unmanned aerial vehicles (drones).	NUBIP	Lusenko V.P, Basarab R.M., Bykin A.V, Rosamaha Y.O., and others

Increasing the role of "Closed soil chambers" in agricultural production and introduction of new technologies in vegetable growing, automation control of technological processes, crops control.	NUBIP	Lysenko V.P. and others
Engineering and agro-irrigation restoration of Danube-Dniester Irrigation System	Institute of Water problem and Reclamation (IWPIM)	Igor Yatsuk, and others
Estimate land cover changes in river deltas as a result of river flow regulation as an ecological and economic resource.	State institution "Scientific Centre for Aerospace Research of the Earth", NUBIP	Golub B. L., Starodubtsev V. M., Basarab R.M., Popov M.O. and other
Investigate the formation of new deltas in the cascade of reservoirs on the Dnieper River and assess their ecological and economic importance		Golub B. L., Starodubtsev V. M., Basarab R.M., Popov M.O. and other