GOVERNMENT OF THE REPUBLIC OF ARMENIA

MINISTRY OF NATURE PROTECTION

TECHNOLOGY NEEDS ASSESSMENT REPORT

ADAPTATION TECHNOLOGY PRIORITIZATION

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TECHNOLOGY NEEDS ASSESSMENT REPORT

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FOREWORD

The impact of Armenia on global climatic system is not significant, our share in global emissions is only 0.014%. Highlighting the need of countries to combine their efforts in contending against climate, Armenia as a developing country, has obligation in limiting greenhouse gas emissions. The quantitative indicators of these contributions are summarized in the Intended Nationally Determined Contributions (INDC) of Armenia, which, as a result of comprehensive consultations, have been approved by both the Government of the Republic of Armenia and the civil society of Armenia and has been presented to the attention of Parties of the UN Framework Convention on Climate Change (UNFCCC). This document represents the official long-term Concept of our country aimed at implementation of the obligation under UNFCCC, and in addition to mentioned mitigation measures also includes climate change adaptation measures, as well as a component on transfer and development of technologies.

We consider the on-going UNEP/DTU TNA project as priority on mentioned technological mechanism, which will develop the path that will ensure continuous selection and implementation of modern and accessible technologies in Armenia, based on examples of several selected mitigation and adaptation projects. TNA project is also important for building of capacities on development and transfer of technologies, thus the results of its first phase are positive and promising.

First Deputy Minister of
Nature Protection of RA  **Simon PAPYAN**

List of abbreviations and acronyms

ADB	Asian Development Bank
AMD	Armenian Dram
ANAU	Armenian National Agrarian University
ArmCTCN	Armenian Climate Technology Centre and Network
AWSC	Armenian Water and Sewerage Company
BSEC	Black Sea Economic Cooperation
CARD	Center for Agribusiness and Rural Development
CIS	Commonwealth of Independent States
CJSC	Closed joint-stock company
CPS	Country Partnership Strategy
CTCN	Climate Technology Centre and Network
DTU	Technical University of Denmark
EBRD	European Bank for Reconstruction and Development
EIF	Enterprise Incubator Foundation
ENPARD	European Neighbourhood Programme for Agriculture and Rural Development
EPIU	Environmental Project Implementation Unit
EU	European Union
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIZ	German Corporation for International Cooperation
GWP	Global Water Partnership
HHMP	Hazardous hydro-meteorological phenomena
HPP	Hydropower plant
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
LLC	Limited liability company
LSGB	Local Self-Governance Bodies
MNP	Ministry of Nature Protection
MoA	Ministry of Agriculture
MoH	Ministry of Health
MSW	Municipal solid waste
MTAES	Ministry of Territorial Administration and Emergency Situations
NGO	Non-governmental organization
OECD	Organization for Economic Co-operation and Development
RA	Republic of Armenia
SDP	Sustainable Development Program
GEF SGP	The GEF Small Grants Programme

SME DNC	Small and Medium Enterprises Development National Center
SNCO	State non-commercial organization
TNA	Technology Need Assessment
TNC	Third National Communication
UDP	UNEP DTU Partnership
UMCOR	United Methodist Committee on Relief
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission of Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organizations
USAID	United States Agency of International Development
USD	United States Dollar
WUA	Water user associations
WB	World Bank
WFD	EU Water Framework Directive
WTO	World Trade Organization
WWTP	Wastewater Treatment Plant

List of figures

List of Tables

Contents

Report I

Technology Needs Assessment Report

Executive Summary

Technology needs assessment has been conducted in the Republic of Armenia to identify and prioritize the technologies that can help the country both to mitigate climate change and adapt to it. Armenia, as a landlocked mountainous country, is very vulnerable to negative consequences of climate change, thus making climate change adaptation an important element of development. It is already obvious that as a result of climate change the average air temperature in the country is and will be rising faster than the global average. Thus the promotion of adaptation of ecosystems and different sectors of economy needs to be initiated as soon as possible in order to avoid major losses.

The Project has been implemented under the overall supervision of the working group of Interagency Council for coordination of requirements and provisions of UN Framework Convention on Climate Change established by Decree N 955-A of Prime Minister of RA of October 2, 2012[1]. It includes representatives of respective ministries and public administration agencies, appointed by the order of Minister of Nature Protection of RA, thus ensuring broader involvement of decision-makers in technology needs assessment process. "Environmental Project Implementation Unit" State Institution adjunct to the Ministry of Nature Protection of RA has acted as the implementer of the Project, while National Focal Point for UNFCCC, Mr. Aram Gabrielyan, has been appointed as National Coordinator.

Based on the analysis of respective national documents and consultations with the working group of Interagency Council for coordination of requirements and provisions of UN Framework Convention on Climate Change there have been selected the sectors for conduction of technology needs assessment, and in case of adaptation, these include agriculture and water. For both sectors there have been established working groups, including project coordinator, expert team leader, sector experts and representatives of given sector.

Both for agriculture and water sectors there has been conducted an analysis of climate change vulnerabilities, based on which there have been identified the technological gaps, addressing of which will help adapting to expected climate change. The analysis has been based on existing models of climate change, including ones used in Third National Communication on Climate Change, all of which show that average air temperature in Armenia will continue rising, while the level of precipitations will be decreasing.

In line with the policy of RA Government, reflected in several documents, including Intended Nationally Determined Contributions of Armenia[2], technology needs assessment process has been based on ecosystem approach, which requires giving of preference to balanced and combined actions. According to Armenian INDC, "*adaptation strategy and contributions are based on the requirement of the UNFCCC Article 2 "Objective", which stipulates to restrain climate change within timeframe sufficient to allow ecosystems to adapt naturally to climate change*". Accordingly, ecosystem approach to adaptation is considered a key element of adaptation strategy of Armenia. It is in line with country's environmental policy and can ensure synergy with respective international conventions and treaties, establishing a basis for inter-sectoral cooperation and supporting cross-border cooperation.

[1] https://www.e-gov.am/decrees/item/11373/

[2] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Armenia/1/INDC-Armenia.pdf

The overall process of technology needs assessment has been open and transparent to ensure wide participation of interested parties in selection and prioritization of technologies in respective sector. After the selection of sectors there have been sent invitations to over 140 stakeholders suggesting to submit information on technologies related to agriculture or water sectors. These included public administration agencies, communities, scientific and educational institutions, private sector, civil society organizations and international donor community.

As a result of work of sector experts and stakeholders there have been identified 10 technologies for water and 12 technologies for agriculture sectors, which have been included in the analysis. For these there have been developed fact sheets, in respective formats, for presenting to stakeholders. Afterwards there has been organized a meeting with stakeholders to present the technological fact sheets and discuss the assessment criteria pre-selected by sector experts together with expert team leaders and project coordinator. Over 50 stakeholders have participated in a meeting held in Yerevan on November 11, 2015, during which they have approved the assessment criteria and familiarized with the short-list of technologies. The assessment itself has been conducted by sending technological fact sheets to all stakeholders by e-mail, together with the criteria, which included:

- Relevance to national strategies/programs
- Ease of implementation
- Compliance with ecosystem approach
- Promotion of private investments
- Promotes adaptation to negative impacts of climate change
- Investment cost
- Need for additional institutional capacity
- Poverty reduction potential
- GHG emissions reduction potential
- Promotion of increased efficiency of use of agro-climatic resources (increased agricultural output) (**for agriculture sector**) *and* Increased water use efficiency potential (**for water sector**).

As a result of the assessment the following technologies have been prioritized by the stakeholders:

Agriculture	**Water**
• Windbreaks as climate change adaptation tool	• Creation of circulatory water system for fisheries
• Local melioration and low-volume drip irrigation for newly planted orchards	• Installation of compact treatment plants and Application of natural and hybrid treatment systems
• Diversification of agriculture	• Spreading and expansion of drip irrigation system

Since project guidelines require determining three most prioritized technologies for further analysis within the framework of the Project, it has been decided to unite interrelated 2nd and 3rd technologies of water sector, in order to include the drip irrigation technology in the future analysis, which is very important for Armenia, taking into consideration the existing trends of precipitations, as well as the key role of agriculture sector in Armenian economy.

Taking into consideration that thanks to invitations on submission of technologies sent to stakeholders and discussions held with respective specialists there is a potential for submission of more technological fact sheets in the future, it is obvious that technology needs assessment process can become an on-going one, if there are respective will and institutional capacity. Thus it is recommended to develop an Armenian Climate Technology Center and Network (ArmCTCN) that can coordinate these activities after the end of TNA Project in Armenia or become its next phase.

Chapter 1. Introduction

1.1 About the TNA project

First technology needs assessment has been conducted in the Republic of Armenia in 2003, within the framework of "Armenia – Country Study on Climate Change. Phase II" Project implemented by the Ministry of Nature Protection in cooperation with United Nations Development Programme, and has been financed by Global Environmental Facility.

Main objective of "Capacity Building in the Republic of Armenia for Technology Needs Assessment and Technology Transfer for Addressing Climate Change Problems" Report produced as a result of Project implementation has been identification and assessment of technological needs related with reduction of greenhouse gas emissions and eradication of the consequences of climate change, as well as creation of conditions for transfer of these technologies. With regards to climate change adaptation it particularly presents the vulnerability assessment results for water resources, agriculture, environment and public health, as well as technologies needed for adaptation to climate change in these areas.[3] The Report has also included the analysis of current situation in economic sector of Armenia with highest GHG emission and changes in emissions for the period of 1990-2000.

Current exercise has been started in 2015 and is implemented under Phase II of GEF-Funded Technology Needs Assessment Project in cooperation with the Ministry of Nature Protection of the Republic of Armenia. Technology Needs Assessment Report has been prepared under the guidance of UNEP/DTU Partnership. The objective of present Report is to identify the most vulnerable sectors of the country in terms of climate change risks and potential technologies needed for the adaptation of those sectors to climate change impact, as well as the priorities of these. This process is important for achieving development of the country while taking into consideration issues related to climate change, such as adaptation to its forecasted negative impacts and reduction of GHG emissions.

The study is based on ecosystem approach, which is one of the key elements of environmental policy of RA Government and implies ensuring the process of integrated and comprehensive management of natural resources.[4]

As other important processes have been developing in parallel with TNA, such as determining of Intended Nationally Determined Contributions of the Republic of Armenia under UN Climate Change Framework Convention, these have been coordinated to ensure integrity and interlinkage of different activities implemented in climate change sector. Bases and approaches to adaptation recommended by INDC have been used for preparation of this report (see Box 1).

Box 1.

1) Adaptation strategy and contributions are based on the requirement of the UNFCCC Article 2 "Objective", which stipulates to restrain climate change within timeframe sufficient to allow ecosystems to adapt naturally to climate change. Thus, the natural ecosystems adaptation approach in INDC is considered pivotal for Armenia's adaptation strategy and actions (contributions), and a basis for the development of the national adaptation plan.
2) The Republic of Armenia embraces the ecosystem approach for adapting to climate change. The approach is in harmony with the environmental policy of the country, can ensure synergy with other international environmental conventions and treaties, will lay the ground for inter-sectoral coordination, and will support establishment of cross-border cooperation and solidarity

[3] http://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TNR_CRE/e9067c6e3b97459989b2196f12155ad5/19789a07b4de493cb72e43c47fd4db1e.pdf

[4] Excerpt N 24 from the minutes of RA Government meeting of June 23, 2011

environment.

3) Adaptation activities will be prioritized based on the most vulnerable sectors to climate change:
   a. Natural ecosystems (aquatic and terrestrial, including forest ecosystems, biodiversity and land cover)
   b. Human health
   c. Water resource management
   d. Agriculture, including fishery and forests
   e. Energy
   f. Human settlements and infrastructures
   g. Tourism

It is also important that INDC stresses the need for adequate technological assistance and existence of respective conditions for technology development and transfer. This has to be done via development of adequate institutional mechanisms for overcoming of barriers for the introduction of innovative technologies on climate change mitigation and adaptation. Among other elements these should include proper legal protection of intellectual property rights. Cooperation and experience exchange with Climate Technology Center and Network (CTCN) and establishment of similar mechanism at the national level can become a logical continuation of the TNA process.

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

i. Armenia: Background Information

The Republic of Armenia declared independence on August 23, 1990, with Yerevan as its capital, and was officially recognized as such in 1991, after the collapse of the Soviet Union. Armenia became a member state of the United Nations since March 2, 1992. It is also a member of the Commonwealth of Independent States (CIS) since December 21, 1991; the Black Sea Economic Cooperation (BSEC) since May 1, 1999; the Council of Europe since January 25, 2001, the World Trade Organization (WTO) since February 5, 2003 and Eurasian Union since January 1, 2015. Since 1993, the Republic of Armenia is a party to the United Nations Framework Convention on Climate Change (UNFCCC). In 2002, Armenia ratified the Kyoto Protocol.

ii. Geography

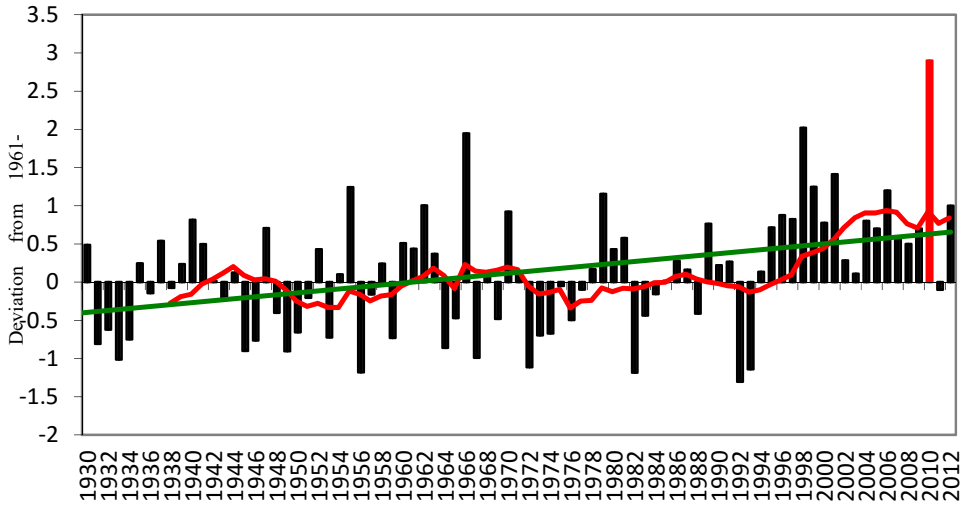
Armenia is a landlocked mountainous country located in South Caucasus region, between the Back and Caspian Seas. It borders with Georgia on the north, Azerbaijan on the east, Iran on the south and Turkey on the west. It has an area of 29,743 km^2, about half of which has an elevation of at least 2,000 meters above the sea level, while only 3% of territory is below 650 meters.

iii. Climate

Armenia has continental climate with dry and warm summers (temperatures fluctuate between 22-36 C^0) and relatively cold and snowy winters (temperatures – between -10 and -5 C^0). Springs are short and autumns are quite long. Due to topography of the country the climate varies significantly in different parts of the country and at different altitudes. Climate zones vary from dry subtropics in the southern and north-eastern parts of the country to mountain tundra at higher elevations. Average annual precipitation levels vary from 235 mm in Ararat valley to over 1,000 mm on Aragats Mountain.

However, both temperature and precipitation characteristics are changing due to climate change. The Figure 1 below shows the air temperature trends during 1930-2012, clearly indicating that the air temperature is rising, and at a higher pace than the global average.

Figure 1. Air temperature deviation from 1961-1990 average.[5]



iv. Demographics

As of 2014 the population of Armenia was 3,017.1 thousand, over 30% of which lived in Yerevan, and urban population made up over 63% of the total population. The maximum population density of 686 persons/km^2 is on the altitudes under 1,000 m, and the minimum (22 persons/km^2) is on altitudes of 2,000-2,500 m. Yerevan is the largest city of Armenia (1,068.3 thousand residents in 2014), followed by Gyumri (119.9 thousand residents in 2014), and Vanadzor (84.3 thousand residents in 2014).

v. Economy

After the dramatic economic downturn immediately following the independence in 1991-1993, Armenian economy started to grow increasingly faster. The annual rate of economic growth in 1995-2000 was 5.4%, increasing to as high as 12.4% during 2001-2006. As a result of 2009 global economic crisis the economy declined by 14.1%. During 2007-2012 the average economic growth rate was 3.3%.

In 2013 gross domestic product of Armenia at current prices was AMD 4,272 billion (USD 10,431 million), and GDP per capita was AMD 1,413 thousand (USD 3,452). As a result of market reforms the economic structure changed from mostly industrial to service and agricultural. Service sector has provided 38.0% of gross profit in 2012, while agriculture has provided 31.4%

vi. Legislation, Development Papers and Reports

Strategic Development Programme of the Republic of Armenia for 2014-2025. The document sets out the overall priorities of socio-economic development of the Republic of Armenia, its goals, the main barriers and constraints to development, and the key reforms and policy instruments needed for achieving priority goals.

SDP covers the period of 2014-2025 and is the country's main socioeconomic development strategy and the basis for medium-term, sectoral and other programme documents.

[5] Figures are based on Third National Communication on Climate Change of the Republic of Armenia, if different is not mentioned.

SDP is the primary guide of the Government and is based on the following four priorities, (1) growth of employment, (2) development of human capital, (3) improvement of social protection system, and (4) institutional modernization of public administration and governance.

The Programme includes provisions regarding the need for risk management in agriculture sector, namely:

- Introduction of agricultural insurance, which shall require assessment of insurance risks in agriculture, based on the results of which there shall be conducted developed of mechanisms for introduction of insurance system,
- Intensification of activities aimed at protection from hazardous atmospheric phenomena, such as hail.

The document also stresses the importance of minimization of environmental risks in parallel with the efforts aimed at ensuring high rates of economic growth. Among others these refer to overexploitation of water resources caused by rapid development of sectors of the economy relying on use of grounds water resources and climate change, as well as increasing danger of desertification.

2010-2020 Sustainable Rural and Agricultural Development Strategy of the Republic of Armenia. The document reflects the importance of addressing of risks related to natural disasters and implementation of adaptation measures, namely, introduction of agricultural insurance. Another important direction is implementation of mud-flow management and land erosion control. Other activities aimed at risk management include piloting of anti-hail systems, introduction of water efficiency technologies, regulation of irrigation water use in drought and water scarcity conditions, etc.

The Law of the Republic of Armenia on Agricultural Cooperatives adopted on December 21, 2015, regulates relationship related to establishing, membership, conduction of activities, implementation, cessation of activity, reorganization, and liquidation of agricultural cooperatives and unions of these and establishes the rights, duties and responsibilities of members of these, as well as the directions of state support of agricultural cooperatives.

The objective of the Law is elimination of barriers limiting sustainable development preventing effective development of agriculture sector, such as small size of farms and fragmentation of land plots developed as a result of land privatization in the beginning of 1990s. Development of cooperatives can promote better coordination of activities between farmers, thus potentially helping climate change adaptation efforts.

Third National Communication on Climate Change. The document provides important information regarding the climate change trends and vulnerability profile of the country. Among the most important phenomena there needs to be mentioned 1.03 C^0 increasing of annual mean air temperature during 1935-2012, as well as 10% decreasing of annual precipitations over the same period. As for hazardous hydro-meteorological phenomena, the frequency of these has also increased with maximum aggregate number of 245 HHMP observed in 2004, and minimum number, 106, in 2006. Extreme frost events have also become more frequent, similar to the number of days with heavy rainfall and hailstorms caused by the recurrence of high cyclones.

Climate change in Armenia is assessed using the CCSM4 model in accordance with IPCC-recommended RCP8.5 (A2) and RCP6.0 (B2) scenarios for emissions. Future climate change projections for temperature and precipitation have been developed up until 2100. Average annual temperature increase projections in the territory of Armenia related to 1961-1990 average show

that, in A2 scenario, the temperature will increase by 1.7 C^0 in 2040, by 3.2 C^0 in 2070, and by 4.7 C^0 in 2100. In B2 scenario, the temperature will increase by 1.3 C^0, 2.6 C^0, and 3.3 C^0, respectively.

According to A2 scenario, the river flow aggregate volume in the Republic of Armenia will decrease by 11.9% by 2030, by 24% by 2070, and 37.8% by 2100 (compared to the 1961-1990 baseline period).

Table 1. Projected changes in aggregate river flows.[6]

Year	Flow, million m^3	Flow change	
		million m^3	%
1961-1990	5,797.0	0	0
2030	5,141.6	-655.0	-11.9
2070	4,405.6	-1,391.5	-24.0
2100	3,602.2	-2,195.0	-24.4

Major negative consequences for Armenian agriculture under projected climate change will include the following: (1) Agro-climatic zones will shift 100 m upward by 2030, and 200-400 m by 2100; (2) Reduced crop yields as a result of temperature increases, reduced rainfall, and increasing evaporation from the soil surface; (3) Reduced productivity and degradation of agricultural land; (4) Increasing negative impact of extreme weather events due to expected increases in their frequency and intensity; (5) Expansion of irrigated land areas and the need for additional irrigation water; (6) More intensive degradation of land, including natural grazing land.

Table 2. Projected impact of climate change on crop yields in 2040-2050.[7]

Crop	Crop productivity changes by cultivation zones		
	Lower (<1,000 m)	Middle (1,001-1,700 m)	Upper (1,701-2,500 m)
Irrigated land			
Alfalfa	-5%	-7%	-2%
Apricot	-5%	-5%	-5%
Grapes	-7%	-5%	-5%
Potatoes	-12%	-9%	-5%
Tomatoes	-16%	6%	50%
Watermelon	-12%	10%	Not cultivated
Wheat	-6%	1%	38%
Rain-fed land			
Alfalfa	-3%	-8%	-1%
Apricot	-28%	-7%	-5%
Grapes	-24%	-12%	-1%
Potatoes	-14%	-14%	-8%
Tomatoes	-19%	-8%	34%
Watermelon	-18%	0%	Not cultivated
Wheat	- 8%	1%	38%

The Law of the Republic of Armenia on National Water Programme of the Republic of Armenia. The Law regulates relationship related to National Water Programme, including the assessment of water

[6] Hovsepyan A., Melkonyan H., Petrosyan Z., Sahakyan V., Astsatryan H., Shoukourian Yu. Climate Change over South Caucasus based on Regional Climate Model Simulations// Conference Proceedings "Computer Science and Information Technology".- Yerevan.- 2011

[7] Егиазарян Г.М., Геворгян А.Р., Мартиросян Р.М. Воздействие дефицита норм орошения на урожайность сельскохозяйственных культур//Известия аграрной науки.- 2009.-N3.-С.33-37 (Yeghiazaryan G.M., Gevorgyan A.R., Martirosyan R.M., Impact of deficit of irrigation norms on yield of agricultural crops// News of agricultural science.-2009.-N3.-P.33-37)

resources, water demand and supply, main objectives and perspectives of water sector protection and development. The objective of the Law is satisfaction of demand for water via efficient management of usable water resources, establishing of environmental protection, regulation and use of water resources, etc.

The Law of the Republic of Armenia on Fundamentals of National Water Policy. The objective of the Law is ensuring accessibility of water resources for different needs, including social and economic development and environment, today and in the future.

Fundamentals of National Water Policy include the following directions: (1) sustainable management of water resources, (2) priorities of water resources use and protection, (3) accounting and assessment of water resources, (4) development of water resources demand and supply, and (5) relationships related to water basin management.

2015-2017 Medium-Term Public Expenditure Framework of the Republic of Armenia. The main objective of the document is increased efficiency of management system of public expenditures. Climate change issues are also covered by the document, namely, within the framework of its impact on agriculture, where the Government clearly indicates adverse effects of changing climate. The document also fixes that climate change and other environmental issues have anthropogenic reasons and require immediate solutions.

2011-2015 State Programme on Prevention of Malaria Importing and Rooting the Republic of Armenia. The Programme is aimed at prevention of spreading of malaria on the territory of the Republic of Armenia, which is currently free of it, and one of the key elements behind the need for development of such measures is climate change, causing increasing of mean air temperature, which creates favorable conditions for growth of mosquito population in aquatic areas.

Other relevant documents include Decrees of RA Government on:

- Adoption of the procedure for monitoring of lands (N 276-N of February 19, 2009),
- Approval of program of activities emerging from RA concept for ensuring food security in the Republic of Armenia (N 1522-N of October 13, 2011),
- Approval of national strategy for natural disaster risks reduction, and action plan for implementation of national strategy for natural disaster risks reduction (N 281-N of March 7, 2012,),
- Approval of Arpi Lake National Park 2011-2015 management plan (N 1854-A of December 22, 2011),
- Establishing of Zangezur Reserve (N 1187-N of October 15, 2009),
- Establishing of Arevik National Park (N 1209-N of October 15, 2009),
- Merger of Shikahogh and Arevik National Park SNCOs, creation of Zangezur Biosphere Complex SNCO, as well as on approval of the statute of Khustup State Sanctuary, and on amendments in a number of RA Government decisions (N 1465-N of December 19, 2013),
- Approval of 2012-2016 strategy programme for preventing and fighting against infectious diseases, and the list of measures to be implemented under the strategy programme (N 1913-N of December 29, 2011),

and excerpts from the minutes of meeting of RA Government on:

- Approval of 2011-2015 state programme for prevention of malaria invasion and ecesis in the Republic of Armenia, and the list of 2011-2015 measures for prevention of malaria invasion and ecesis (N 23 of June 17, 2012),
- Approval of the programme for fighting against infectious disease transmitters in Armenia, and 2014-2018 schedule for implementation of measures under said programme (N 22 of May 29, 2014).

1.3 Vulnerability assessments in the country

Armenia is vulnerable to climate change due to its mountainous terrain and arid conditions. Moreover, it is one of the most sensitive countries in terms of climate change among the countries of Europe and Central Asia, as stated by the World Bank[8]. Existing desertification processes will further accelerate due to increasing of temperatures and reduction of precipitations. Other negative consequences of these include reduction of ecosystem services, as well as emergence of new risks for human health and sectors of economy that are climate-dependent. For instance, agriculture will be one of the major sectors of the economy to be affected by declining precipitation, especially, taking into consideration that large portions of agricultural lands depend on rain as the only source of water. Energy sector, namely hydro-power plants, is another sector that will be affected by climate change, as reduced river flow will cause reduction in electricity generation. Forecasted intensification of extreme climatic events will have adverse effects for human health, property, agriculture and infrastructure. Natural ecosystems will also be affected by climate, including the biodiversity, forests, wetlands, etc.

Taking this into consideration, during recent years, within the framework of climate change national communications, the hydrometeorological service of the Republic of Armenia has developed climate change scenarios, including ones for the regions of the country.[9] Particularly, Vayots dzor province has been selected as a pilot region for the assessment of vulnerability to climate change and development of adaptation measures[10]. The choice of the region has been justified by its great diversity of climate conditions, relative diversity of economic sectors, as well as weaker influence of humans on nature in comparison with other provinces.

Review of air temperature trends in the Republic of Armenia clearly indicates that there is a steady increasing of not only annual mean temperatures, as presented above, but also increased frequency of extreme temperatures. The absolute maximum temperature of $43.7C^0$ for the whole period of meteorological observations in Armenia has been recorded in Meghri region in 2011, exceeding the previous record by $0.7C^0$. Figures 2 and 3 below provide more details on average temperature trends in summers and winters, respectively.

[8] Reducing the vulnerability of Armenia's agricultural systems to climate change: impact assessment and adaption options, Yerevan, World Bank, 2014

[9] Melkonyan H., Hovsepyan A., Hovhannisyan D., Vardanyan L., Climate Change Modeling assessment in the area of Armenia/ National Academy of Scientific-technological newsletter- Yerevan-2009

[10] Development of adaptation plan of Vayots Dzor region of Armenia under climate change, UNDP, 2014

Figure 2. 1935- 2011 average summer temperatures.

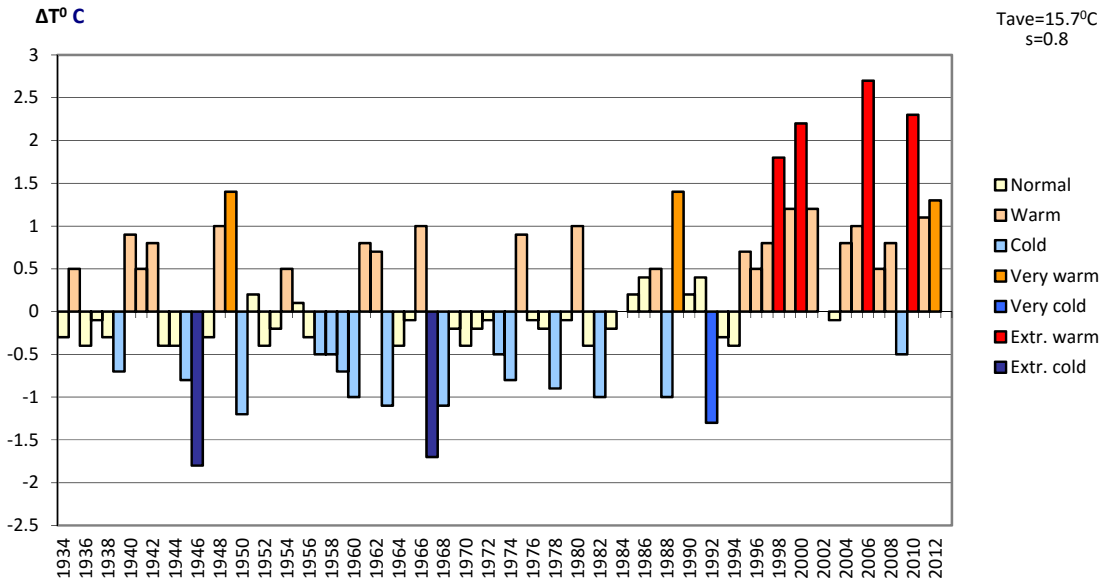
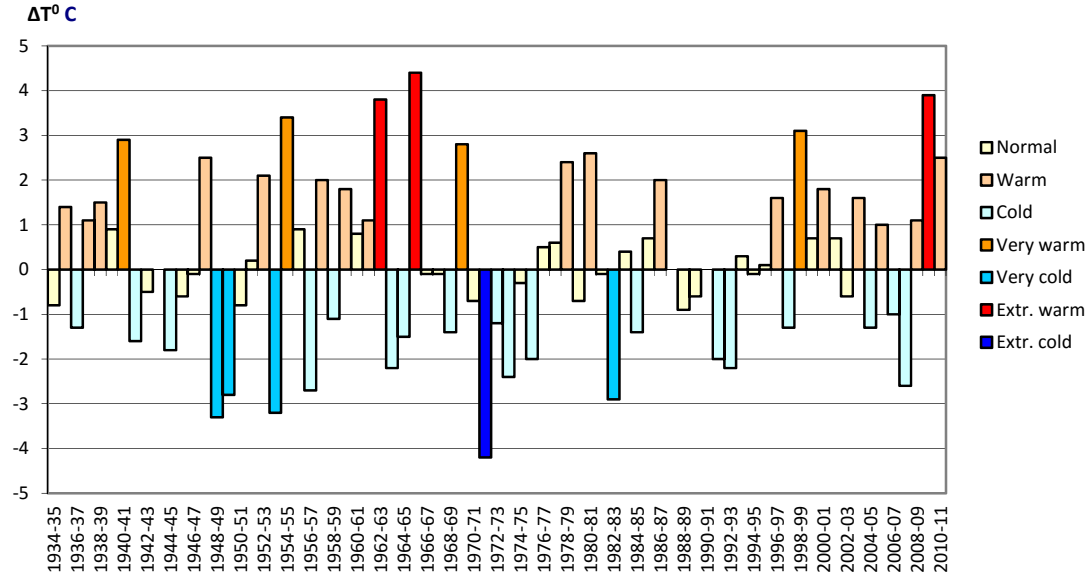
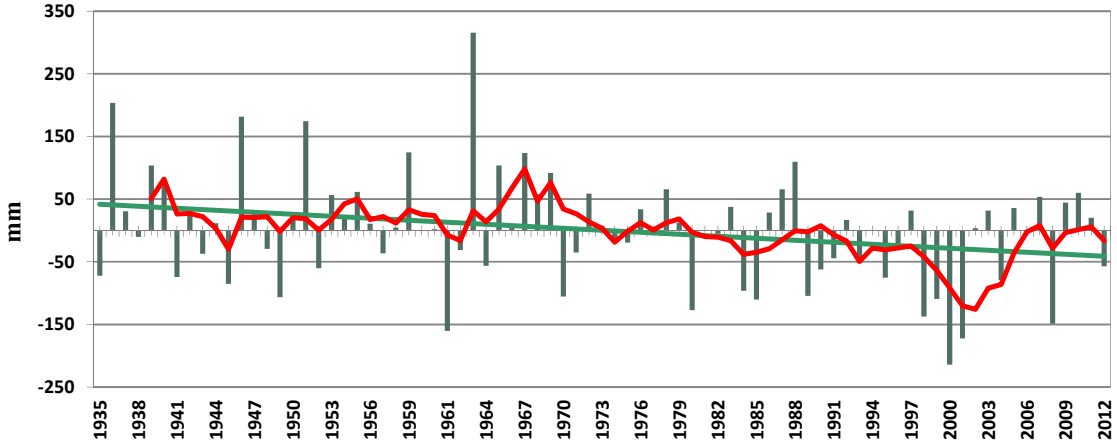


Figure 3. 1935- 2011 average winter temperatures.



As it has been mentioned above, the level of precipitation is also declining due to climate change. Observations show that while during 1935-1996 the decrease in annual precipitation was only 6%, in 1935-2012 it has already been 10% (see Figure 4). Also, it has to be mentioned that precipitations have different trends in different regions of the country. While north-eastern and central regions of Armenia become more arid, in southern and north-western regions the level of precipitation has increased during the last 80 years.

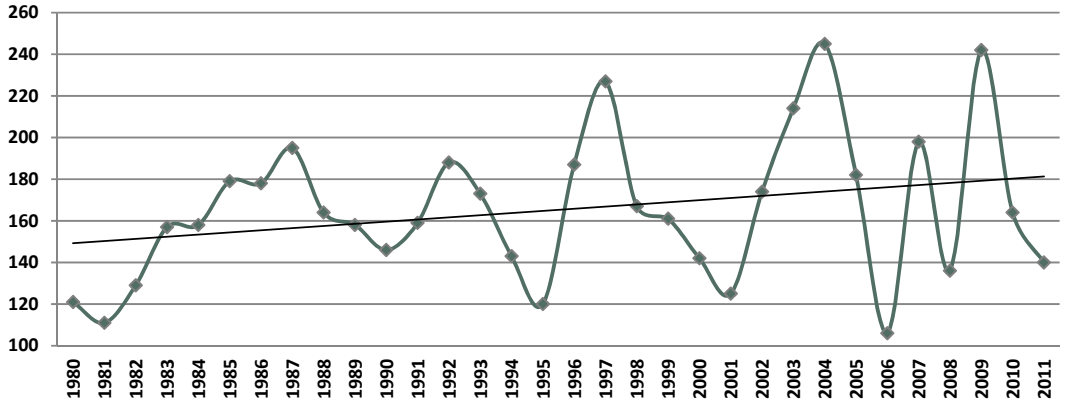
Figure 4. Deviation of annual average precipitation in the territory of Armenia from the average of 1961-1990.



Another significant consequence of climate change is the increased frequency and intensity of extreme hydro-meteorological events globally and in Armenia. As a result, there has also increased the damage to the various aspects of human activities caused by these. Also hail, frost, strong winds, heavy rainfall, droughts, heat waves contribute to general and intensification of other natural disasters, such as landslides, mudflows, forest fires, rock-falls, etc.

The analysis of most frequent phenomena observed in Armenia during 1980-2012 has shown that the maximum number of hazardous events has been observed in 2004, and the minimum has been in 2006, 245 and 106, respectively (see Figure 5). Shirak holds the record in terms of the amount of hail, while Tashir and Ijevan regions lead in terms of heavy precipitations. Ararat Valley is the riskiest in terms of frost events.

Figure 5. Number of extreme hydro-meteorological events in 1980-2012.



CCSM4 model is used to assess climate change in the Republic of Armenia, in accordance with RCP8.5 and RCP6.0 scenarios for CO2 emissions, recommended by IPCC. According to RCP6.0 scenario (equivalent of SRES B2 scenario), by 2100 CO_2 concentration will reach 670 ppm, while according to RCP8.5 it will be 936 ppm. Forecasts for ambient air temperature developed up to 2100 indicate that it will continue increasing during the whole year. RCP8.5 scenario forecasts that by 2100 the average annual temperature in Armenia will reach $10.2C^0$ exceeding the baseline (1961-1990) by $4.7C^0$.

Results of analysis of precipitation trends show that by mid-century annual precipitation in Armenia may increase by 16.3%, in accordance with RCP8.5 scenario, while RCP6.0 scenario shows no changes in precipitation. However, this refers to annual averages, while summer precipitation will decrease significantly in accordance with both of scenarios (see Table 3).

Table 3. Changes in annual and seasonal precipitation in the territory of Armenia compared to the average of 1961-1990, mm[11]

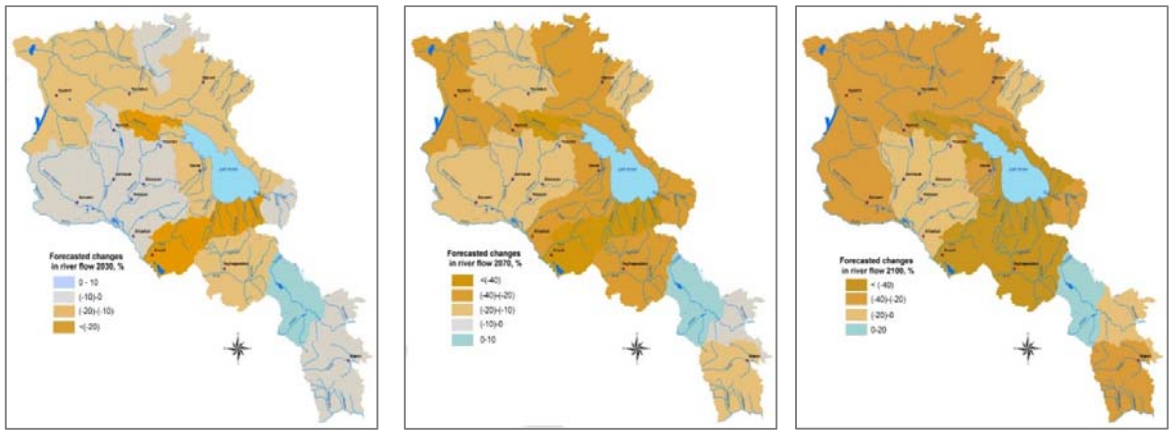
Season	1961-1990 average	Scenarios	2011-2040	2041-2070	2071-2100
Winter	114	RCP, 6.0	5.3	5.8	6.2
		RCP, 8.5	-5.7	16.3	2.9
Spring	211	RCP, 6.0	1.2	4.2	2.6
		RCP, 8.5	4.2	-8.0	2.4
Summer	148	RCP, 6.0	-10.1	-10.8	12.8
		RCP, 8.5	-23.0	-3.4	-13.0
Autumn	119	RCP, 6.0	5.0	3.2	1.2
		RCP, 8.5	2.5	8.6	13.6
Year	592	RCP, 6.0	5.3	5.8	6.2
		RCP, 8.5	-5.7	16.3	2.9

While in most of the regions of the country summers are already dry and hot, these characteristics will worsen further, as a result creating several issues for sectors depending on water supply or otherwise related to it, such as agriculture, energy and healthcare.

Water is extremely important for Armenia's development, especially for agriculture, where 80% of crops are produced on irrigated lands, and energy (up to 40% of power generation of the country is provided by hydro energy). Besides, ground water provided 96% of potable water (2013).

Armenia has uneven spatial distribution of water, with water scarcity issues in central part of the country, where the population is the densest. While Hrazdan River is the main source of water in this part of the country, it has significant annual flow fluctuations, reaching up to 50%. The projected changes in river flows in Armenia are shown in Figure 6 below.

Figure 6. Projected changes in river flows in Armenia for 2030, 2070 and 2100.



2030 **2070** **2100**

Agriculture is one of the most important sectors of Armenian economy, accounting for around 20% of GDP. While the main goal of the sector is provision of 75-80% of basic foods produced

[11] Third National Communication on Climate Change of the Republic of Armenia

domestically, it is also one of the most vulnerable and dependent sectors from climate perspective. As a result, climate change will have a direct impact on the sector, creating more risks for it. Droughts, hails, early frost and other adverse weather phenomena occur almost every year, damaging crops in different parts of the country, namely, during 2009-2013 damage to agriculture caused by these is estimated at around AMD 72 billion or USD 177 million.

Several objective and subjective reasons, such as vertical zonation, mountainous terrain, land shortage, etc., create significant risks for the agriculture. Average person can have access to only 0.14 ha of arable land, while up to 80% of the land is in different phases of desertification processes, mostly caused by irrational use. Climate change will add to these and worsen the situation further. It will result in the following main consequences: (1) shift of agro-climatic zones 100 meters upwards and 200-400 meters by 2030 and 2100, respectively, (2) reduction of crop yield caused by reduction of rainfall, increased temperatures and evaporation, (3) reduced fertility of agricultural land, (4) increased damage from more frequent and intensive extreme weather events, (5) increased demand for irrigation water, and (6) intensification of land degradation.

Changing agro-climatic zones will result in increased percentage of irrigated land, thus putting more pressure on already vulnerable water resources. Over 200 thousand ha of land is irrigated in Armenia, and the temperature rise will result in increased demand for irrigation water (See Table 4).

Table 4. Additional water demand for crop production by irrigation zone[12]

Irrigation zones	Altitude from sea level, m	Additional water demand by 2100 in comparison with current water demand norm, million m^3
Ararat valley	900-1800	172.0
Shirak	1400-2200	13.2
Lake Sevan basin	1900-2200	2.04
Northeastern	400-1400	4.2
Lori-Pambak	900-1700	6.6
Vayots Dzor-Syunik	700-2200	4.04
Total		**202.08**

Natural ecosystems and biodiversity will also be affected by climate change. Studies conducted in this direction during recent years show that forest ecosystems[13], rare flora[14] and fauna[15] species and Lake Sevan[16] are especially vulnerable to adverse effects of climate change.

Forests cover about 11% of the territory of Armenia or nearly 350 thousand ha. Due to diversity of climate conditions of the country forests in different parts of Armenian and at different altitudes have different structure and composition. While oak forests grow in nearly all forested areas, beech

[12] Reducing the vulnerability of Armenia's agricultural systems to climate change: impact assessment and adaption options, Yerevan, World Bank, 2014

[13] Fayvush G., Kalashyan M., Manvelyan K., Nalbandyan A. Forest Biodiversity of Armenia's Syunik Marz and Global Climate Change. 2008

[14] Fayvush G. Some changes in alpine flora and vegetation of Armenia under Global Climate Change impact // Frei, E.R.; V.; Rixen, C.; Wipf, S. (eds) 2013: Faster, Higher, More? Past, Present and Future Dynamics of Alpine and Arctic Flora under Climate Change. Abstracts. International conference, September 22 to 25, 2013 Bergün, Switzerland. Birmensdorf, Swiss Federal Institute for Forest, Snow and Landscape Research WSL.

[15] Williams, J.E., A.L. Haak, H.M. Neville, W.T. Colyer. Potential consequences of climate change to persistence of cutthroat trout populations// North American Journal of Fisheries Management.- 2009.-29.-P.533-548.

[16] Ecology of Lake Sevan in the Period of Water Level Rise. Results of investigations of Russian-Armenian Biological Expedition on Hydroecological Study of Lake Sevan (Armenia) (2005-2009). Makhachkala: Nauka. 2010.- 348p.;

forests mostly grow in the north of the country and on northern slopes. There are also low-stand density birch, alpine maple and mountain ash forests growing in sub-alpine zones.

Risks related to forests are mostly due to shift of vertical zone and resulting changes in ecosystems, wildfires, diseases and pest. It is expected that as a result of these Armenia may lose up to 17.5 thousand ha of forests by 2030, if no adaptation measures are implemented.[17] Certain projects are implemented towards preventions of wildfires, but more needs to be done in order to manage the increased frequency of the latter.

Rare flora species will be most vulnerable to climate change due to their narrow ecology. If these do not find new habitat areas, it is expected that as a result of ecosystem changes about 238 species will be significantly impacted, while conditions for 140 species will improve. As for studied fauna species, the impact of climate change will be favorable for some of these, while others will be affected extremely adversely. [18]

Despite its status of the most important water ecosystem of the country Lake Sevan has been long subjected to adverse anthropogenic effects, the most significant of which has been the dropping of water level by more than 20 m, resulting in changes of lake's thermal conditions and ecosystem. Increasing of the water level by 3 meters since 2003 has resulted in further changes of ecosystem.

Forecasted increasing of water temperature in Lake Sevan by up to $4C^0$ by 2100 caused by climate change the cold-water fish species will be subject to serious threat and may be replaced by thermophilic species, though overall fish production can increase. At the same time rapid increasing of the number of carp species may have serious effect on native species due to reduced availability of feed.

Climate change will also affect human health, mainly through temperature rising, changes in precipitation patterns, etc. It can have direct and indirect effect, with the first including increase in accidents caused by extreme weather events, while the latter will be associated with increased human morbidity rate caused by changes in temperature and precipitation. Increased number of days with extreme temperatures and volatility of atmospheric pressure associated with climate change can have adverse effects on human health. Climate change can also become a reason for spreading of currently uncommon diseases, causative agents, carriers and natural foci of which are present in Armenia. These include dangerous infections like plague, tularemia, anthrax, western tick-borne encephalitis, hemorrhagic fever with renal syndrome, Crimean-Congo hemorrhagic fever, West Nile fever, brucellosis, Q-Fever, as well as other dangerous infections such as cholera, malaria, tick typhus, leishmaniasis, leptospirosis, etc.[19]

[17] Fayvush G., Kalashyan M., Manvelyan K., Nalbandyan A. Forest Biodiversity of Armenia's Syunik Marz and Global Climate Change. 2008

[18] Fayvush G. Some changes in alpine flora and vegetation of Armenia under Global Climate Change impact // Frei, E.R.; V.; Rixen, C.; Wipf, S. (eds) 2013: Faster, Higher, More? Past, Present and Future Dynamics of Alpine and Arctic Flora under Climate Change. Abstracts. International conference, September 22 to 25, 2013 Bergün, Switzerland. Birmensdorf, Swiss Federal Institute for Forest, Snow and Landscape Research WSL.

[19] Котанян А.О., Мкртчян С. Г. Особенности климато-погодных условий г. Еревана и оценка влияния повышенной летней температуры на здоровье // Матер. Междун. заочн. научно-практ. конфер., Вопросы современной медицины- Новосибирск, 2011.-Ч. II (Kotanyan A.O., Mkrtchyan S.G. Peculiarities of climatic-weather conditions of Yerevan and assessment of impact of increased summer temperature on health // Materials of international distant scientific-practical conference, Issues of modern medicine- Novosibirsk, 2011.-P. II)

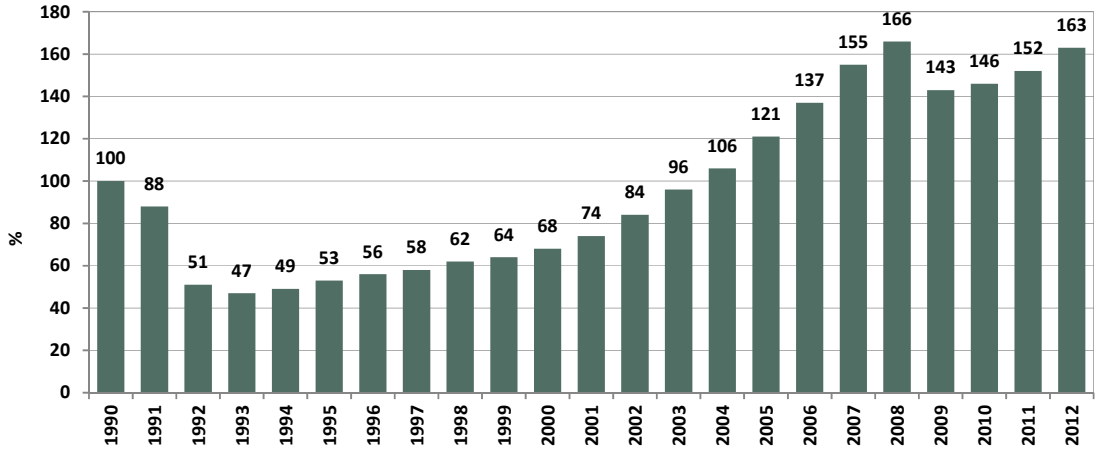
1.4 Sector selection

1.4.1 Overview of key sectors of Armenian economy

i. Economy

During the Soviet period Armenian economy has been mostly industrial and included sectors such as chemicals, electronics, machinery, processed food, synthetic rubber, textiles, etc. The share of agriculture in the economy of the Republic has been only 20%, while providing 10 % of total employment. Mining and energy sectors have been the other important sectors. The first one has been specialized in production of copper, zinc and gold, while the latter is known for the Armenian Nuclear Power Plant and developed hydro energy.

Figure 7. GDP dynamics of Armenia for 1990-2012 compared to 1990, %



Source: Armenian National Statistical Service (1990-2013)

As a result of breakdown of centrally planned economy, traditional trade channels, as well as the blockade by Azerbaijan and Turkey only few industrial enterprises have been able to survive, so the industrial sector shrank dramatically. In its turn, by 1993 GDP of the country has fallen by around 60% in comparison with 1989. Following this period of crisis Armenia has registered strong economic growth since 1995 thanks to development of new sectors, including precious stone processing and jewelry making, communications, etc. (See Figure 7 for details).

In the beginning of 2000s Armenian economy has been among the fastest growing economies of the world with two-digit average rates during 2001-2006. As a result of global economic crisis of 2008-2009 the economy decreased again, by 14.1%, and afterwards the economic growth has slowed down. Table 5 below presents details of economic indicators for 1995-2012.

Table 5. Main macroeconomic indicators of Armenia, 1995-2012

Indicator	1995	2000	2005	2010	2011	2012
GDP (billion AMD)	522	1,031	2,243	3,460	3,778	3,998
GDP (million USD)	1,287	1,912	4,900	9,260	10,142	9,950
GDP in purchasing power terms (billion USD)	6.9	7.3	12.6	20.4	17.9	19.7
GDP per capita in purchasing power terms (billion USD)	2,115	2,260	4,164	6,728	5,925	6,508
GDP index in comparison to the previous	106.9	105.9	113.9	102.2	104.7	107.2

year (million USD)						
Inflation (%)	32.2	0.4	2.2	8.2	7.7	2.6
Export (million USD)	271	300	974	1,041	1,334	1,380
Import (million USD)	674	885	1,801	3,749	4,115	4,261
External state debt (million USD)	373	860	1,093	3,300	3,570	3,739

Source: Armenian National Statistical Service (1995, 2001, 2006, 2011, 2013)

Economic reforms implemented since the independence and the above-mentioned reasons have changed the structure of national economy, resulting in decreasing of industry and increasing of construction and service sectors (See table 6).

Table 6. Structure of the GDP of Armenia for 1990-2012, %

	1990	1995	2000	2005	2010	2011	2012
Industry	44.0	24.3	21.9	18.8	15.5	17.1	17.2
Agriculture	13.0	38.7	23.2	18.7	17.0	20.3	19.1
Construction	18.0	8.5	10.3	21.7	17.3	13.0	13.2
Services	25.0	24.8	35.5	32.3	40.8	41.2	42.7
Net Taxes	-	3.1	9.1	8.5	9.0	8.4	7.8

Source: Armenian National Statistical Service (1990, 1995, 2006, 2011, 2013)

ii. Energy

Energy consumption fell dramatically in the beginning of 1990s as a result of economic recession, as well as energy crisis. Starting from 1995 in parallel with slow economic recovery energy consumption is steadily growing (see Table 7).

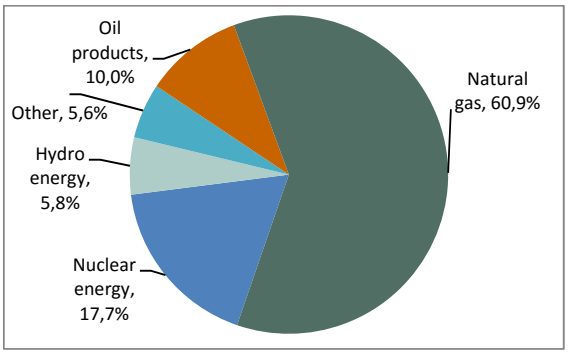
Table 7. Energy consumption in Armenia for 1990-2012, PJ

Energy carriers	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Natural Gas	151.4	43.1	47.0	47.0	38.2	42.6	47.0	58.4	61.5	62.8	69.7	61.4	61.1	72.0	87.4
Oil Products	162.8	21.2	12.9	14.8	14.7	15.7	16.2	14.7	15.0	15.2	16.8	14.5	16.0	15.4	14.4
Coal	13.4	0.4	-	-	-	-	-	-	0.0	0.03	0.03	0.04	0.03	0.1	0.09
Firewood	0.1	3.5	3.4	3.3	3.1	2.8	2.6	2.3	1.8	0.4	0.4	0.5	0.5	0.4	0.7
Manure	-	-	5.4	5.6	5.8	6.1	6.3	6.4	6.7	6.4	6.2	5.9	5.9	6.2	6.8
Liquid gas	0.0	0.1	0.6	0.8	0.9	0.9	1.0	0.9	0.7	0.5	0.4	0.4	0.3	0.3	0.3
Hydro energy	6.7	7.1	4.5	3.5	6.0	7.1	7.3	6.4	6.6	6.7	7.3	8.2	10.3	8.9	8.32
Nuclear energy	-	2.2	21.7	21.5	24.8	21.7	26.1	29.4	28.6	27.7	26.9	27.2	27.2	27.8	25.4
Total	**334.4**	**77.6**	**95.5**	**96.5**	**93.5**	**96.9**	**106.5**	**118.5**	**120.9**	**119.7**	**127.7**	**118.1**	**121.3**	**131.1**	**143.4**

Source: Armenian Ministry of Energy and Natural Resources (1990- 2001); "ArmRosgasprom" CJSC (2002-2012), Armenian National Statistical Service (1990, 1995, 2000, 2005, 2007); Armenian Customs Service (2007-2012)

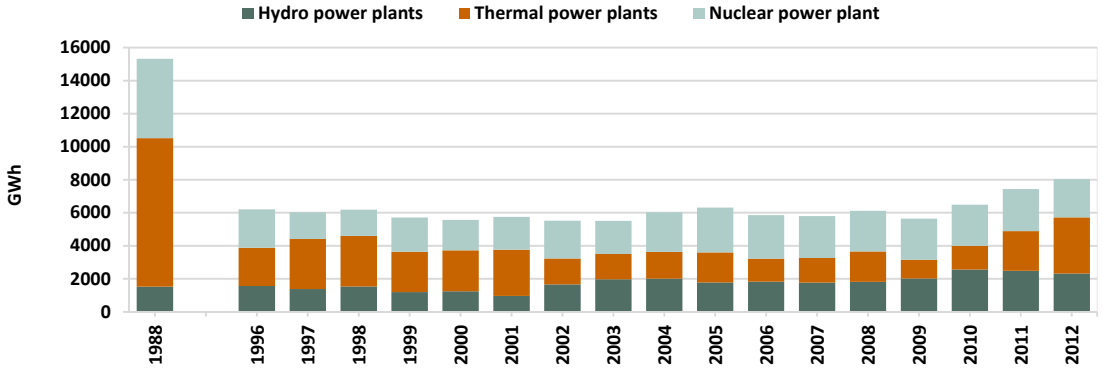
Since the Republic of Armenia does not have any significant sources of fuel it has to rely on import. Internal primary energy resources, which include hydropower, nuclear energy and biomass, cover only 36% of total energy consumption of the country. Natural gas is the main fuel used in Armenia. Its share in total fuel consumption has reached 68-74% in 2000-2010 (See Figure 8 for details).

Figure 8. Total primary energy consumption in Armenia, 2012



Electricity is mainly produced in thermal, hydro, and nuclear power plants. The total installed capacity has been 3,521 MW in 2010, including 1,561 MW from thermal power plants, 1,145 MW from hydro power plants, and 815 MW from the nuclear power plant (See Figure 9 for details).

Figure 9. Power production of Armenia, 1988-2012



Source: Armenian Ministry of Energy and Natural Resources (1988-2011); Armenian Statistical Yearbook (2002-2011)

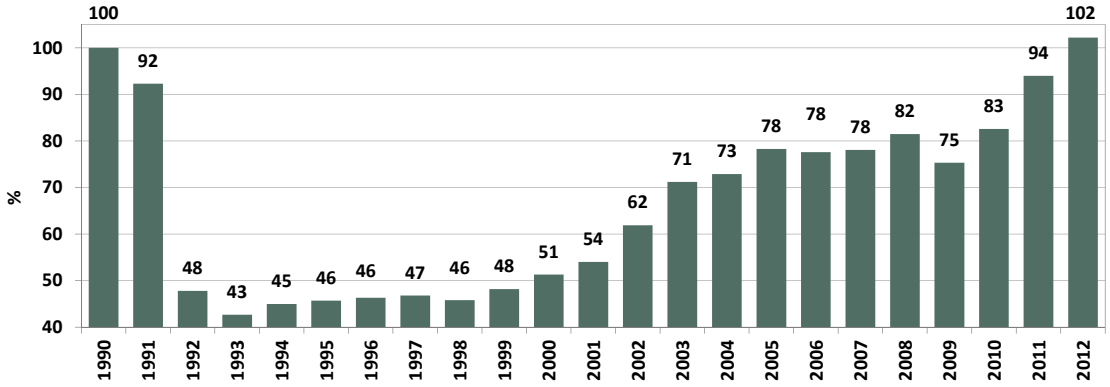
Since the collapse of centralized heat-supply systems most of the Armenian households and public/commercial buildings are heated using local gas boilers. Total production of thermal energy for industrial and urban needs in 2010 has been as low as 15% of 1990 level. Majority of residential houses, especially in urban areas, are heated using apartment-level gas or electricity equipment, which also provide hot water. Nevertheless, in 2008 there has been reconstructed a district heating system using a unit based on co-generation in one of the residential districts of Yerevan. Thanks to recovery of heating systems of public-commercial buildings using gas boilers the generation of thermal energy has doubled during from 2000 to 2010.

Due to energy crisis caused by blockage by Azerbaijan the gas supply has dropped significantly in the beginning of 1990s. But starting from 2000 there has been launched an extensive programme of system recovery, thanks to which the level of gasification has reached 96% by 2010, becoming a significant factor for the stability of energy supply. Though most of the gas consumed in Armenia is coming from Russian Federation there is also an alternative source of gas coming from Iran thanks to pipeline constructed in 2007. Gas supply from Iran is exchanged with power – Armenia supplies 3kWh of energy for 1m^3 of gas.

iii. Industry

Due to difficulties related to transition from centrally planned economy to market economy the industry in Armenia has collapsed after the independence. By 1993 the industrial production has been as low as 43% of the level of 1990. Thanks to stabilization and growth that has started in 1994 the level of industrial production in 2010 has reached 82.6% of 1990 level (See Figure 10 for details).

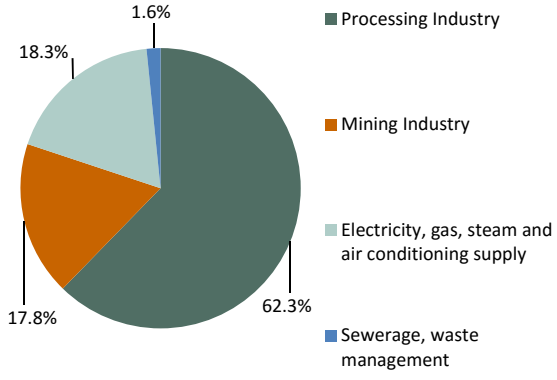
Figure 10. Dynamics of industrial production for 1990-2012 compared to 1990 level, %



Source: Armenian National Statistical Service (1990-2013)

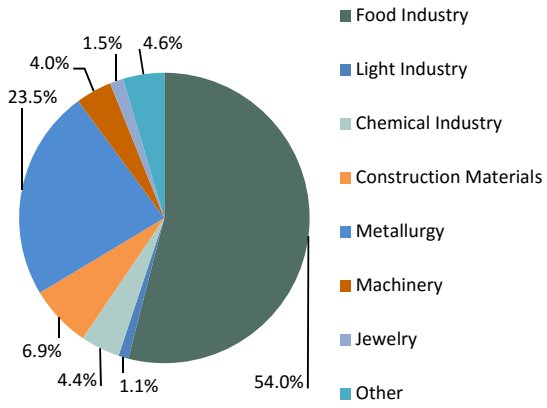
Nevertheless, the industry itself and its composition have changed. While prior to independence machine building (34%) and light industry (24.9%) have been the leading sectors of industrial sector, currently these have secondary roles, providing 4.4% and 1.1% of industrial production, respectively. At the same time, the share of previously less important non-ferrous metallurgy and food processing has increased 8.8% and 16.3% to 31% and 54%, respectively (See Figures 11 and 12 for details).

Figure 11. Structure of industrial output by types of economic activity, 2012



Source: Armenian National Statistical Service (2013)

Figure 12. Structure of processing industry, 2012



Source: Armenian National Statistical Service (2013)

iv. Agriculture

In 2012 agricultural lands occupied 2,052.4 thousand ha, including 448.4 thousand ha of arable lands (21.9%), 33.4 thousand ha of perennial plantings (1.6%), 121.6 ha of hayfields (5.9%), 1,056.3 thousand ha of pasture (51.5%), and 392.7 thousand ha of other land (19.1%).

The economic crisis of the beginning of 1990s has affected the agriculture too. As a consequence of land privatization previously large farms have been turned into around 340 thousand small farms, the average size of which is around 1.4 ha. This in turn resulted in reduced efficiency of land

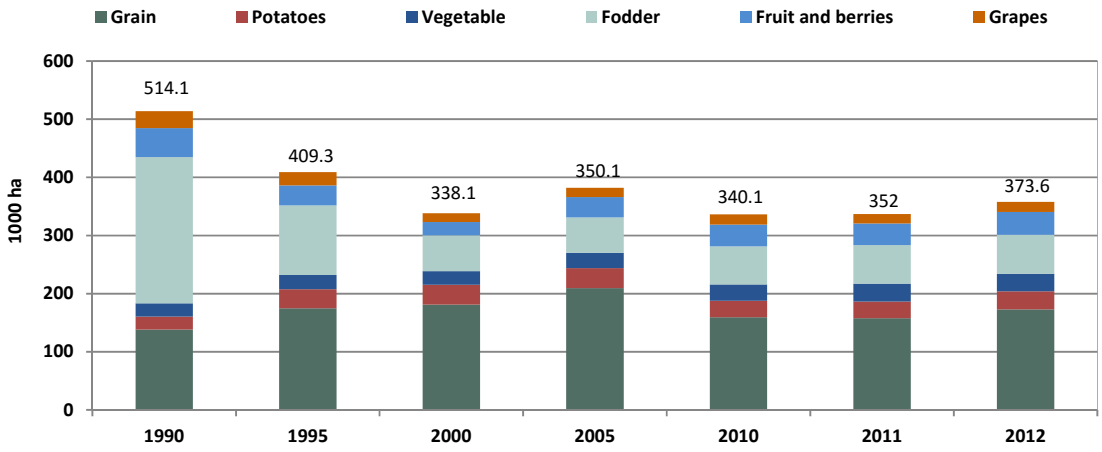
management and production infrastructure. Overall, since the transition to market economy there has been registered drawback in most of characteristics of the sector, including 30% reduction of crop, reduction of livestock numbers, halving of irrigated land area, as well as threefold reduction of use of chemical fertilizers (See Figure 13 and Table 8 for details).

Table 8. Numbers of livestock and poultry, thousand heads

Livestock/poultry	1990	1995	2000	2005	2010	2011	2012
Cattle	690.0	507.5	478.7	573.3	570.6	571.4	599.2
Sheep and goats	1,291	603.2	548.6	603.3	511.0	592.5.	590.2
Pigs	329.3	79.6	70.6	137.5	192.6	114.8	108.1
Horses	-	-	11.5	10.8	10.1	12.1	9.9
Poultry	11245	3100	4255.1	4861.7	4134.6	3462.4	4023.5

Source: Armenia National Statistical Service (1990, 1995, 2001, 2006, 2013)

Figure 13. Areas of agricultural land by crops, 1990-2012



Source: Armenian National Statistical Service (1990, 1995, 2001, 2006, 2013)

Further reduction of agricultural productions has been prevented and stabilization has been ensured thanks to implementation of several projects by the Government and international organizations. As a result, the agricultural production has started growing, reaching 7.7% average annual growth rate in 2000-2006, though later decreasing to 2.2% (See details in Table 9).

Table 9. Production of main types of agricultural output, thousand ton

Agricultural output	1990	1995	2000	2005	2010	2011	2012
Grain	271.0	262.7	224.8	396.2	326.4	440.7	456.1
Potatoes	212.5	427.7	290.3	564.2	482.0	557.3	647.2
Vegetables	389.7	450.9	375.7	663.8	707.6	787.1	849.0
Watermelons	31.4	54.0	52.8	117.8	132.5	180.9	205.1
Fruit and berries	155.5	146.1	128.5	315.6	128.5	239.4	331.7
Grapes	143.6	154.9	115.8	164.4	222.9	229.6	241.4
Meat (slaughter weight)	145.0	82.4	49.3	56.0	69.5	71.7	73.9
Milk	432.0	428.3	452.1	594.6	600.9	601.5	618.2
Eggs (million pieces)	606	518	385.4	518.2	702.2	633.6	658.1

Source: Armenian National Statistical Service (1990, 1995, 2001, 2006, 2013)

During recent years the average share of agriculture in GDP of Armenia has been around 18%, while the share in labor market is much higher, reaching 44% of total workforce.

v. Forestry

Forests cover about 11% (334.1 thousand ha) of the territory of Armenia; while historically the forest covered up to 40% of the territory of modern Republic of Armenia. Forests in Armenia are located extremely unevenly, with 62% of those located in the north-east, 36% in the south, and only 2% in the central parts of the country. Forests of the country are rich in biodiversity with 274 aboriginal trees and shrubs, including 25 endemic species. Main forest species include beech, oak, hornbeam, and pine, which make 89.1% of forest cover and 97.2% of forest reserves.

By 1920s Armenia had about 20% forest cover, but during 20th century forests in Armenia have gone through three phases of overexploitation – during industrialization in 1920-30s, during WWII, as well as more recently during the energy crisis of early 1990s. As a result, the forests have lost much of their economic and environmental reserves and value, leading to loss of biodiversity and quality of stands. Illegal logging still remains a serious issue, though officially registered cases have significantly reduced since 2000s.

As a result of degradation forest ecosystems have lost part of their ability of absorption of carbon from the atmosphere. There is need for implementation of major reforestation projects in order to help forest regeneration. So far, efforts in this direction are not sufficient with only 2,150 ha forests planted during 1998-2006, and 2,754 ha in 2006-2012.

All forests of Armenia are owned by the state, except for small portion (up to 1,000 ha) planted by communities and NGOs in recent years. Management of forests is implemented by the Ministry of Agriculture through “Hayantar” (Armforest) state non-commercial organization and its 20 forestry branches throughout the country, and the Ministry of Nature Protection through protected areas established on around 100 thousand ha of forest land. The Forestry Code also provides the possibility of forest management by the communities, if those wish so and are able to develop a management plan and get its approval from the Ministry of Agriculture. Up to date such plans have been developed for 11 communities, but at the moment only two communities (Koghb and Jujevan villages in Tavush province) manage forest with the support of donor organizations.

The Forest Code of 2005 provides classification of forests of Armenia as important for protective, special and production purposes. Protective forests include upper and lower belts with 200 m forest width, as well as forests growing in the semi-desert, steppe and forest-steppe zones. This fact is very important for reducing forest vulnerability under climate change, as logging is limited in this type of forest.

The National Forest Policy and Strategy of Armenia, as well as National Forest Programme (2005) of Armenia ensure preservation, rehabilitation, natural reproduction and sustainable use of forests.

vi. Waste

48 landfills covering 219 ha of land are used for storage of collected municipal solid waste (MSW). Urban communities have the largest landfills, including Yerevan (30 ha), Vanadzor (13 ha), Gyumri (10 ha), Armavir (8 ha), Ejmiadzin (7 ha), and Hrazdan (6 ha). No waste classification or sorting is conducted in any of the landfills. In average, 700 thousand tons of waste is generated annually in Armenia, of which around 510 thousand tons are transferred to landfills. Only Yerevan landfill is managed.

1.4.2. UNFCCC related processes in the Republic of Armenia

UNFCCC has been ratified by the Republic of Armenia in 1993 as a Non-Annex I Party, and Kyoto Protocol has been ratified in 2002.

The Ministry of Nature Protection of the Republic of Armenia is responsible for coordination of activities aimed at implementation of the Convention in the country. The Ministry develops long-term action plans, which are approved by RA Government. The following legal acts have been developed by RA Government in order to implement the Convention: Decree of RA Government on the Approval of the procedures of forecasting, warning and response to dangerous meteorological phenomena related to atmospheric excessive pollution, climate change and ozone-layer condition (N 1186-N of October 16, 2008), Decree of RA Government on the Approval of the action plan on implementation of RA obligations emanating from a number of international environmental conventions (N 1594-N of November, 10 2011), which define the implementation measures and responsible agencies.

RA Law on Atmospheric air protection has been amended to prohibit burning of vegetable residues and areas with dry vegetation in pastures and grasslands, as well as in agricultural, forested, and specially protected areas. The objective of the provision is restoring and storing of organic carbon in soil and ground vegetation, as well as protection of soil and soil layer from erosion and desertification. The Decree on the Approval of land monitoring procedure (N 276 of February 19, 2009) has the same objective. The latter requires state monitoring procedures for determination of organic carbon content, among 15 important indicators of soil and soil-layer protection.

In 2012 RA Government has approved Decree on National strategy on disaster risk reduction of the RA and the action plan for the national strategy on disaster risk reduction (N 281-N of March 7, 2012).

Armenia has presented its statement to the UNFCCC Secretariat regarding association with the Copenhagen Accords (2010). This statement represents the position of the Republic of Armenia on continuing the Kyoto Protocol and limiting GHG emissions.

Prime Minister of Armenia has approved Decree N 955 of October 2, 2012 on the Establishment of an Inter-Agency Coordinating Council on the implementation of requirements and provisions of the UNFCCC and the approval of the composition and rules of procedures of the Inter-Agency Coordinating Council. The Council is composed of representatives of 14 ministries, 2 state agencies adjunct to Government, the Armenian Public Services Regulatory Commission, the Armenian National Academy of Sciences, and the UNFCCC National Focal Point. The chairperson of the Council is the Minister of Nature Protection.

The Council was established to implement UNFCCC provisions, in particular, measures defined by the Decree N 1594, Armenia's productive participation in the Convention developments.

The Council will ensure cooperation between regional, intergovernmental and international organizations, participatory approaches to communities, civil society and the scientific community, and capacity building. The Council meets twice a year and, between the meetings, uses formal channels of intergovernmental cooperation.

To support the operations of the Council, there is also established a working group comprising of representatives of state agencies, as well as climate change experts and consultants.

RA Government adopted Protocol Decree N 16 of April 25, 2013 on the Approval of the concept of the establishment of innovative financial-economical mechanisms in the field of environment. Based on it the Government adopted Protocol Decree N 47 of November 14, 2013 on the Approval of the concept of the establishment of innovative financial and economical mechanisms in the field of environment. These documents show the commitment of RA Government to developing proposals

on establishing a civic revolving investment fund. The fund is aimed at establishing the relevant financial mechanism for climate change mitigation (GHG emissions reduction and sinks development) and adaptation (combating climate change impact) measures. Fund resources should be created through companies' environmental fees (those using natural resources and having an impact on the environment).

1.4.3 Process and results of sector selection

The Republic of Armenia has identified its priority directions in strategies and programmes developed during recent years. These include long-term documents, as well as annual programmes of the Government, and strategies and reports of line ministries and other public agencies. Namely, 2014-2015 Prospective Development Strategic Programme of the Republic of Armenia focuses on:

- Industry and export promotion,
- Tourism development,
- Development of information technologies,
- Agriculture and rural development, and
- Small and medium enterprises (across the economy).

Among the infrastructures the Programme prioritizes development of:

- Potable water supply system,
- Irrigation system,
- Transport, and
- Energy.

Considering the above-mentioned, as well as the vulnerability assessment of sectors of Armenian economy, conducted within the framework of Third National Communication on Climate Change, presented below, the project adaptation team and coordinator team decided to focus on identification and prioritization of technologies for agriculture and water sectors. In the process of sector selection key criteria included prioritization of the sectors in national development strategies/programmes, impact of given sectors on ecosystems and climate change, impact of climate change of these, the role of these in national economy, social impact, etc. The summary of the assessment is presented in Table 10 below.

Table 10. Assessment of sectors

Sector	Assessment Criteria				
	Impact on ecosystems and climate change	Vulnerability to climate change	Importance for the national economy	Social impact of the sector	Total
	1 – low impact, 5 – high impact	1 – low level of vulnerability, 5 – high level vulnerability	1 – low importance, 5 – high importance	1 – low impact, 5 – high impact	
Tourism	3	3	2	2	10
Agriculture	***4***	***5***	***4***	***5***	***18***
Water Resources	***3***	***5***	***4***	***4***	***16***
Settlements and infrastructure	4	3	3	3	13
Human health	2	4	3	5	14

Energy	5	2	4	3	14

The results of the assessment done by the project team have been shared with the Steering Committee members and approved by the latter.

In 2012 the agriculture sector provided 19.1% percent of GDP of Armenia, and together with processing industry it provides about 26%, making the second largest sector of Armenian economy after the service sector. Gross product of agriculture in 2012 has been about US 1.9 billion, where the share of crop production has been 60%, while cattle breeding has provided 40%. Agriculture has an exceptional role in terms of food security of the country, currently covering 60% of national needs.

866 communities of Armenia out of 915 are rural, with 36% of population living there, thus agriculture also has an important strategic role in terms of rural development. In 2012 over 437 thousand people have been employed in agriculture sector, making 37% of total employment, and around 80% of rural employment.

RA Government prioritizes the agriculture sector for two main reasons. First, it is one of the most important parts of value chain of food processing industry, which in turn is one of the sectors with significant export potential. Secondly, development of agriculture is extremely important for increased productivity of the sector and development of non-agricultural employment in rural areas, as well as for ensuring even territorial development.

Bulk of incomes of rural population comes from agriculture, thus poverty level in rural communities mostly depends on agricultural development. To ensure development of agriculture RA Government, among other things, prioritizes promotion of cooperation, construction of greenhouses, introduction of modern technologies, and increasing of the level of water availability. Agriculture is one of the most vulnerable sectors in terms of climate change. Detailed analysis of risks of the sector has already been presented above.

Third National Communication on Climate Change proposes the following adaptation measures for the agriculture sector:

- Creation of risk-preventing infrastructure for agricultural producers, and reduction of agricultural dependence on climate conditions,
- Inventory-making and improvement of grassland and pasturelands,
- Prevention of crop and animal diseases, and pest control,
- Selection and cultivation of more drought-resistant hybrids adapted to local conditions, including maintenance and dissemination of traditional crop varieties,
- Development of an advisory and information system in the agriculture sector,
- Institutional and professional capacity building for the application of climate change models.

TNA project team has taken these into consideration while developing the long-list of adaptation technologies for prioritization. The complete list of adaptation technologies related to agriculture is presented in respective section of the report.

Despite improvement in potable water supply, there are still remaining issues that need solution. Namely, the system is not equally developed in all regions of Armenia, and while the national

average daily duration of water supply is 16 hours, in 9 cities out of 36 serviced by Armenian Water Sewage Company it has been less than 12 hours. As for rural communities, about ¼ of rural population has had access to potable water only during 5 or less hours per day.

Issues associated with irrigation water supply are more serious. The rate of increasing of surface of irrigated agricultural land areas is very slow and in 2012 there have been 130.7 thousand ha of irrigated land areas, exceeding 2008 indicators by only 1% (See details in Table 11)

Table 11. Irrigated land and volume of supplied water in 2008-2012.

	2008	2009	2010	2011	2012
Land plots serviced by water users' associations	128.9	128.1	128.8	129.4	130.7
Volume of supplied water, million m^3	576.7	412	396.5	415.3	472.1
Specific water consumption, thousand m^3/ha	4.47	3.22	3.08	3.21	3.61

Source: State Committee of Water Economy of the Ministry of Agriculture of RA

Number of adaptation and vulnerability assessment programmes related to irrigation water has been implemented during recent years, including:

- "Vulnerability assessment of water resources in transboundary river basins (Khrami-Debed and Aghstev) and recommendations for appropriate adaptation measures under climate change", UNDP (2010-2011),
- "Armenia: the water sector vulnerability under climate change", UNDP (2012),
- "Assessment of water resources of Vorotan, Voghji, Meghriget river basins under climate change", USAID (2013),
- "Study for introduction of Integrated Water Resources Management principles in 6 water basin management areas", Sher (2013),
- "Promoting reforms in economic mechanisms of water management", OECD (2013),
- "Toward Integrated Water Resources Management in Armenia Analysis", World Bank (2013-2014),
- "Defining target areas and identification of appropriate targets for Armenia", UNECE Water and Health Protocol (2013-2014).

Results of vulnerability analysis have been presented above, and adaptation measures recommended by the Third National Communication on Climate Change include the following:

- In developing plans for the management of all major river basins of Armenia consideration should be given to climate change factors (taking into account the EU Water Framework Directive Common Implementation Strategy Guidance Document No. 24),
- Optimization of the hydrological observation network and upgrading of equipment in compliance with Armenian water legislation and EU Water Framework Directive requirements,
- Provision of water-use permits with due consideration of climate change risks,
- Development of regulations for long-term water-resources planning, and creation of decision-making tools,

- Creation of hydrological reserves and development of institutional status for all river-basin watershed areas,
- Assessment of ground water resources,
- Revising the methodology for determining environmental flow,
- Construction of new small water reservoirs and rehabilitation of non-operating ones,
- Ground water monitoring,
- Reduction of leakage from drinking-water supply and irrigation systems. Development and implementation of economic mechanisms for leakage reduction,
- Development and introduction of economic mechanisms for promoting the application of advanced water-saving irrigation methods in agriculture.

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

2.1 National TNA team

Agreement on conduction of Technology Needs Assessment in the Republic of Armenia has been signed between the Ministry of Nature Protection of Armenia and UNEP DTU Partnership (UDP) in 2015. Following this, UNFCCC focal point in RA, Mr. Aram Gabrielyan, has been appointed as TNA National Coordinator. Responsibilities of National Coordinator included overall coordination of Project activities, including work with respective national institutions and high-level decision makers.

In this regard, there has been established a Project Steering Committee, the responsibilities of which have been assigned to the Working Group of Interagency Council for coordination of requirements and provisions of UN Framework Convention on Climate Change established by Decree N 955-A of Prime Minister of RA of October 2, 2012. Main responsibilities of the Committee include monitoring of project implementation, provision of strategic guidance to the team and conduction of prioritization of sectors for adaptation and mitigation. The composition of the Working Group is presented in Table 12 below.

Table 12. Composition of the Working Group of Interagency Council for coordination of requirements and provisions of UN Framework Convention on Climate Change[20]

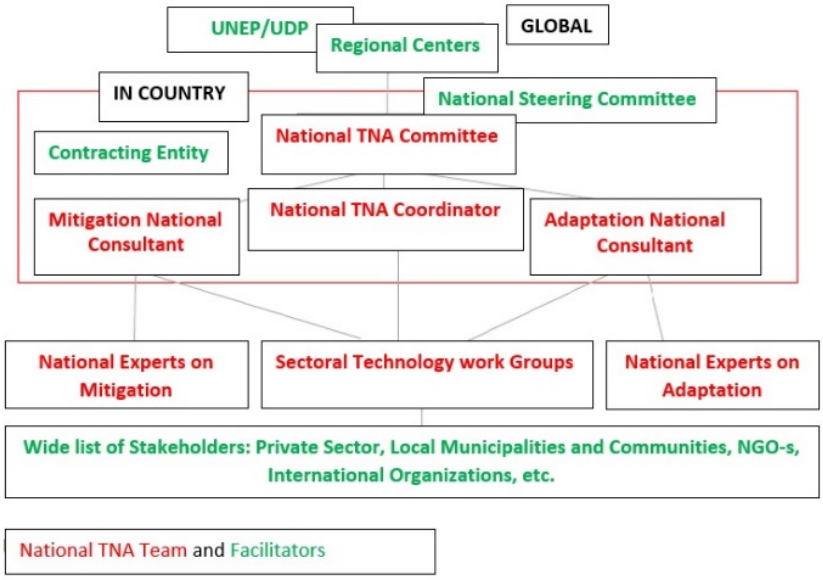
N.	Name	Organization/Affiliation	Position
1.	Aram Gabrielyan	UN Framework Convention on Climate Change	National Focal Point
2.	Tehmina Arzumanyan	Ministry of Nature Protection	Press Secretary of the Minister
3.	Naira Alaverdyan	Ministry of Nature Protection	Head of Secretariat
4.	Kristine Grigoryan	Ministry of Justice	Head of Department of International Mutual Legal Assistance and Foreign Relations
5.	Vardan Vardanyan	Ministry of Energy and Natural Resources	Head of Mining Department
6.	Ruzan Asatryan	State Committee of Science of the Ministry of Education	Head of the Department of Organization of Scientific Activities
7.	Sergey Aghinyan	Public Services Regulatory Commission	Head of Development and Monitoring Department
8.	Artak Simonyan	State Employment Agency of the Ministry of Labor and Social Issues	Deputy Head
9.	Hamlet Melkonyan	Hydrometeorology and Monitoring State Service of Armenia SNCO of Ministry of Territorial Administration and Emergency Situations	Deputy Director
10.	Levon Farmanyan	Ministry of Finances	Deputy Head of the Department of International Cooperation
11.	K. Gyurjyan	General Department of Civil	Deputy Head of Airworthiness Department

[20] Based on Order N 31-A of the Minister of Nature Protection of RA of February 17, 2016 on Making Amendments to Order N 98-A of the Minister of Nature Protection of RA of May 21, 2013.

		Aviation	
12.	Yelena Khalatyan	Hydrometeorology and Monitoring State Service of Armenia SNCO of Ministry of Territorial Administration and Emergency Situations	Head of Climate Studying Unit
13.	Varduhi Asaturyan	Ministry of Foreign Affairs	Head of UN unit of the Department of International Organizations
14.	Aneta Babayan	Ministry of Economy	Head of Economic Reforms and Donor Coordination Unit of the Department of Economic Development Policy
15.	Asya Muradyan	Ministry of Nature Protection	Head of Climate Change and Atmospheric Air Protection Policy Unit of the Department of Environmental Protection
16.	Hrayr Aslanyan	Ministry of Health	Head of Public Health Unit
17.	Artur Petrosyan	Ministry of Agriculture	Head of Forestry Unit
18.	Narine Avetyan	Ministry of Urban Development	Head of Housing Fund Management and Utilities Infrastructures Unit of the Department of Housing Policy and Utilities Infrastructures
19.	Lusine Avetisyan	Ministry of Nature Protection	Head of Environmental Protection Economic Mechanisms, Standards and Technical Regulations Unit of the Department of Strategic Environmental Projects and Monitoring
20.	Hrayr Mkrtchyan	State Committee of the Real Estate Cadastre adjunct to RA Government	Head of Registration Unit of the Department of Registration and Land Management
21.	Nelli Baghdasaryan	National Statistical Service	Head of Social Sector and Environmental Statistics Unit
22.	Yelena Papyan	Armenian Roads Directorate SNCO of the Ministry of Transport and Communication	Chief Specialist of Traffic Safety Technical Support Unit
23.	Mesrop Gharibyan	Public Services Regulatory Commission	Chief Specialist of Economic Unit of Development and Monitoring Department
24.	Larisa Kharatova	Ministry of Nature Protection	Chief Specialist of External Affairs Unit of the Department of International Cooperation
25.	Hripsime Babayan	Ministry of Territorial Administration and Emergency Situations	Chief Specialist of Local Self-Governance Department
26.	N. Sargsyan	Ministry of Urban Development	Chief Specialist of Urban Development Policy Unit of the Department of Urban Development Policy and Spatial Planning
27.	Naira Mandalyan	National Statistical Service	Leading Specialist of Social Sector and Environmental Statistics Unit

The diagram of TNA national team structure and institutional arrangements of the Project is provided in Figure 14 below.

Figure 14. TNA National Coordination and Participation, Institutional Structure of the Project



The national team consists of two groups: Adaptation and Mitigation. Mr. Vardan Melikyan and Mr. Tigran Sekoyan, have been appointed as Adaptation Expert Team Leader and Mitigation Expert Team Leader, respectively. Responsibilities of expert team leaders included organization of meetings and seminars with stakeholders, identification of priority areas and respective technologies through a participatory process, leading of the analysis of the results of consultations with the stakeholders, preparation of the final report on technology needs assessment process and results, etc.

Experts under adaptation component included Mr. Samvel Avetisyan (agriculture) and Ms. Arevik Hovsepyan (water), while Mr. Mkrtich Jalalyan, Mr. Anastas Aghazaryan, Ms. Arevik Hovsepyan have been involved under mitigation component. Each of sectoral experts has been responsible for identification of technologies for their respective sector, development of technological fact sheets for these, participation in project-related meetings and seminars, prioritization of selected technologies, etc.

Contracting facility of the Project is Environmental Project Implementation Unit State Institution. It is the successor of previously operating “Natural Resources Management and Poverty Reduction Project” EPIU State Institution, and “Environmental Project Implementation Unit” SNCO has been restructured on the bases of the latter. The main objective of the institution is provision of efficient implementation of the RA environmental sector projects. The principal topics of its activities include programs and activities of the Ministry of Nature Protection of RA and territorial administration agencies, environmental sections of RA State Budget, as well as ones developed under the financing provided to the RA by grant and international creditor organizations of foreign states approved by the RA Government. Namely:

- Provision of implementation of state sector projects of reasonable usage and reproduction of environment of Armenia: lithosphere, soil, water, atmosphere, fauna and flora, as well as natural resources and preservation of specially protected areas,
- Fulfillment of state sector projects and state orders on management of natural recourses and environment conservation,
- Implementation of preliminary and international investment projects in environment sector.

The national team leader, consultants and experts worked in close collaboration with the National TNA committee and various work groups. They have supported the entire TNA process, by leading and undertaking activities such as research, analysis and synthesis in support of TNA project.

2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

During implementation of TNA there has been made sure that the level of engagement is as high as possible and all potential interested parties are aware of Project activities and can provide their input. Prior to the beginning of Project implementation TNA National Coordinator and sectoral experts have developed a list of stakeholders to be consulted with on different phases of TNA project and which has been periodically updated at later stages. It has included Government agencies, civil society, local communities, private sector, academic and research institutions, as well as international organizations (See Table 13 for the complete list).

Figure 15. Scheme of cooperation and creation of the database on TNA.

Since based on the analysis of national priorities and climate change vulnerabilities, as well as consultations with Projects experts, agriculture and water sectors have been selected for further analysis, the list of stakeholders, presented below, included organizations and institutions involved in these sectors. All identified stakeholders have been contacted prior to the beginning of TNA process to inform about implementation of the Project and to invite for submission of technologies that can fit in the assessment process.

In parallel with sector experts some of the stakeholders have also worked on development of technology fact sheets that have later been used in technology prioritization process. Besides, some

of the stakeholders have contacted Project team to present their ideas on potential technologies and these have also been developed into fact sheets or integrated into others technology fact sheets, if possible.

During several formal and informal meetings Project team has presented the TNA process to all interested parties. This helped to ensure broader involvement in the planning, decision-making processes and will later potentially help with promotion of Project results and involvement of donors in implementation of prioritized project ideas.

Table 13. List of TNA Project Stakeholders.

Organization	Phone	E-Mail
Public Administration Bodies		
Ministry of Agriculture	011 524 641	agro@minagro.am
Ministry of Economy	011 597 110	secretariat@mineconomy.am
Ministry of Finances	060 700 304	press@minfin.am
Ministry of Healthcare	010 582 413	info@moh.am
Ministry of Nature Protection	010 521 099	min_ecology@mnp.am
Ministry of Territorial Administration and Emergency Situations	010 317 843	info@mtaes.am
ARNAP Foundation of MTAES	010 317 742	arnap@arnap.am
Disease Control and Prevention National Center of MoH	010 621 336	cdc@web.am
Hayantar SNCO of MoA	010 651 738	arm_forest@yahoo.com
Hydrometeorology and Monitoring Service SNCO adjunct to MTAES	010 530 316	levon.vardanyan@mes.am
National Environmental Inspectorate adjunct to MNP	011 818 523	min_ecology@mnp.am
State Committee for Water Management adjunct to MoA	010 540 909	scws@scws.am
State Food Security Service adjunct to MoA	010 206 040	ssfs@ssfs.am
State Health Inspectorate adjunct to MoH	010 651 660	info-apt@moh.am
Water Resource Management Agency adjunct to MNP	011 818 548	min_ecology@mnp.am
Zikatar	010 563 081	zikatar_center@yahoo.com
NGOs, CSOs		
Armenian Red Cross Society	060 625 052	redcross@redcross.am
Center for Agribusiness and Rural Development	060 440 550	card@card.am
Country Water Partnership	010 209 603	cwp.armenia@gmail.com
Ecolur	010 562 020	inga@ecolur.org
Foundation for Preservation of Wildlife and Cultural Assets	093 044 088	ruben.khachatryan@sunchild.org
Green Lane	010 575 995	nune@greenlane.am
Khazer	010 534 652	khazer@nature.am
National Association of Consumers	010 249 204	info@armconsumer.am
Protection of Consumers' Rights	010 543 818	lusineyagubyan@yahoo.com
Researchers for Bio-heating Solution	055 732 241	info@rbhs.am
Technology Transfer Association	010 556 243	technologytransferassociation@gmail.com
Union of Incoming Tour Operators of Armenia	099 584 546	info@touropearator.am
Communities		
Akhtala, Lori province	0253 52264	akhtala.lori@mta.gov.am
Basen, Shirak province	095 365 600	basen.shirak@mta.gov.am
Bavra village, Shirak province	093 453 240	bavra.shirak@mta.gov.am
Jermuk, Vayots dzor province	0287 21212	jermuk.vayotsdzor@mta.gov.am
Odzun, Lori province	077 707 038	odzun.lori@mta.gov.am
Private Sector		
Armenian Water and Sewerage CJSC	060 650 171	info@armwater.am
ArtFood Artashat Cannery	010 282 382	info@artfood.am
Biga Armenian-Dutch JV	010 547 719	info@biga-armenia.com

Coca-Cola	010 541 028	reception.am@cchellenic.com
Ecotechnology	099 646 064	ecotechnology.am@gmail.com
Hrashk Aygi LLC	010 447 782	info@hrashkaygi.am
Jinj Consulting	010 246 023	EAM@jinjconsult.com
Mirg LLC (Ayrum Cannery)	094 910 200	yrummirg@gmail.com
Nor Akunq	0237 20982	norakunq2002@gmail.com
Semina Consulting CJSC	093 543 610	info@semina.am
Unifish	010 255 848	info@unifish.am
Yerevan Brandy Company	010 510 100	info_ybc@pernod-ricard.com
Yerevan Jur	010 569 357	com@yerevandjur.am
Academic/Research Institutions		
American University of Armenia	060 612 526	president@aua.am
Armenian National Agrarian University	010 524 541	info@anau.am
Center for Ecological Noosphere Studies	010 572 924	ecocentr@sci.am
ICARE	010 522 839	info@icare.am
Institute of Hydroponics Problems	010 565 162	hydrop@netsys.am
Scientific Center of Vegetable and Industrial Crops (Darakert)	0236 61293	biotechlab01@yahoo.com
Yerevan State University	010 555 240	info@ysu.am
International Organizations		
Asian Development Bank	010 546 373	ddole@adb.org
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	010 560 396	giz-armenia@giz.de
Embassy of France	060 651 950	cad.erevan-amba@diplomatie.gouv.fr
Embassy of Georgia	010 200 738	yerevan.emb@mfa.gov.ge
EU Delegation	010 54 64 94	Delegation-Armenia@eeas.europa.eu
European Bank for Reconstruction and Development	011 354 501	davism@ebrd.com
Food and Agriculture Organization	010 525 453	FAO-AM@fao.org
International Union of Conservation of Nature		luba.balyan@enpi-fleg.org
KfW Development Bank	094 465 499	zara.chatinyan_extern@kfw.de
Organization for Security and Co-operation in Europe	010 229 610	yerevan-am@osce.org
REC Caucasus	011 575 148	nune.harutyunyan@rec-caucasus.org
United National Development Program	060 530 000	registry.am@undp.org
United National Industrial Development Organization	010 544 667	a.simonyan@unido.org
US Agency for International Development	010 464 700	usinfo@arminco.com
World Bank	010 520 992	yerevan@worldbank.org
World Health Organization	010 512 004	whoarm@euro.who.int
World Wide Fund for Nature	010 546 156	kmanvelyan@wwfcaucasus.org

2.3 Development of ArmCTCN

Since in the future there may appear new ideas and new technologies it has been decided by the Project team that TNA and technology prioritization should be considered an on-going process leading to organization of national inventory system for technologies in all spheres of climate change adaptation and mitigation. It can also potentially lead to development of Armenian Climate Technology Centre and Network (ArmCTCN).

The need and expedience of establishing of ArmCTCN are determined by the Third National Communication on Climate Change of Armenia and INDC of Armenia.

Particularly, the Gaps, Constraints, and Capacity Needs for Convention Implementation Section of Third National Communication includes provisions on *Technology development and transfer* and *Science, education, personnel training and public awareness*, directly indicating the need for development a national climate technology mechanism (ArmCTCN) to address relevant needs. Table 14 below presents more details on this.

Table 14. Needs to overcome gaps, barriers, and constraints for addressing climate change-related issues

Gaps, constraints	Comments	Needs
Technology development and transfer		
Lack of system for development, transfer and introduction of technologies to addressing climate change issues.	The absence of operational systems for the development and transfer of technologies hinders the organization and regular implementation of mitigation and adaptation projects, as well as cooperation with the Technology Centre and Network established under the Convention.	Identify and assess technological needs and define ways to meet these needs. Based on the arrangement, operation principles and functions of the Technology Centre and Network, create a country-level "Technology Mechanism" as a framework for cooperation between legal and physical entities participating in this process.
Science, education, personnel training and public awareness		
Poor involvement of the scientific community in studies on climate change.	The scientific community does not pay proper attention to climate change mitigation and adaptation issues, or the development of technology to either address or commercialize them.	Involve representatives from both the scientific community and businesses in the climate technology mechanism (ArmCTCN). Provide targeted financing mechanisms for the implementation of scientific and research activities in sectors more vulnerable to climate change.

In addition to Third National Communication, Armenian INDC also includes provisions regarding the establishment of ArmCTCN with regards to technology transfer, namely to:

- Ensure adequate technological assistance and create favorable environment for technology development and transfer.
- Establish institutional mechanisms to overcome barriers for the introduction of innovative technologies for climate change mitigation and adaptation, including strengthening the system of legal protection of intellectual property right.
- Ensure an open and transparent system of technology introduction and transfer as a contribution to the INDC, such as through the cooperation and experience exchange with "Climate Technology Center and Network" (CTCN) and through the establishment of a similar mechanism in the country (ArmCTCN).

The experience and practice developed in TNA will become a basis for the functioning of ArmCTCN. Actually, TNA will become a pilot component of ArmCTCN, and after the end of the Project it will be continued as ArmCTCN.

It is believed that the structure and operations of ArmCTCN will mimic CTCN, thus it will include a) **consortium**, which will include respective local professional organizations, as well as representations of international organizations, such as UNIDO, UNDP, UNEP, etc., b) **network**, which will include

interested organizations and individuals, on volunteer basis. The function of secretariat of ArmCTCN will be implemented by National Designated Entity, which will liaise between ArmCTCN and CTCN.

ArmCTCN will be coordinated by the working group of Interagency Council established by Decree N 955-A of Prime Minister of RA of October 2, 2012, on the Approval of composition and order of work of Interagency council for coordination of requirements and provisions of UN Framework Convention on Climate Change.[21] In case of successful implementation of pilot project on ArmCTCN it will be a contribution of the Republic of Armenia within the framework of INDC.

[21] https://www.e-gov.am/decrees/item/11373/

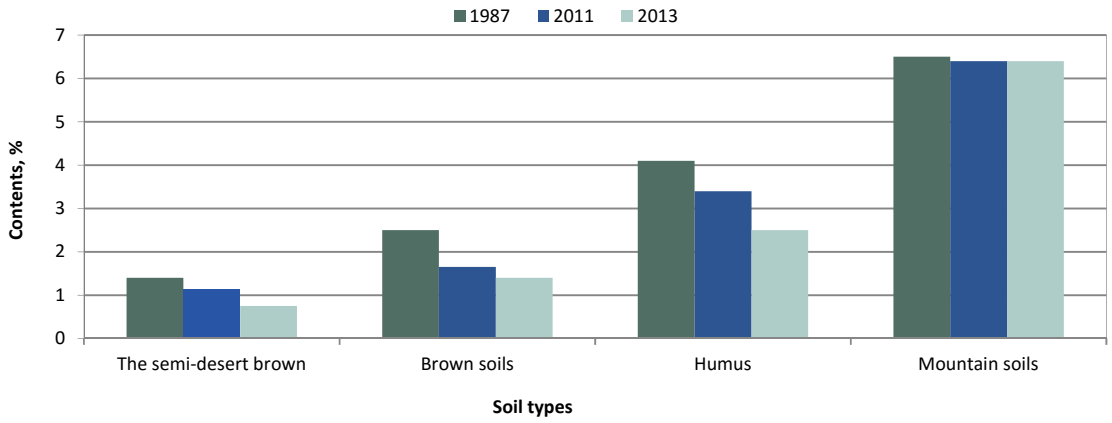
Chapter 3. Technology Prioritization for Agriculture

3.1 Key Climate Change Vulnerabilities in Agriculture

Major negative consequences forecasted for agriculture of Armenia as a result of climate change include shifting of agro-climatic zones, reduction of crop yields, reduction of fertility of agricultural land, increasing of adverse effects of extreme weather events, increasing of demand for irrigation water, and degradation of lands.

An important aspect of climate change vulnerability of agriculture is its impact on land resources. It is expected that increased temperatures and reduced precipitation, namely rainfall, will lead to more evaporation from soils and increased secondary salinization, as well as increased water and wind erosion, especially due to heavy rains and floods. There will also be other consequences, such as decline in natural moisture of soil, reduction of non-irrigated lands, as well as intensification of landslides. Climate change and anthropogenic factors have affected virtually all types of land in Armenia, with especially significant impact on humus contained in soil, which declines in all soil types except mountain grasslands (see details in Figure 16).

Figure 16. Organic carbon content in 0-25 cm soil layer



Due to redistribution of agro-climatic zones there will change the ratio of irrigated and non-irrigated lands, potentially leading to higher demand for irrigation water resources, which are also vulnerable. The total area of irrigated land in Armenia is 207.8 thousand ha. As a result of forecasted temperature rise and intensification of evaporation of moisture from the soil surface, additional demand for irrigation water for agricultural land will total over 202 million m^3 (See Table 15 for details).

Table 15. Additional water demand for crop production by irrigation zone

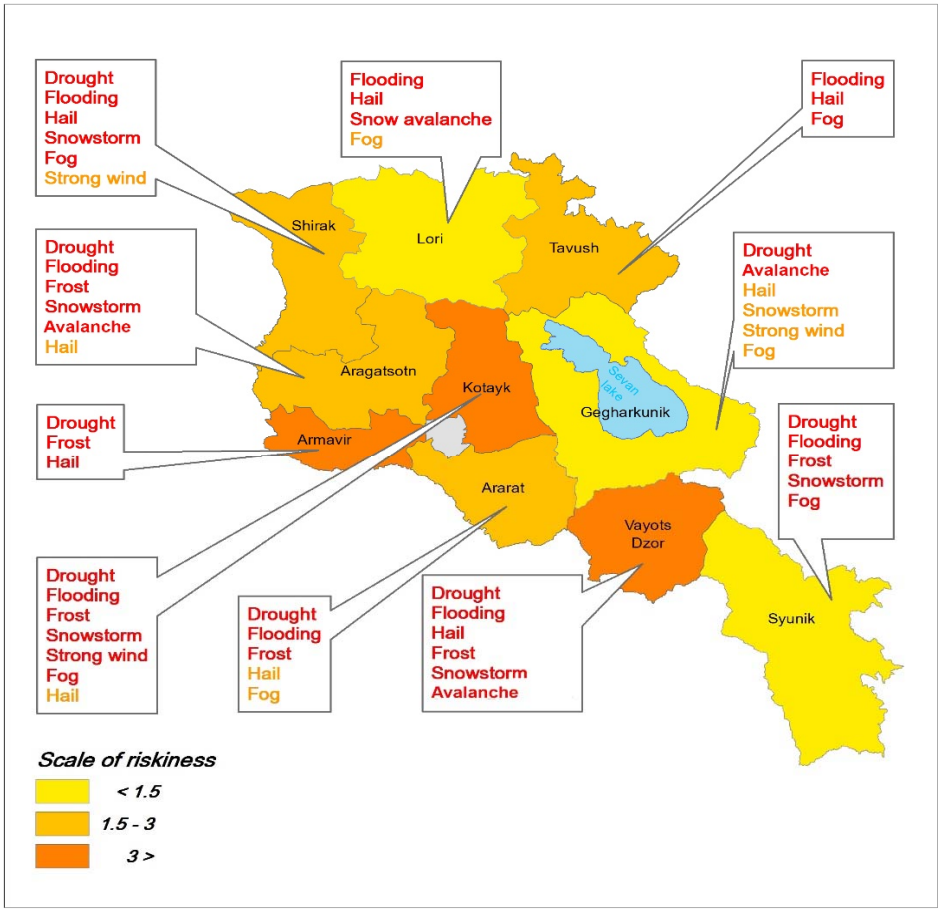
Irrigation zones	Altitude from sea level, m	Additional water demand, million m^3
Ararat valley	900-1800	172,0
Shirak	1400-2200	13.2
Lake Sevan basin	1900-2200	2.04
Northeast	400-1400	4.2
Lori-Pambak	900-1700	6.6
Vayots Dzor-Syunik	700-2200	4.04

Total	**202.08**

In the case of 5-25% atmospheric precipitation sufficiency, water-supply vulnerability in non-irrigated agricultural zones of Aparan, Amasya, Sevan, Lori, Tavush, and Ijevan regions will increase by 50-100%. These areas will end up in an insufficient humidification zone; high crop production will not be possible without irrigation. Water supply vulnerability of highland zones in these areas will increase by 30-40%.

Intensification of extreme weather events is another risk related to agriculture. Vulnerability of provinces of Armenia to climate risks is presented in Figure 17.

Figure 17. Vulnerability of Armenian provinces to hazardous hydrometeorological phenomena



Source: Hydromet Service

There has been conducted an agro-economic analysis, taking into consideration that in Armenia the price risk is lower (0.18) than crop-yield risk (0.22). The AMBAV/AMBETI model has been applied to assess the impact of climatic factors on yields. The assessment findings show that the vegetative season has shifted, and currently begins in March instead of April (1960-1970s).

Currently there is no agricultural insurance system in Armenia. As a result, there will be need for subsidization programmes to reduce vulnerability of incomes received from agriculture to climate risks.

Climate change can have direct (impact of increased temperature on animals), and indirect (effect on the spread of diseases, pests, parasites, and pasture productivity decline) impact on livestock production.

Climate change affects natural pastures and grasslands. During the grazing season, family farms get about 70% of the annual production of milk, more than 50% of meat, and 100% of the wool as a result of activities conducted on natural grazing lands. The importance of natural pasture is emphasized by the fact that the major breeds of cattle, sheep and goats in Armenia are fully adapted to mountainous and high-mountainous pastures of the country.

The majority of grazing lands in Armenia has deteriorated over the last two decades as a result of irregular grazing, and lack of control and improvement measures. Pastures around settlements have been subjected to intense overgrazing, while productivity of remote pastures has decreased as a result of underuse. The forecasted climate change will have further adverse impact on natural grasslands and grazing land.

As a result of shifts in natural zones, the areas of more valuable alpine and sub-alpine grazing land will be reduced by 19% and 22%, respectively, while semi-desert and meadow-steppe areas will increase by 17%, and grazing land with relatively low productivity, by 23%, unless the negative impacts of climate change are mitigated. The impact of climate change on main livestock products has been projected based on official statistics and analytical reports (See Table 16). As a result of structural changes in natural zones, milk production will fall by 52.4 thousand tons, meat production by 15.1 thousand tons, and wool production by 116.4 tons.

Table 16. Projection for changes in pasture areas and milk production due to climate change

Natural zones	% by zones	Actual, in 2012		Projected, in 2030	
		Pastures, thousand ha	Milk production, thousand tons	Pastures, thousand ha	Milk production, thousand tons
Semi-desert	8.5	89.8	23.0	111.8	28.6
Steppe	20.7	218.6	111.9	218.6	111.9
Meadow-steppe	15.5	163.7	92.1	214.5	120.7
After forest	12.4	131.0	72.5	131.0	72.5
Sub-alpine	28.3	299.0	210.5	210.6	148.3
Alpine	13.7	144.7	144.8	120.1	120.2
Off-zone	0.9	9.5	3.3	10.0	3.5
Total	**100**	**1,056.3**	**658.1**	**960**	**605.7**

Climate change-related changes to natural pasture could lead to serious fluctuations in the volume of livestock products. Given that pastures in Armenia are under disproportional use, it will be possible to offset expected losses through increased livestock populations and fodder-crop production by implementing activities designed to improving balanced use of pasture.

3.2 Decision context

Since agriculture is one of the main sectors of Armenian economy, significant efforts are already implemented to modernize it and make it more competitive in international markets. The Ministry

of Agriculture of RA, as the main public agency responsible for policy development in agriculture sector is acting based on 2010-2020 agriculture and rural sustainable development strategy of the Republic of Armenia. The main objective of the latter is promotion of modernization and increased competitiveness of the sector through overcoming of consequences of the financial crisis and development of anti-crisis mechanisms.

Respective sub-goals of the Strategy include:

- Overcoming of the consequences of financial and economic crisis in agriculture and agricultural processing industry and development of integration processes;
- Development of agricultural and inter-sectoral sectoral cooperation;
- Improving of marketing of agricultural and agricultural processing goods and increasing of export;
- Increased competitiveness of agriculture and promotion of know-hows;
- Efficient use of land, water, labor and intellectual resources of agriculture;
- Ensuring food security compliance with international standards;
- Increasing of non-agricultural employment in rural areas and increasing of incomes of rural population;
- Development of infrastructures of rural communities via implementation of participatory projects;
- Development and increased accessibility of agricultural services;
- Improving of structure of agricultural sectors and promotion of production of goods with high added value;
- Protection of the environment and natural landscapes, development of agro-tourism and organic agriculture.

World Bank study “Reducing the Vulnerability of Armenia’s Agricultural Systems to Climate Change” suggests the following options for adaptation to climate change:

- Improving irrigation capacity and efficiency through new investments or rehabilitation;
- Shifting to new crop varieties;
- Optimizing fertilizer application;
- Improving the hydrometeorological network;
- Enhancing extension services;
- Optimizing basin-level water efficiency;
- Increasing water storage capacity;
- Installing hail nets for selected crops.

Other relevant initiatives include “ENPARD Armenia Technical Assistance: Producer Group and Value Chain Development” project implemented by UNIDO and UNDP. One of the key elements of the Projects is climate change adaptation. Taking into consideration that significant part of Armenia is prone to natural disasters like droughts and floods, and most likely these will worsen due to climate change, the Project highlights the importance of good practices helping to increase the resilience of rural communities. Three outputs and respective activities of the Project shall include:

- Strengthened and newly established primary producer groups:

- Identification of value chains in the targeted provinces;
- Identification of existing and the potential for new business-oriented producer groups;
- Education of producers as to organizational development options;
- Establishing of new producers' groups;
- Developing of managerial, administrative, and operational capacities of producer groups;
- Documenting of lessons learned for appropriate legislation for producer groups;
- Promotion of participation and access of women, youth, and other vulnerable groups;
- Developing of models for the further establishment of sustainable producer groups.

o Producer groups effectively engaged in value addition:
- Identification of business-oriented producer groups that aim to engage in value addition;
- Installation of appropriate technologies/equipment and improve technical performance of producer groups' value addition capacities;
- Studying of existing and potential markets and support producer groups to develop new and improved value added products;
- Improving producer groups' technical capacities in storage and packaging of value added products;
- Helping producer groups develop marketing capacities and linking them to buyers of value added products;
- Building of value addition producer groups' entrepreneurial and business planning capacities;
- Linking of producer groups to existing finance schemes
- Improving of value addition producer groups' capacities to comply with food safety and quality standards;
- Supporting value addition producer groups to engage in cleaner production and energy saving technologies and practices;
- Supporting the access of women, youth and other vulnerable groups to participate in value addition.

o Strengthened value chains that provide improved access to affordable, better quality food:
- Conduction of analysis of selected value chains and develop intervention strategies;
- Supporting the government agencies and value chain actors to better coordinate, support, and link value chain components;
- Improving of producer access to primary production knowledge, market price information, and extension services;
- Developing of Good Agricultural Practices (GAP) and disaster risk management approaches;
- Improving of producer access to better quality production inputs and related services;

- Supporting of producers to improve harvesting techniques, post-harvest handling, and storage;
- Building of producer groups' capacities to source quality products and set up effective supplier networks;
- Supporting traders, transporters and marketers to better service targeted value chains;
- Developing of innovative financing facilities and services, and improving of access to capital.

3.3 Overview of Existing Technologies in Agriculture

Prior to independence agriculture sector has mostly been managed via collective farms, which have been providing bulk of agricultural produce. After the privatization of land large collective farms have been divided into much smaller ones, leading to issues related to management efficiency.

Since irrigation has been required by almost all crops produced in Armenia, building of irrigation canals and system has been one of the priorities of the state starting from 1920, thanks to which by 1960s the arable land area has been enlarged by 20%. By this time most of the farms have also been electrified and equipped with necessary machinery. In 1989 farms were operating about 13,400 tractors and 1,900 combines, and while many of these have been sold or have become outdated since then, in 2006 Armenian farmers have owned 14,600 tractors and 1,700 combines.

Since the irrigation canals constructed during the Soviet period have gradually become unusable, major projects have been implemented, mainly under financing of Lincy Foundation and the Millennium Challenge Corporation, to restore these and build new ones. Currently about 80% of crops are produced on irrigated lands.

Recently drip irrigation is becoming more and more popular, as farmers begin to realize the efficiency of such systems, both in terms of water saving and more accurate application of water and fertilizers. Few large farms, such as Tierras de Armenia vineyards, are equipped with various types of drip irrigation systems, which are also used in orchards planted by "Armenian Fruit" project implemented by IFAD in Vayots dzor, Aragatsotn and Tavush provinces.

Anti-hail nets are a relatively new technology penetrating Armenian agriculture sector. Traditional way of protection from hails in Armenia has been the use of canons, but these require existence of expensive radar systems, which Armenia currently does not have, and also its use is problematic in border areas, due to conflict with Azerbaijan. Anti-hail nets can become a good alternative for the canons, plus these do not harm the environment or make any interference in atmospheric processes. Pilot projects on installation of anti-hail nets have been implemented by UNDP in Tavush province and the results are very promising.

Absence of agricultural insurance is among the main gaps of the sector, making it less protected from the consequences of climate change. The Government of Armenia considers this a serious issue and the Ministry of Agriculture is taking steps towards gradual introduction of the system. For this purpose, the Ministry cooperates with international organizations, such as KfW, USAID, UNDP, as well as local insurance companies, namely, Ingo Armenia, which is interested in implementation of a pilot project on insurance of cattle.

Distant pastures have traditionally been used during the summer seasons to feed the cattle and sheep, but due to fragmentation of farms and economic hardship currently most of the farmers do not take their cattle to distant pastures, due to which these are gradually degrading. Reconstruction of roads and irrigation of these pastures can promote the restoring of formerly existing practices, thus reducing the pressure on pastures located next to villages and helping development of cooperation.

Fisheries are one of the new directions of agriculture sector that are promoted by RA Government. These are mainly located in Ararat Valley and use ground water for their needs. Recent studies have shown that this may cause rapid deterioration of ground water resources, thus there is need for introduction of water saving technologies, particularly, closed cycle systems.

Thanks to cooperation between Armenian potato producers and several foreign companies, there are implemented activities aimed at localization of highly productive potato varieties and application of respective cultivation technologies. Currently over 20 new varieties of potato are cultivated in Armenia. Seeds of highly productive varieties of winter wheat, spring barley and fodder crops are imported from Russia and Ukraine starting from 2010.

Recently there is widely introduced the technology of cultivation of early vegetables and potato under polyethylene membrane. Specifically, in farms of Armavir province there is applied cultivation of vegetables in grooves and beds covered by polyethylene membrane.

As for fruit production, there is becoming wide-spread the planting of dwarf orchards and application of integrated, especially biological methods of disease and pest control. On the other hand, thanks to climate change it is becoming possible to cultivate subtropical fruits (persimmon, pomegranate, kiwi, jujube, etc.) in Syunik, Tavush and Ararat provinces.

Thanks to Concept of promotion of greenhouses in the farms of the Republic of Armenia approved by Protocol Decree of RA Government N 53-1 of December 26, 2013, main objective of which is development of greenhouses with surface of up to 1,000 m^2, recently there are made significant investments in construction of greenhouses, including passive solar greenhouses in mountainous areas.

In cattle breeding sector there are made attempts of introducing several progressive technologies, including:

- buffalo breeding, ostrich farming and fisheries with closed systems,
- open air keeping of cattle during winters,
- aerosol methods of disease control,
- effective methods of mastitis control, etc.

3.4 Adaptation Technology Options for Agriculture and Their Main Adaptation Benefits

The following technology options have been selected for agriculture sector based on consultations with stakeholder and analysis done by the sector expert. Two of the technology fact sheets have been received from stakeholders, including the 2nd and 5th options.

1. Pasture management,

2. Application of new generation of biodegradable water absorbent Aquasource in agriculture and decorative orchards,
3. Agriculture insurance as climate change adaptation tool,
4. Windbreaks as climate change adaptation tool,
5. Plastic and glass greenhouses with solar batteries, natural pest control and biological fertilizers,
6. Construction of temporary shelters and facilities for stockbreeders using straw bales,
7. Diversification of agricultural production in the communities located at lower elevations,
8. Establishing of a laboratory on forecasting of natural disasters and early warning,
9. Introduction of "Golden Spray" micro-raining system in communities with excessive water demand,
10. Local melioration and low-volume drip irrigation for newly planted orchards,
11. Planting of sea buckthorn forests as a means of land erosion prevention, regulation of river flows and source of additional income for locals,
12. Fruit drying community clusters.

3.5 Criteria and process of technology prioritization

Criteria of technology prioritization have been jointly selected by project experts, expert team leader and Coordinator, as well as other experts representing the sector, prior to submitting for the approval of stakeholders. The selection of criteria has been conducted based on Multi Criteria Analysis Guidance of UDP, and the criteria included costs, benefits, social, economic and environmental ones. The full list of criteria used for technology prioritization is presented in Table 17.

Table 17. Criteria of technology prioritization for agriculture sector.

N	Criteria
1.	Relevance to national strategies/programs
2.	Ease of implementation
3.	Compliance with ecosystem approach
4.	Promotion of private investments
5.	Promotion of adaptation to negative impacts of climate change
6.	Investment cost
7.	Need for additional institutional capacity
8.	Poverty reduction potential
9.	GHG emissions reduction potential
10.	Promotion of increased efficiency of use of agro-climatic resources (increased agricultural output) leading to vulnerability reduction

The criterion of compliance with ecosystem approach has been considered especially important, since it reflects the overall approach of RA Government in terms of implementation of environmental projects. Box 2 below explains it in more details.

Box 2

- Ecosystem approach requires considering the impact of respective activities related to using of resources within the context of coexistence of flora and fauna, and their interaction, interrelationship and integrity with the environment, instead of individual animal or plant species.
- Ecosystem approach to use of resources requires moderating, or normalizing and limiting the use of resources in such manner that will allow ecosystems to restore their natural balance

thanks to their self-healing potential, without losing internal ability.

- Whether that shall be use of natural resources or environmental impact, ecosystem approach requires dealing with ecosystems and moderating activities taking into consideration the capacities and abilities of ecosystems.

As for the other criteria, "Ease of implementation", "Investment cost", and "Need for additional institutional capacity" represent the costs related to technologies, while the rest are the benefits, of which "Promotion of increased efficiency of use of agro-climatic resources (increased agricultural output) leading to vulnerability reduction" and "Promotes adaptation to negative impacts of climate change" are the most significant ones in terms of adaptation to climate change.

The preliminary weighting of criteria has also been conducted by project experts, expert team leader and Coordinator, as well as other experts representing the sector, while stakeholders have later approved it during a meeting, where technology fact sheets, criteria have also been presented to them. Taking into consideration the above-mentioned, the highest weight has been given to the "Compliance with ecosystem approach" (20%), while "Promotion of increased efficiency of use of agro-climatic resources (increased agricultural output) leading to vulnerability reduction" and "Promotes adaptation to negative impacts of climate change" follow it (15% each). Relevance to national strategies/programs, ease of implementation, and investment cost have received smaller weights (10% each), while promotion of private investment, need for additional institutional capacity, poverty reduction potential and GHG emissions reduction potential have received the smallest weights. Thus the weight of criteria has been directly correlated to the relevance with the main objective of the analysis.

Table 18 presents the weight given to each of the criteria.

Table 18. Weighting of criteria for the assessment of agriculture sector technologies.

Criterion	Allocation of budget (total = 100)	Weight, %
Relevance to national strategies/programs	10	10%
Ease of implementation	10	10%
Compliance with ecosystem approach	20	20%
Promotion of private investments	5	5%
Promotes adaptation to negative impacts of climate change	15	15%
Investment cost	10	10%
Need for additional institutional capacity	5	5%
Poverty reduction potential	5	5%
GHG emissions reduction potential	5	5%
Promotion of increased efficiency of use of agro-climatic resources (increased agricultural output) leading to vulnerability reduction	15	15%

The process of technology prioritization has been conducted in two phases. First, there has been organized a meeting with project stakeholders where experts and team leaders have presented the sectors selected for analysis both in adaptation and mitigation directions. During a half-day meeting with about 50 participating representatives of stakeholder organizations there have been presented the vulnerability profiles of agriculture and water sectors, as well as recommended technologies

(presented in Annex I). The multi-criteria assessment tool has also been presented to the participants together with the criteria selected for each sector and weights of these.

Following the meeting with stakeholders, the technology fact sheets and the assessment tool have been sent by e-mail to all meeting participants, as well as some of the key stakeholders that have not been able to send a representative for participation in the meeting. Stakeholders have been asked to fill the assessment tool taking into consideration their understanding of the importance of different technologies as per different criteria. 15 stakeholders have sent back the filled multi criteria assessment tool within next 2 weeks and these have been taken into consideration in the analysis.

The investment costs have been assessed by the sector experts and included into multi criteria assessment tool separately, since these are measurable and can be assessed with quite high accuracy by project experts. Table 19 below presents cumulative scores given to agriculture sector technologies by stakeholders, which have later been endorsed by the project steering committee during a follow-up meeting in December, 2015.

Table 19. Overall scores of agriculture sector technologies given by stakeholders.

Option/Criterion	Relevance to national strategies/programs	Ease of implementation	Compliance with ecosystem approach	Promotion of private investments	Promotes adaptation to negative impacts of climate change	Investment cost	Need for additional institutional capacity	Poverty reduction potential	GHG emissions reduction potential	Promotion for increased efficiency of use of agro-climatic resources (increased agricultural output) leading to vulnerability reduction
Units	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	AMD/ beneficiary[22]	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
Preferred value	High	High	High	High	High	Low	High	High	High	High
Pasture management	3.3	3.0	4.4	3.0	3.7	5,952.0	2.3	3.3	2.7	4.0
Application of new generation of biodegradable water absorbent "Aquasource"	3.5	3.3	3.6	3.5	3.4	103,500.0	3.3	3.0	2.8	4.1
Agricultural insurance as climate change adaptation tool	4.1	2.4	3.4	3.9	3.7	26,000.0	2.3	4.4	2.6	3.7
Windbreaks as climate change adaptation tool	4.3	4.1	4.3	3.4	4.3	194,600.0	3.6	3.2	3.4	4.0
Plastic and glass greenhouses with solar panels, natural pest control and organic fertilizers	4.1	3.4	3.9	3.9	4.1	3,750,000.0	2.8	3.6	3.6	4.1
Construction of temporary shelters and facilities for stockbreeders	3.4	3.8	3.8	2.9	3.8	60,000.0	3.0	2.9	2.6	3.1
Diversification of agriculture	4.0	3.6	4.1	4.0	4.2	9,016.0	2.6	3.8	2.8	4.0
Establishing of a laboratory for forecasting of natural disasters and early warning	4.1	2.7	3.7	2.9	4.1	162.0	2.2	3.4	2.3	4.0
Introduction of "Golden Spray" micro-raining system in communities with excessive water demand	4.0	3.1	3.9	3.6	4.3	930,654.0	2.8	3.8	3.1	4.2
Local melioration and low-volume drip irrigation for newly planted orchards	4.3	3.3	4.0	3.6	4.1	428,600.0	3.0	3.9	3.3	4.6
Planting of sea buckthorn forests as a means of land erosion prevention, regulation of river flows and source of additional income for locals	3.8	4.2	4.0	3.3	4.0	180,000.0	2.9	3.2	3.2	3.8
Fruit drying community clusters	3.3	3.9	3.7	4.2	3.7	-[23]	3.1	3.6	2.7	3.6

[22] Investment cost in Armenian drams per each beneficiary of given project.

[23] Further research is needed to calculate the investment cost of given technology.

3.6 Results of technology prioritization

As a result of summarization of assessments made by stakeholders and financial assessments made by experts the technologies have been ranked the following way:

Table 20. Ranking of agriculture sector technologies.

Rank	Option	Weighted Score
1	**Windbreaks as climate change adaptation tool**	**87.4**
2	**Local melioration and low-volume drip irrigation for newly planted orchards**	**79.5**
3	**Diversification of agriculture**	**73.4**
4	Introduction of "Golden Spray" micro-raining system in communities with excessive water demand	68.8
5	Planting of sea buckthorn forests as a means of land erosion prevention, regulation of river flows and source of additional income for locals	63.8
6	Plastic and glass greenhouses with solar panels, natural pest control and organic fertilizers	62.1
7	Pasture management	53.6
8	Establishing of a laboratory for forecasting of natural disasters and early warning	49.6
9	Application of new generation of biodegradable water absorbent "Aquasource"	42.3
10	Agricultural insurance as climate change adaptation tool	41.3
11	Fruit drying community clusters	36.0
12	Construction of temporary shelters and facilities for stockbreeders	35.1

The prioritized technologies will be analyzed further in order to identify barriers that will need to be overcome to make these marketable. The remaining options will also remain in the pipeline and further analysis of these shall be done if need arises.

Chapter 4. Technology prioritization for Water Sector

4.1 Key Climate Change Vulnerabilities in Water Sector

The vulnerability assessment of the water resources of model water objects - Arpa, Debed, Vorotan, Voghji, Meghriget river basins – has been conducted using the WEAP model[24]. The vulnerability of Lake Sevan water resources has also been analyzed.

Vulnerability of Water Resources in the Arpa River Basin

Using WEAP software, the monthly, seasonal, and annual value of the Arpa river flow has been modelled using A2 and B2 scenarios for 2030, 2070, and 2100. The annual average flow of Arpa will significantly decrease compared to the baseline (1961-1990) period (see Table 21).

Table 21. Projected change in Arpa River flow

River – observation point	Scenario	Flow change							
		1961-1990		2030		2070		2100	
		million m^3	%	million m^3	%	million m^3	%	million m^3	%
Arpa-Areni river	**A2**	728.8	0	578.9	-21	532.8	-27	489.1	-33
	B2	728.8	0	604.0	-17	573.5	21	513.7	-30

The estimated river flow of Arpa will increase only in winter: by 12% in accordance with A2 scenario; and by 17.9% in accordance with B2 scenario. In parallel with ambient air temperature increasing, there will be an increase in rainfall, while snowfall will decrease.

The river flow will become more vulnerable as a result of reduced snow stored in winter.

Debed and Aghstev River Basins

In 2009-2011 the UNDP "Climate change in the South Caucasus" project analyzed and assessed the vulnerability of the river flows of trans-border river basins of Debed and Aghstev, according to ECHAM5, GFDL CM2.X, GISS-ER and HadCM3 regional atmospheric-circulation models. By testing historical data, these models have been adopted by South Caucasus countries to generate the most reliable results. Thus, the results for average values derived by the aforementioned four models show that, in A2 scenario, the flow of Debed River will fall by 10-11% by 2040; by 29-37% in 2041-2070; by 55-62% in 2100. By 2040 Aghstev River flow will decrease by 11-14%; by 2070 – 31-37%; by 2100 – 62-72% (see Table 22).

[24] Sieber J, Swartz C. and Huber-Lee A. Water Evaluation and Planning System User Guide for WEAP 21. Stockholm Environment Institute. Tellus Institute, Boston, Massachusetts.- 2005.

Table 22. Projected change in flow of Aghstev and Debed rivers, A2 scenario[25]

River – observation point	Flow change							
	1961-1990		2030		2070		2100	
	million m^3	%	million m^3	%	million m^3	%	million m^3	%
Debed-Ayrum river	1054	0	937	-11	669	-37	402	-62
Dzoraget-Gargar river	480	0	427	-10	343	-29	215	-55
Pambak-Tamanyan river	336	0	300	-11	240	-29	160	-53
Aghstev-Ijevan river	286	0	255	-11	196	-31	108	-62
Voskepar (with its tributary Kirants)-Voskepar	67	0	58	-14	42	-37	19	-72

Vorotan River Basin

The vulnerability of water resources as a result of climate change in Vorotan River basin has been assessed within the framework of the USAID "Clean Energy and Water" programme during the development of Vorotan River basin management plan. According to the assessment, in case of A2 scenario, snowfall will also increase by 2100 in parallel with the projected increase in the total annual average precipitation amount in the river basin: in Vorotan mountain pass by about 24 mm (16%); in Goris by about 15 mm (16%); in Sisian by about 8 mm (17%).

At the observation points of Vorotan-Vorotan, Voratan-Tatev HPP, Gorisget-Goris and Loradzor-Lchen river basins, the projected decrease in natural river flow by 2100 is 4%, 9%, 8% and 25%, respectively. At the observation points in Tsghuk-Tsghuk, Sisian-Arevis and Vorotan-Gorhayk, the projected flow will grow by 11-15%. This means that the mid- and upstream river flows will increase, while it will decrease downstream (see Table 23). This is due to intensive evaporation driven by the projected high temperature in the downstream part of the Vorotan River.

Table 23. Projected changes in the Voratan River flow

River – observation point	Scenario	Flow change							
		1961-1990		2040		2070		2100	
		million m^3	%	million m^3	%	million m^3	%	million m^3	%
Vorotan - Gorhayk river	**A2**	131.9	0	137.9	5	145.0	10	152.8	16
	B1	131.9	0	136.7	4	141.4	7	148.3	12

According to natural flow projections in various observation points of the river basin, it is expected that the annual natural river flow will increase by about 3%. In terms of seasonality, it is predicted that, by 2100, Vorotan-Gorhayk flow will increase by approximately 21.4 million m^3 (16%) (A2 scenario); 16.8 m^3 (13%) (B1 scenario).

[25] Assessment of vulnerability of water resource to climate change in transboundary river basins (Khrami-Debed and Aghstev) and recommendations on the corresponding adaptation measures. Yerevan, 2011.

Araks-Akhurian River Basin[26]

The vulnerability of Araks and Akhurian rivers annual flows for 2040, 2070, and 2100 has been projected using CCSM4 model data-emissions scenarios (RCP8.5 (A2) and RCP6.0 (B2)). According to the assessments, there will be no significant change in flows for both river basins by 2040. In 2071-2100, it is expected that the flow in the Haykadzor sector of Akhurian River will fall by 2.1% (A2)/ 4.4% (B2); in 2071-2100 the flows will reduce by 10.5% (A2)/5.7% (B2).

For both scenarios there will be some increase in Araks River flow: 3-4% in 2041-2070, and 1-2% in 2071-2100.

Hrazdan, Azat, Vedi River Basins[27]

Climate change impacts on river flows vary for different river basins. For instance, it is projected that by 2040 there will be a 2-3% increase in annual river flow in Azat and Vedi river basins, while in upper streams of Hrazdan River there will be a reduction of 2-3% (A2). In 2041-2070 there is a projected decrease in river flows for all three river basins: 3-4% in 2070 in Azat and Vedi river basins, and 6-7% in Hrazdan river basin; in 2100 the projected decrease will reach 12-14% and 15-20%, respectively.

Lake Sevan[28]

Water temperature changes were projected under A2 and B2 scenarios for 2030, 2070 and 2100 using ambient air and water temperatures interconnection formulae.

The results indicate that Lake Sevan's water temperature, according to A2 scenario, will increase by 4 C^0 against the baseline (9.4 C^0) by 2100; for B2 – by 3.6 C^0. Therefore, it is projected that in 2030 Lake Sevan inflow will decrease by more than 50 million m^3 against the baseline (787 million m^3); in 2070 – by about 110 million m^3; in 2100 – by about 190 million m^3. This means that the water level will start going down by about 16 cm per year (see Table 24).

Table 24. Projection of inflows in Arpi reservoir and Lake Sevan, A2 scenario, million m^3

Reservoir	1961-1990	2030	2070	2100
Lake Arpi Reservoir	60.15	56.12	51.43	45.47
Lake Sevan	787.00	734.00	673.00	595.00

4.2 Decision context

Water sector is regulated by the State Committee of Water Economy of the Ministry of Agriculture of RA and Water Resources Management Agency of the Ministry of Nature Protection of RA. Major documents regulating the relationship in this sector include National Water Programme and Fundamentals of National Water Policy.

Most of the projects in this sector are implemented by the financing of international financial and donor organizations. The most recent projects in water sector include the following ones:

[26] Third National Communication on Climate Change of the Republic of Armenia
[27] Third National Communication on Climate Change of the Republic of Armenia
[28] Third National Communication on Climate Change of the Republic of Armenia

- **Water Supply and Sanitation Sector Project (2012 - 2017)**. The Project is the phase 2 financing of the original Armenia Water Supply and Sanitation Sector Project (approved in 2007). It will include upgrade and rehabilitation of water supply networks across 10 subprojects, covering 17 towns and 92 villages. The project loan is USD 50 million (USD 40 million contributed by ADB and USD 10 million contributed by RA Government).
- The **Country Partnership Strategy** (CPS) for Armenia has been prepared in the context of global economic crisis and its impact on Armenia. It focuses on the near term needs of addressing vulnerability and mitigating the adverse poverty effects of the crisis, as well as laying the foundation for promoting medium term competitiveness and growth. The CPS presents an integrated strategy for the World Bank Group. It reflects Armenia's transition to International Development Agency/International Bank for Reconstruction and Development (IDA/IBRD) blend status from fiscal year 2009, as well as the full integration of the International Financial Corporation (IFC) programme for the country.
    - *Water*. The Bank has been very active in building a new public-private partnership in delivery of water to businesses and the public through two ongoing projects -- Yerevan Water and Municipal Water projects. Additional Finance for the Municipal Water Project has been provided in FY09 to help extend the management contract and set further quality benchmarks.
    - *Irrigation and Drainage*. The Irrigation and Drainage sector continues to be a major development challenge for the Government. While much has been achieved, the needs for irrigation rehabilitation investments in Armenia remain high. Future irrigation projects should continue the reforms started in the sector and place larger focus on water management issues, including wider use of modern irrigation techniques and more efficient use of water. This may help reduce water delivery costs and increase sustainability of the irrigation sector.
- **Rehabilitating Water and Wastewater Networks in Armenia**. In July 2011, the EBRD extended a EUR 6.5 million sovereign loan to the Republic of Armenia to improve water supply and wastewater services in 17 towns across Armenia. The funds will be on-lent to the state-owned Armenian Water and Sewerage Company (AWSC) to finance the rehabilitation of water and wastewater networks, as well as the construction of two wastewater treatment plants. AWSC is currently operated by the French company SAUR under a long-term management contract. The aim of the project is to significantly reduce water losses and improve drinking water availability for approximately 300,000 residents.
- **UNDP/GEF Reducing Trans-boundary Degradation in the Kura-Aras River Basin**. The Project will assist the Kura-Aras riparian states to 1) identify the principal threats and root causes of the trans-boundary water resources of the Kura Aras-River Transboundary Basin and 2) develop and implement a sustainable programme of policy, legal and institutional reforms and investments to address these threats. Balancing overuse and conflicting uses of water resources in transboundary surface and groundwater basins is seen as the critical issue in the basin and will be a principal focus of project attention from the very outset of project related activities. The Project will create synergies with and build upon a range of initiatives being undertaken by the countries themselves and those of bi-lateral and multi-lateral donors that have given priority to the Basin.
- **Transboundary river management for the Kura River - Phase II - Armenia, Azerbaijan, Georgia (2008–2011)**. The Project reinforces regional cooperation in monitoring and managing water resources in the Kura river basin, through training, capacity strengthening, streamlining data collection, information and know-how exchanges. Budget: EUR 4.0 million + EUR 1.2 million for equipment. It aims to improve the water quality in the Kura River basin through trans-boundary cooperation and implementation of the integrated water resources

management approach. The project supports the development of a common monitoring and information management system to improve transboundary cooperation and enhances the capacities of environmental authorities and monitoring establishments engaged in long-term integrated water resources management in the Kura River basin.

- **Environmental Protection of International River Basins (2012 – 2016)**. Reinforces current actions in environmental protection and water resources management, supported by previous EU funded transboundary projects in the region in terms of cooperation as well as convergence towards the principles of Integrated Water Resources Management (IWRM) and the EU Water Framework Directive (WFD), by joint development of River Basin Management Plans (RBMP) in selected pilot river basins of wider Black Sea region. Countries: Armenia, Azerbaijan, Belarus, Georgia, Moldova, Russian Federation, and Ukraine. Budget: EUR 7.5 million.
- **Revive a River (2009-2013)**. As part of this Global Development Alliance project, UNDP with the participation of the Municipality of Dilijan, the Coca Cola Corporation, and the Government of Armenia (through EBRD funding and Municipality of Dilijan) will install a wastewater treatment plant on Aghstev River. In addition, the sewage network and collectors will be either repaired or reconstructed. The project will also partner with the community as part of environmental and cultural heritage protection activities along the river. Budget is: USD 3.5 million / USAID share: USD 200,000. The project is implemented by the UNDP.
- **Clean Energy and Water Programme (2011 - 2015)**. The purpose of this project is to provide assistance to Armenia's energy and water sector activities that will help improve the country's energy and water security. To this end, the project will help promote integrated energy and water planning, advise the Government of Armenia on issues regarding sustainable hydropower development and water management, and help local communities and enterprises in selected water basins to improve the accessibility, quality and affordability of energy and water services. Budget: USD 5.7 million, implemented by Mendez England & Associates (ME&A).

4.3 Overview of Existing Technologies in Water Sector

While potable water supply and sanitation sector are managed by large companies, including Armenian Water and Sewerage CJSC and Yerevan Jur CJSC, irrigation water is supplied by water users' associations spread all over the country.

In addition to use of natural water springs (ground and surface), in several settlements, where river water is used as a source of potable water (Lernajur, Artik, Sevan, Tsaghkunk), there has been applied an alternative technology of water intake – natural and artificial underflow water intakes. This technology enables using, instead of river water, the water from the layer feeding the river, which is cleaned by passing through natural or artificial filters, and its quality complies with potable water standards. This method enables ensuring respective quality of water without construction of potable water treatment plants, thus leading to decreased cost of operation of the system and smaller impact on natural ecosystems.

Although up to date there have been implemented and there are underway several projects aimed at upgrading of water supply system, the flow losses in the areas serviced by operators are still high (80-85%). Flow losses detection activities are implemented by operators, using instrumental methods. But these are not regular and operators only react to emergency situations, due to lack of respective technical and professional capacities.

As for sewerage, currently there is almost no treatment of wastewater in Armenia and the wastewater is directly discharged into rivers. As a result, the water quality immediately downstream of most of the settlements is low, while in general river water quality is sufficient thanks to self-cleansing capacities of rivers. Capital city of Yerevan is the worst polluter, as it is the largest settlement of Armenia discharging most of its wastewater directly into water bodies.

Wastewater collection and treatment systems are available in all urban and about 20% of rural communities. Existing 20 WWTPs have been designed for mechanical and biological treatment and disinfection of wastewater. Municipal sanitation systems are used for collection of wastewater, which later goes to WWTPs, often by gravity flow. Nevertheless, despite existence of collection systems, in most of the cases the wastewater is directly discharged into rivers and other water bodies, due to the absence of necessary facilities for collection and transfer of wastewater to WWTPs.

Most of wastewater treatment plants have been constructed prior to 1990 and are outdated. Since then these have become inefficient and costly due to increasing of energy prices.

As of 2014, there have been opened wastewater treatment plants in Gavar, Martuni, and Vardenis, towns. Within the framework of "Water project for small communities of Armenia" of European Bank for Reconstruction and Development and European Investment Bank there have been constructed wastewater treatment plants in Jermuk and Dilijan towns in 2015. Only mechanical treatment is conducted on these plants and operation is conducted by Armwater CJSC. A community level treatment plant has been constructed in Parakar community of Armavir province of RA using hybrid treatment technology (with elements of conventional and natural treatment). It has been constructed within the frameworks of a pilot project financed by GEF SGP and GWP. On this plant there is conducted mechanical and biological treatment. There have also been installed few compact treatment plants, which enable treatment of wastewater of individual objects. Other large-scale sanitation projects are foreseen under the joint financing of KfW, European Union and European Investment Bank.

Innovative technologies used in irrigation system include drip irrigation and raining systems, which are not accessible for most of the farmers due to high price. Drip irrigation systems are mostly used in greenhouses, since these have small areas and require smaller investments. Nevertheless, there have already been established several dozens of hectares of vineyards, which use drip irrigation.

For the purpose of provision of water to irrigated land plots there is planned reconstruction of water reservoirs within the framework of several projects during the upcoming 10 years (Vedi, Kaps, Yeghvard, Mastara), which will enable irrigation of about 21.5 thousand ha of agricultural land. In parallel with reconstruction of Yeghvard reservoir there is also planned transition to gravity flow irrigation, as a result of which there will be no need for currently operated 9 pump stations, leading to saving of 28.5 million kWh of electricity.

Fisheries are one of the new directions of agriculture sector that are promoted by RA Government. Currently there are operated about 300 fisheries in Armenia, majority of which (76%) is located in Armavir and Ararat provinces. In remaining 8 provinces of RA there are operated 70 fisheries (24% of fisheries), more than half of which is located in Gegharkunik, Lori and Shirak provinces. According to data of RA Ministry of Agriculture, currently there are 2,670 ha of water surface used for industrial

fisheries. 60% of water used for industrial fisheries is groundwater, while 40% is surface. Currently there are more than 250 fisheries operated in Ararat artesian basin, which use groundwater of the Valley for their needs (there are operated 450 wells).

The renewable groundwater reserves of the Valley are 1,226 million m^3, while fisheries have been provided with water use permits for 1,496 million m^3. There are mostly operated conventional flow fisheries, where water flows through fishery system only once and then discharges into environment. While flowing through the fishery system the water supplies oxygen to fish and removes dissolved or suspended particles. As a result of operation of fisheries using flow system, annually 800 million m^3 of water from Ararat artesian basin flows into Arax River, and then to neighboring countries. Transition to circulatory (semi-closed) and closed water supply systems will enable decreasing water consumption several times and using water resources more effectively (in case of circulatory system the volume of fresh water is about 30%, and in case of closed system – 3-5%).

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

The following technology options have been selected for water sector based on consultations with stakeholder and analysis done by the sector expert.

1. Distribution of cultivation areas of agricultural crops in accordance with water supply and demand
2. Saving of water resources within water supply system via reduction of flow losses and introduction of monitoring system
3. Spreading and expansion of drip irrigation system
4. Construction of small water reservoirs at community level
5. Creation of circulatory water system for fisheries
6. Protection of surface water resources from pollution (application of alternative technologies for wastewater treatment - installation of compact treatment plants)
7. Protection of surface water resources from pollution (application of alternative technologies for wastewater treatment - application of natural and hybrid treatment systems)
8. Protection of water sources via construction of underflow water intakes
9. Economy of water resources - introduction of irrigation systems using artificial raining equipment
10. Improving of ground water reserves management tools

4.5 Criteria and process of technology prioritization

Criteria of technology prioritization have been jointly selected by project experts, expert team leader and Coordinator, as well as other experts representing the sector, prior to submitting for the approval of stakeholders. The selection of criteria has been conducted based on Multi Criteria Analysis Guidance of UDP, and the criteria included costs, benefits, social, economic and environmental ones. The full list of criteria used for technology prioritization is presented in Table 25.

Table 25. Criteria of technology prioritization for water sector.

N	Criteria
11.	Relevance to national strategies/programs
12.	Ease of implementation
13.	Compliance with ecosystem approach
14.	Promotion of private investments
15.	Promotion of adaptation to negative impacts of climate change
16.	Investment cost
17.	Need for additional institutional capacity
18.	Poverty reduction potential
19.	GHG emissions reduction potential
20.	Increased water use efficiency potential

The criterion of compliance with ecosystem approach has been considered especially important, since it reflects the overall approach of RA Government in terms of implementation of environmental projects. Box 2 explains it in more details.

As for the other criteria, "Ease of implementation", "Investment cost", and "Need for additional institutional capacity" represent the costs related to technologies, while the rest are the benefits, of which "Increased water use efficiency potential" and "Promotes adaptation to negative impacts of climate change" are the most significant ones in terms of adaptation to climate change.

The preliminary weighting of criteria has also been conducted by project experts, expert team leader and Coordinator, as well as other experts representing the sector, while stakeholders have later approved it during a meeting, where technology fact sheets, criteria have also been presented to them. Taking into consideration the above-mentioned the highest weight has been given to the "Compliance with ecosystem approach" (20%), while "Increased water use efficiency potential" and "Promotes adaptation to negative impacts of climate change" follow it (15% each). Relevance to national strategies/programs, ease of implementation, and investment cost have received smaller weights (10% each), while promotion of private investment, need for additional institutional capacity, poverty reduction potential and GHG emissions reduction potential have received the smallest weights. Thus the weight of criteria has been directly correlated to the relevance with the main objective of the analysis.

Table 26 present the weight given to each of the criteria.

Table 26. Weighting of criteria for the assessment of water sector technologies.

Criterion	Allocation of budget (total = 100)	Weight, %
Relevance to national strategies/programs	10	10%
Ease of implementation	10	10%
Compliance with ecosystem approach	20	20%
Promotion of private investments	5	5%
Promotes adaptation to negative impacts of climate change	15	15%
Investment cost	10	10%
Need for additional institutional capacity	5	5%
Poverty reduction potential	5	5%

GHG emissions reduction potential	5	5%
Increased water use efficiency potential	15	15%

The process of technology prioritization has been conducted in two phases. First, there has been organized a meeting with project stakeholders where experts and team leaders presented sectors selected for analysis both in adaptation and mitigation directions. During a half-day meeting with about 50 participating representatives of stakeholder organizations there have been presented the vulnerability profiles of agriculture and water sectors, as well as recommended technologies (presented in Annex II). The multi-criteria assessment tool has also been presented to the participants together with the criteria selected for each sector and weights of these.

Following the meeting with stakeholders, the technology fact sheets and the assessment tool have been sent by e-mail to all meeting participants, as well as some of the key stakeholders that have not been able to send a representative for participation in the meeting. Stakeholders have been asked to fill the assessment tool taking into consideration their understanding of the importance of different technologies as per different criteria. 15 stakeholders have sent back the filled multi criteria assessment tool within next 2 weeks and these have been taken into consideration in the analysis.

The investment costs have been assessed by the sector experts and included into multi criteria assessment tool separately, since these are measurable and can be assessed with quite high accuracy by project experts. Table 27 below presents cumulative scores given to agriculture sector technologies by stakeholders, which have later been endorsed by the project steering committee during a follow-up meeting in December, 2015.

Table 27. Overall scores of water sector technologies given by stakeholders.

Option/Criterion	Relevance to national strategies/programs	Ease of implementation	Compliance with ecosystem approach	Promotion of private investments	Promotes adaptation to negative impacts of climate change	Investment cost	Need for additional institutional capacity	Poverty reduction potential	GHG emissions reduction potential	Increased water use efficiency potential
Units	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	AMD/ beneficiary[29]	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
Preferred value	High	High	High	High	High	Low	High	High	High	High
Distribution of cultivation areas of agricultural crops in accordance with water supply and demand	3.7	2.8	3.8	3.0	4.3	2,000.0	2.9	3.8	3.1	4.4
Reduction of flow losses and introduction of monitoring system	4.6	2.3	4.3	3.4	4.1	19,783.0	2.4	3.9	2.2	4.8
Spreading and expansion of drip irrigation system	4.0	2.9	4.3	3.6	4.4	2,592,000.0	2.9	3.3	3.4	4.8
Construction of small water reservoirs at community level	4.0	2.3	3.8	3.4	3.8	13,000.0	3.1	4.0	3.0	4.6
Creation of circulatory water system for fisheries	4.6	3.3	4.4	3.5	4.1	685.0	3.0	3.3	3.1	4.8
Installation of compact treatment plants	4.9	2.5	4.3	3.4	4.1	114,400.0	3.0	3.3	3.3	4.6
Application of natural and hybrid treatment systems	4.6	3.3	4.4	3.6	3.9	104,000.0	3.0	3.1	3.4	4.3
Protection of water sources via construction of underflow water intakes	4.1	2.6	4.0	2.3	3.9	7,000.0	2.7	2.9	3.0	4.1
Economy of water resources - introduction of irrigation systems using artificial raining equipment	3.9	2.1	3.6	3.3	4.3	250,000.0	2.7	3.1	3.1	4.4
Improving of ground water reserves management tools	4.4	1.9	4.3	2.5	4.0	2,674.0	2.2	3.0	2.9	4.6

[29] Investment cost in Armenian drams per each beneficiary of given project.

4.6 Results of technology prioritization

As result of summarization of assessments made by stakeholders and financial assessments made by experts the technologies have been ranked the following way:

Table 28. Ranking of water sector technologies.

Rank	Option	Weighted Score
1	**Creation of circulatory water system for fisheries**	**84.5**
2	**Installation of compact treatment plants**	**72.3**
3	**Application of natural and hybrid treatment systems**	**70.3**
4	Spreading and expansion of drip irrigation system	70.1
5	Reduction of flow losses and introduction of monitoring system	66.7
6	Distribution of cultivation areas of agricultural crops in accordance with water supply and demand	51.9
7	Improving of ground water reserves management tools	48.0
8	Construction of small water reservoirs at community level	43.9
9	Economy of water resources - introduction of irrigation systems using artificial raining equipment	39.9
10	Protection of water sources via construction of underflow water intakes	35.4

The prioritized technologies will be analyzed further in order to identify barriers that will need to be overcome to make these marketable. The remaining options will also remain in the pipeline and further analysis of these shall be done if need arises.

Chapter 5. Summary and Conclusions

Technology Needs Assessment has been conducted in the Republic of Armenia with the main objective of identifying technologies that can help reducing the vulnerability of the country to negative effects of climate change. To this end there have been conducted several activities, namely, as the first step, there has been established the organizational structure of the Project, which included the Steering Committee, Project Coordinator, Adaptation and Mitigation Expert Team Leaders, as well as Sectoral Experts. This has ensured active participation of stakeholders in decision making, including selection of sectors for the analysis, as well as identification and prioritization of respective technologies.

Stakeholders from public institutions, academia, civil society, private sector and international organizations have been involved in the process of identification and prioritization of technologies to ensure possibly broad representation of various interests and awareness on technological needs. This has been done in different ways, including bilateral meetings, seminars, exchange of e-mail, etc. As a result, total of about 140 stakeholders have been contacted and about 50 of them have participated in Project events.

Water and agricultural sectors have been identified as the most vulnerable in Armenia and technology needs assessment has been conducted for these. Agriculture is one of the most important sectors of Armenian economy, with over 30% share in GDP, while at the same it carries major losses caused by natural hazards like hail, droughts, freezing, etc., frequency of which increases due to climate change. Water is important for most of the sectors of economy, as well as ecosystems, which are the key element of environmental policy in Armenia. Water-saving technologies are especially important due to reducing precipitations and increasing temperatures.

Based on existing documents, such as Armenia's Third National Communication on Climate Change, there has been described the impact of climate change on priority sectors and vulnerability of these. Respective adaptation technologies have been identified by sectoral experts and stakeholders, after which these have been discussed with stakeholders and Project management to prioritize the technologies for agriculture and water sector. Multi-Criteria Assessment tool has been used for technology prioritization and as a result the following technologies have been prioritized:

Agriculture	**Water**
• Windbreaks as climate change adaptation tool	• Creation of circulatory water system for fisheries
• Local melioration and low-volume drip irrigation for newly planted orchards	• Installation of compact treatment plants and Application of natural *and* hybrid treatment systems
• Diversification of agriculture	• Spreading and expansion of drip irrigation system

During the next phase of the Project there will be conducted barrier and market analysis of prioritized technologies to identify the enabling environment necessary for implementation of these in Armenia.

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Annex I: Technology Factsheets for selected technologies

Technology Fact Sheets – Agriculture

Application of new generation of biodegradable water absorbent "Aquasource" in agriculture and decorative gardening[30]	
Introduction	Aquasource is a new generation of substances with an exceptional capacity of absorption and storing of humidity. Aquasource is a potassium-containing biodegradable absorbent (polymer) – water absorbent substance, 1 gram of which absorbs 350-400 grams of water, and returns it to the plants as needed. Located around the root system of each plant Aquasource ensures 50-60% of irrigation water saving, increasing of survival rates of seedlings up to 98% and increases yield by 40-50%, depending on plant species and soil composition.
Technology characteristics	Aquasource biodegradable absorbent is foreseen for application in agriculture and decorative gardening. Aquasource is based on polymer molecule characterized by huge volumes of water absorption and storage capacity. Aquasource can absorb and bind in its molecules humidity from irrigation water, precipitations, frosting and fog. 1 gram of Aquasource can absorb and store water exceeding its own weight 350-400-fold, or otherwise, 10 grams absorb 3.5-4 liters of humidity. Aquasource can accumulate humidity together with nutrients dissolved in soil (or added chemical substances and natural fertilizers) providing plants with water and nutrients for long time, depending on individual needs of these. Advantages of these substance are not limited only by humidity and nutrients accumulation, it also saves and reduces irrigation by 50-60% (reduces labor costs, time and financial costs), reduces input of fertilizers by 40% (reduces labor costs, time and financial costs) thanks to its physical characteristics it improves soil structure, ensuring ventilation and drainage, increases the volume and types of rhizosphere, improves buffering capacity of soil, even in case of presence of acidic and alkaline compounds in it (soil capacity of maintaining natural pH), increases survival rate of seedlings and seeds up to 98%, ensures acceleration of development process and decreases the period of fruitage (fruits ripen 10-14 days earlier). Aquasource is safe for people, bacteria, fish, birds, animals and microorganisms living in soil. The fertility increases by 40-60% (depending on plants species and soil composition), excels with high environmental standards, NO ACRYLAMIDE is used for its production. It is sterile, not poisonous, inert against pesticides, maintains its characteristics in all climatic and thermal conditions, remains active for 7 years, and decomposes into H_2O, CO_2, NH_3 and potassium, which can also be used by plants, during the following 5 years. It has high stability

[30] Developed by Ecotechnology LLC

	against UV rays.
Costs, including	
cost to implement adaptation options	Taking into consideration low volumes of output, currently the cost of 1 kg of Aquasource is AMD 3,900. One seedling requires 3 grams of Aquasource for one full vegetation cycle (for 1 ha there need to be used 120 kg of Aquasource – 120 kg x AMD 3,900 = AMD 468,000), 30-50 grams are required for planting of trees, vines and shrubs (0.03 g x AMD 3,900 = AMD 117), 20 kg of Aquasource are needed for one hectare of wheat (20 kg x AMD 3,900 = AMD 78,000) (tests are still underway), about 20-30 grams of Aquasource are needed for 1 m^2 of decorative and athletic lawns. Room plants require 6 grams of Aquasource, in average.
cost of not modifying the project	If no modifications are made there will be at least 50% loss of water resources, important elements will continue washing out from soil, farmers will be spending the same amount of time for irrigation, there will be respective lost opportunity of yield and income increasing if Aquasource is not used.
Potential development impacts, benefits	
Economic	Increased yield, payback of all costs related with garden/vegetable crops and increasing of incomes by at least 20-30%, safe for water saving. For example, in case of tomato –average yield from 1 ha is 60000kg. Aquasource ensures crop increase by 30% - 18000kg. 18,000 kg x AMD 50 = AMD 900,000, thus the profit will be: AMD 432,000 = AMD 900,000 – AMD 468,000 In addition, Aquasource decreases the time needed for watering, potentially leading to additional incomes.
Social	Mitigation of risk of reduction of rural population incomes as a result of climate change.
Environmental	50-60% saving of water resources, it promotes increasing of the volume of rhizosphere. Aquasource accelerates the growth of grass, flowers, orchards, green spaces, thus increasing carbon sequestration, prevents soil erosion.
Status	Starting from 2012 Ecotechnology LLC, the producer of the substance, has cooperated and implemented pilot projects with CARD, OXFAM, UMCOR, UNDP, Project Implementation Unit of the Ministry of Agriculture of RA and several private cooperatives and individual farmers. In 2014 Ecotechnology LLC participated in National Cleantech Ideas Competition within the framework of UNIDO GEF Global Cleantech Innovation Programme for SMEs in Armenia, by applying to Water Resources component, and has become the national winner. Partners of the programme included the Ministry

	of Economy, the Ministry of Nature Protection, the Ministry of Energy and Natural Resources, the Ministry of Agriculture, Enterprise Incubator Foundation (EIF), Small and Medium Enterprises Development National Center (SME DNC). In November, 2014 Ecotechnology LLC has had an opportunity to present its technology and business model to venture funds, investors, clean technology experts in San Francisco, by participating in Cleantech Open annual global business forum organized in Silicon Valley, USA. In March 2015 Ecotechnology LLC participated and won matching grants competition of Enterprise Incubator Foundation (EIF) and currently has an opportunity to organize large-scale production of Aquasource, which is planned for second half of 2016.
Barriers	Importing of raw materials from abroad, and as a consequence, need for large investments to reduce the costs.
Acceptability to local stakeholders	Starting from 2012 Ecotechnology LLC, producer of the substance, has cooperated and implemented pilot projects with CARD, OXFAM, UMCOR, UNDP, Project Implementation Unit of the Ministry of Agriculture of RA and several private cooperatives and individual farmers. Currently Aquasource biodegradable absorbent is sold in Yerevan and specialized shops of other cities of Armenia. The price is AMD 5,570 per 1 kg.
Endorsement by experts	Aquasource biodegradable absorbent has been subjected to independent expert study in Scientific Center of Vegetable and Industrial Crops SNCO. Currently a dissertation thesis on the topic of effects of Aquasource on plants is being defended in Scientific Center of Vegetable and Industrial Crops, in partnership with the Academy of Sciences of Russian Federation.
Timeframe	Aquasource biodegradable absorbent is produced in Armenia, by Ecotechnology LLC, and any quantity can be supplied based on preliminary order. With one application Aquasource will work in soil up to seven years in case of perennial plantations. In case of vegetables it may also work up to 7 years if no plowing is applied, otherwise the absorbent has to be applied each year. Taking into consideration the above-mentioned it is recommended to conduct a pilot project for vegetables in 2017 and perennial plantations during 2017-2013.
Institutional capacity	Application of Aquasource biodegradable absorbent is very easy and simple and any farmer will be able to do it after reading the instructions.
Adequacy for current climate	Aquasource biodegradable absorbent has been tested under almost all climate conditions of Armenia (Ararat Valley, Meghri, Tavush, Shirak, Lori, Gegharkunik, Vayots dzor, Aragatsotn) and the results have been good.
Size of beneficiaries group	Farmers, gardeners and owners of orchards are interested in Aquasource, and it is used in any phase of crop growth and for any crop. The areas of application of Aquasource are huge, starting from adding to room flowers to ensure storing of humidity to industrial

	production and melioration of territories polluted as a result of atmospheric phenomena.

Pasture management	
Introduction	According to data of National Statistical Service of RA current condition of 1,055,300 hectares of pastures of Armenia is extremely poor. Anthropogenic factors, as well as climate change have a very serious impact on pastures of Armenia. Currently, almost half of pastures are subject to degradation and the biological productivity of these has dropped 1.5-2 folds in comparison with 1950s. Management of these land resources to date has been at a low level, resulting in significant reduction of surfaces useful for grazing [31]. Temperature increasing and decreasing of precipitations accelerates the process of degradation of pastures, thus there is need for implementation of adaptation projects to prevent negative phenomena to the extent possible.
Technology characteristics	It is suggested conducting inventory and assessment of pastures via State Committee of the Real Estate Cadastre of RA, establish cooperatives of pasture users and implement pastures' improvement, watering and regime grazing activities based on participatory principle, with public support and efforts of cattle breeders. There is particularly need for improving the vegetation of pastures, conducting sowing of wild herbs in damaged areas, accumulating natural spring water for watering purposes and installing of drinkers or puddles to make the access of cattle easier. Provision of respective living conditions for cattle breeders in distant pastures.
Costs, including	AMD 3.32 billion
cost to implement adaptation options	During the first phase, there will be conducted air photographing, inventory and shaping of especially high-value alpine pastures of Aragatsotn (131.2 thousand ha), Gegharkunik (181.6 thousand ha), Lori (145.6 thousand ha), Shirak (114.6 thousand ha) and Syunik (147.2 thousand ha) provinces, using a drone, which will require around 720 thousand ha * USD 150/thousand ha = USD 108 thousand or around AMD 52 million. In the second phase there will be conducted removing of lumps, seeding of areas with low level of vegetation, reconstruction of roads and watering system, which will require USD 5.76 million or AMD 2.8 billion (in average, USD 8,000 per 1,000 ha).
cost of not modifying the project	In accordance with different climate change scenario, if no respective mitigation and adaptation measures are implemented, the total area of pasture in Armenia and their productivity will decrease by 4-10 percent. As a result, the number of cattle will

[31] http://www.undp.org/content/dam/armenia/docs/CE_ProDoc_Arm_Final.pdf

	decrease by 30% and the output of livestock products will decrease by 28-33%[32].
Potential development impacts, benefits	
Economic	Annual income of USD 140 thousand per 1,000 ha, and income of USD 100.8 million or AMD 48.4 billion from 720,000 ha.
Social	Increasing of incomes and employment of cattle breeders, reduction of rural poverty.
Environmental	Biodiversity protection and enrichment, prevention of degradation and erosion of pastures.
Status	Currently about 50% of pastures are used and the degradation process has a continuous nature.
Barriers	Due to transfer of ownership of pastures to border communities, the communities, and as a rule the large ones that have previously had distant pastures, have lost their pastures and are not interested in participating in climate change adaptation and pasture improvement projects. Severe insufficiency of public support to improvement of pasture management. Imperfection of the legal field.
Acceptability to local stakeholders	The project is acceptable for the Ministry of Agriculture, Ministry of Nature Protection, State Committee of the Real Estate Cadastre, territorial administration and local self-governance bodies, cattle breeders, milk processing businesses and civil society.
Endorsement by experts	Thanks to the support of WB similar adaptation measures are implemented in developed countries, and during recent decade also in developing countries, including in Armenia, though at a limited scale.
Timeframe	The reasonable timeframe is 3-4 years.
Institutional capacity	Acquisition of air photographing equipment and development of institutional framework, training of specialists and organization of education of cattle breeders.
Adequacy for current climate	Recommended adaptation option corresponds with existing climate and promotes mitigation of negative impacts of climate change.
Size of beneficiaries group	470.4 thousand rural residents of above-mentioned provinces are direct beneficiaries of the project.

Establishing of a laboratory for forecasting of natural disasters and early warning	
Introduction	For the most effective adaptation to climate change all sectors of the economy, and especially the agriculture, need an effective system of risks forecasting and early warning. In Armenia that function is reserved for the Ministry of Territorial Administration and Emergency Situations (MTAES). The damage caused to agriculture by different adverse phenomena (hail, freezing,

[32] http://www.undp.org/content/dam/armenia/docs/CE_ProDoc_Arm_Final.pdf

	drought, floods, etc.) in the Republic during recent years show, that there is need for modernization and capacity building of disasters forecasting and early warning system. For that purpose, it is recommended to establish a Laboratory for forecasting of natural disasters and early warning on the basis of Emergency Management Academy of MTAES of RA and Armenian National Agrarian University (ANAU).
Technology characteristics	Structure of MTAES of RA includes the Department of population protection policy and programs and information flow management, ”Center of Active Impact of Atmospheric Phenomena” and "Hydrometeorology and Monitoring Service" SNCOs, which implement climate forecasting and anti-hail protection functions. But it is well-known that climate change activates synergetic processes, thus requiring coordinated scientific studying of reviews and researches. For that purpose, it is recommended to establish a laboratory for forecasting of natural disasters and early warning based on interagency principle, by uniting institutional capacities of MTAES and scientific potential of ANAU. Main functions of the laboratory will be monitoring, assessment of potential threats of natural disasters on the territory of RA, including most acute negative factors of climate change, and informing respective agencies, including Information Providing and Notification Center CJSC of the Ministry of Territorial Administration and Emergency Situations of RA, regarding these.
Costs, including	
cost to implement adaptation options	Premises can be provided by MTAES, and in the initial phase there will be needed 7 employees with average monthly remuneration of AMD 180 thousand, as well as AMD 1.2 million for equipping and communication services of each office. In addition, there will need to be acquired 2 mobile express laboratories for conduction of field studies, cost of which is around AMD 30 million. According to preliminary assessment the operational cost for the first year of work of the laboratory will be AMD 16.4 million for salaries + AMD 8.4 million for furnishing and equipping of offices + AMD 30 million for the mobile laboratory = AMD 54.8 million. As an alternative there can be ordered a targeted study via tender conducted by National Inspectorate of Education of RA, efficiency of which cannot be high.
cost of not modifying the project	The cost of not modifying the project will include the annual damage caused to agriculture and environment due to late forecasting of natural disasters and late warning. The annual damage caused by climate change to the agriculture alone is about AMD 4 billion, which can be considered the cost of not modifying the project.
Potential development impacts, benefits	
Economic	Average annual damage caused by natural disasters is about 15-17% of gross agricultural product or AMD 16 billion as of 2014.

Social	At least ¼ reduction of damages as a result of operation of the laboratory will result in saving of up to AMD 4 billion, exceeding the costs more than 70 times. Rural population will be better protected and can involve in higher value agriculture.
Environmental	Natural disasters also damage the environment; thus environmental benefit is also obvious.
Status	Activities of services of MTAES system do no ensure significant results in terms of climate change adaptation of agriculture, timeliness of forecasts is low.
Barriers	Lack of interagency coordination, lack of operative management experience, insufficient intellectual capacities, low level of technical equipment.
Acceptability to local stakeholders	Interests of all parties coincide.
Endorsement by experts	FAO and World Bank experts highlight this issue, and in 2010-2012 there has been provided certain technical assistance to the Ministry of Agriculture of RA, Hydrometeorological service and National Statistical Service of RA.
Timeframe	2016-2017
Institutional capacity	Investment of about AMD 55 million during the first year and studying of best international practice.
Adequacy for current climate	There is need, and the system corresponds with the challenges of climate change adaptation,
Size of beneficiaries group	About 340 thousand farmers of Armenia and the agricultural processing system as a whole.

Plastic and glass greenhouses with solar panels, natural pest control and organic fertilizers[33]	
Introduction	Agriculture is an extremely important sector for Armenia, responsible for the significant part of employment, livelihood in rural areas, food security, rural development and export. But this sector is extremely sensitive to potential adverse changes of climate and temperature, precipitations and natural disasters (for instance, droughts, heat waves, floods). As a result of global climate change, the lack of water resources and rain lead to reduction of soil humidity, resulting in serious consequences for agricultural lands. Thought geographical and climatic peculiarities of Armenia also promote activation of desertification process on the territory of Armenia, and as a result there takes place degradation of land resources, deterioration of biological resources and biodiversity, and of course, worsening of social conditions of population. Climate change creates risks, challenges and new opportunities for the sector. Introduction of plastic and glass greenhouses with solar panels in Armenia will become an important step for development of the sector. Solar energy will be used not only to obtain heat, but also

[33] Developed by Scientific Center of Vegetable and Industrial Crops SNCO.

	to operate water pumps. In these greenhouses there will be used natural pest control means and organic fertilizers.
Technology characteristics	The new technology produces heat and electricity via solar batteries. The system nurtured by solar batteries consists of certain number of solar panels. It is effective for heating of the greenhouse also during the night, thus having positive impact on productivity of crops. The system provides enough energy needed for agricultural activities. That electricity is also used for operating of the water pumps, which pull water from wells. Water is stored in special reservoirs and used in subsequent processes. That water is used both to water and heat greenhouse. Excess heat will be accumulated in special batteries. The main aim of this technology is to combine two technologies for more efficiency.
Costs, including	
cost to implement adaptation options	The cost of construction of a 100 m^2 will be about AMD 2.5-5.0 million. Professional training and consulting are not included.
cost of not modifying the project	The damage caused by climate change to the agriculture is about AMD 4 billion annually.
Potential development impacts, benefits	In case of propagation in a greenhouse there decrease the risks of damage by natural phenomena. The yield is protected from external adverse climate conditions, such as freezing, hail, downpours. Development of greenhouses and organic farming. Increased incomes of farmers, about 40% saving of finances.
Economic	Generally, during recent years the development of plastic and glass greenhouses has become more active, especially in foothill zones – Vayots dzor and Tavush provinces. Given the landscape and unpredictable weather conditions of Armenia greenhouses are topical and advisable, since these make vegetation season longer and better manageable. Given technology is provided for mountains/foothills and lower zones. These characteristics enable effective utilization of sunlight, as an alternative source of energy, while saving large volumes of electricity and financial means. According to international practice solar batteries save about 40% of the electricity cost.
Social	Within unheated greenhouses vegetables can be produced during certain months of the year. Thus the income is not stable. While in greenhouses heated by solar batteries this problem will be solved and farmers will have income during the whole year, paying for the source of energy only once. In addition, solar batteries will also operate the water pumps. Many rural communities have a serious problem of irrigation water and use of ground water is conducted by pumps. Use of solar batteries in agriculture ensures saving of financial means, which in turn ensures additional incomes for farmers.
Environmental	Use of solar panels solves several environmental issues, while mitigating the impact of climate change on agriculture. These include restoration of degraded lands, mitigation of climate

	impact on agriculture, reduction of GHG emissions, decreased volume of use of pesticides, thus leading to protection of biodiversity and natural resources. Since settlements of foothills and mountain zones are mostly close to or are in direct contact with natural landscapes, the impact of agriculture on these also has to be taken into consideration. Pesticides and insecticides, chemical fertilizers used in agriculture cause serious damage to biodiversity. Application of natural fertilizers and integrated means of vermin control solves that issue too.
Status	There are some plastic and glass greenhouses in Shirak province, which are heated by solar batteries. Some of the greenhouse complexes of the country use biological means of control, such as predatory insects. But there are no water pumps operated by solar batteries. Also, there are no farms that include the whole complex of solutions.
Barriers	High costs
Acceptability to local stakeholders	As an economically feasible technology it will be widely used by farmers, since it will ensure saving of financial means and increased incomes.
Endorsement by experts	There is a lot of experience in introduction of similar technologies, especially in Western Africa. All of these projects have been successful and have ensured increased incomes for farmers. Thus, it can be expected that it will be effective in our country too.
Timeframe	5 years
Institutional capacity	Farmers' training and raising awareness of people from rural areas on the importance of saving energy and using alternative sources of energy for agriculture.
Adequacy for current climate	Solar intensity in Armenia is high and increases with the elevation. Average annual balance of radial energy reaches 62-69 ccal/m^2. The maximum indicators are registered in June and July, and the minimum in December. The average annual number of sunless days varies from 19 (Sevan peninsula) to 64 (Ijevan). The maximum number of sunless days is registered in winter, January – 9-12 days, and the minimum in summer (during 2-3 months there are almost no sunless days). During the winter there are more sunless days in foothills, and during the summer – in middle mountain zone.
Size of beneficiaries group	Farmers from all provinces of Armenia (up to 340 thousand farmers).

Introduction of Golden Spray micro-raining system in communities with excessive water demand	
Introduction	Surface irrigation is applied on more than 90% of irrigated lands of Armenia, resulting in 40-50% water losses. These losses increase 1.5-2 folds in lands with excessive water demand. Climate change trends, on one hand, require increased volume of irrigation water per hectare, and on the other hand, reduce the flow of surface waters. Thus preference has to be given to water saving

	technologies and highly efficient plants. Under the conditions of complex landscape of foothill zone the introduction of raining method of irrigation can be quite effective. But high demand of electricity can be a serious obstacle for introduction of this method. This obstacle can be overcome by application of Golden Spray micro-raining system. Golden Spray is a flexible pipe with holes used for micro-raining of land. Water is taken from a source and necessary pressure of 0.8-1.0 is provided using a mobile pump with petrol micro-engine. The main objective of the project is reduction of irrigation water consumption and payments via introduction of new effective technologies in lands with excessive water demand, while at the same time ensuring high incomes of farmers via intensive farming practices.
Technology characteristics	On the territories with excessive water demand cultivation of fruit crops is economically effective. Before newly planted orchard fruits, it is advisable to use the areas between the lines for production of vegetables and berries. The technology has been applied in the orchard of Krupnoplodnaya (Large fruit) variety of sweet cherry planted in Voskevaz community of Aragatsotn province of RA in 2013, where interline areas have been mulched with polyethylene membrane in spring 2014 and there has been conducted planting of strawberry (Fresca F1) field. There has been applied Golden Spray micro-raining system. It is a flexible pipe with holes used for micro-raining of land that reduces energy consumption in areas with excessive water demand 4-16 folds. Since the norms and regimes of irrigation of fruits and berries differ, the irrigation network consists of two parts. The fruits have been irrigated using a separate micro-hydrant (stem) method, water for which has been supplied by a polyethylene pipe, using thin pipes coming out of small holes made next to stems. This enables supplying the water directly to the nutrition area of trees. Strawberries cultivated in interline areas are irrigated using micro-raining pipes Golden Spray 4, each of which covers 600m^2. Water is supplied to the pipes using a pump operated by a petrol micro-engine.
Costs, including	
cost to implement adaptation options	Costs required for planting and cultivation of 1 ha of sweet cherry orchard during 4 years, before fruiting, will make AMD 3,610 thousand, in 5th year the incomes obtained from the orchard will make AMD 1,500 thousand.
cost of not modifying the project	Currently due to inefficient land use in 52 communities with excessive water demand the annual loss is about AMD 12 billion.
Potential development impacts, benefits	
Economic	Total cost of strawberry cultivation in interline areas of 1 ha of sweet cherry orchard during 4 years will be AMD 6,128 thousand. Annual income received from strawberry will be AMD 3,174 thousand.

	As a result, farmers can compensate 4 years' costs in 1.9 years. In case of such cultivation there will be a possibility for compensation of invested costs in 3 years, and to receive real income during the following years. Income received by farmers in fourth year will be AMD 6,472 thousand. While in case of convenient cultivation income can be expected only in 6.4 years.
Social	1. Reduction of payments for irrigation water about 2 folds, 2. Before the fruit bearing age of trees necessary income is received from interline areas, 3. Reduction of manual labor related to watering.
Environmental	Introduction of the technology will enable to: 1. Reduce irrigation water demand, 2. Avoid water erosion, 3. Avoid soil induration and improve its structure.
Status	Currently the issue of territories with excessive water demand is not solved. Payment of fees in accordance with consumed water makes farming inefficient.
Barriers	In reality the system of payments for irrigation water does not depend on actual use of water, since it is based on established norms. This does not motivate farmers to introduce water saving technologies. State support – subsidy system is not targeted.
Acceptability to local stakeholders	Proposed project is profitable for farmers in case of real measuring of actually consumed water. This technology is interesting for water user associations (WUA) only in case of application in territories with excessive water demand, since in these areas it is almost impossible to collect the fees for consumed water. In the areas with normal irrigation introduction of this technology is not profitable for WUAs, since the results of their activities depend on the volume of realized water. Thus, the system is based on expenses and inefficient.
Endorsement by experts	The technology has been piloted in Voskevaz community of Aragatsotn province of RA and ensured high efficiency, it complies with international best practice.
Timeframe	2016 – 2020
Institutional capacity	The technology is not complex, applied equipment is accessible and easy to operate. Golden Spray A system produced in South Korea is widespread. Small mobile pumps are produced by multiple companies.
Adequacy for current climate	The adaptation technology corresponds with current climate conditions and will become increasingly important under climate change.
Size of beneficiaries group	52 communities of Armavir, Ararat and Kotayk provinces of RA have lands with excessive water demand, irrigation of which requires additional water, costing AMD 1.5 billion. But due to insufficient water supply and absence of water saving technologies each year farmers lose more than AMD 12 billion.

Agricultural insurance as climate change adaptation tool

Introduction

As a result of climate change natural risks of agriculture become more frequent and less predictable. Only during the last decade as a result of spring freezing, hails, drought and floods the average annual damage caused to agriculture of RA has been around AMD 20 billion. In terms of management of agricultural risks, importance is given to development of irrigation, anti-hail and anti-flood systems. But due to peculiarities of agriculture, even in that case the level of risk remains high. Thus, as a guarantee of stable income for farmers, importance is given to the agricultural insurance. Currently, due to high risks of the sector insurance companies avoid implementation of agricultural insurance schemes. Small sizes of farms, difficulties of implementation of innovative technologies and low level of solvency are among other obstacles. Nevertheless, international practice shows that application of insurance based on public private partnership is an important guarantee of effective business. Thus, during the first phase it is recommended implementing a pilot project on voluntary insurance of vineyards and fruit orchards, as well as vegetable crops in Armavir province of RA.

Technology characteristics

Based on average data for 2010-2014 there has been determined the gross output of vegetables, fruits and grapes, then via assessment of insurance risks of these years there has been calculated the minimum premium for 70% compensation and the total and per hectare amount of insurance premiums have been determined. Taking into consideration the low level of solvency of farms and the international practice of agriculture insurance the option of 50% public participation is preferable (Table 1).

Selection of Armavir province of RA is dictated by intensiveness of climate phenomena there during recent years. Preference has been given to the most valuable crops, the impact of risks related with which is more significant for farmers. Obtained data shows that this option of insurance is accessible for farmers and profitable for insurance companies.

A joint project on agricultural insurance, particularly insurance of cattle, has been developed by the Ministry of Agriculture and Ingo Armenia Insurance Company, but due to lack of funds in 2016 state budget the Government has not provided 50% co-financing.

Table 1.

Insurance estimations for Armavir province of RA
(based on average data of 2010-2014)

Indicators	Vegetables	Melons	Fruits	Grapes
Gross product, AMD million	32705.3	12035.6	18472.0	23043.1
Insurance payments, %	3.0	3.0	3.5	4.0
Total insurance payments, AMD million	981.2	361.1	646.5	921.7
Insurance payment per hectare, AMD thousand	110.4	103.7	79.0	129.7

	Public participation, 50%, AMD thousand	55.2	51.9	39.5	64.9
Costs, including					
cost to implement adaptation options	In case of 100% participation of farmers in recommended crop insurance scheme based on the example of Armavir province of RA the amount of public support will be AMD 1,455.2 million. For comparison, the hail of May 12, 2013 alone has caused damages in 47 communities, and the total damage has exceeded AMD 22 billion. State support has to be provided from the state budget of RA via depositary system of the Ministry of Finances of RA.				
cost of not modifying the project	If the project shall not be implemented, then after each natural disaster there will increase the discontent of farmers with the government, since partial assistance provided by the state does not cover the damage.				
Potential development impacts, benefits					
Economic	Ensures stability of expanded reproduction, implying production, financial results of which enable compensating incurred costs, ensuring net profit and investing part of that amount into expansion of production.				
Social	Compensation of losses of farmers and poverty reduction.				
Environmental	Thanks to rapid restoration of consequences of disasters, there will be regeneration of orchards and reduction of GHG emissions.				
Status	No agricultural insurance is implemented yet.				
Barriers	High risks of the sector, low insolvency of policyholders, lack of trust in insurance companies.				
Acceptability to local stakeholders	The technology is acceptable for insurer, policyholders and the Government. The insurer receives an opportunity for expansion of the market, the policyholders ensure at least 70% compensation of losses, and the Government addresses the request for compensation of losses carried by farmers each year due to natural disasters, eases social tensions and creates preconditions for management of risks in agriculture.				
Endorsement by experts	Agricultural insurance is applied in many countries of the world. This option is used for agricultural insurance in some of EU countries, including Cyprus – 100%, Austria – 78%, Germany – 43%, Spain – 26%. It is widely used in USA, Canada, Argentine and other countries[34].				
Timeframe	Pilot project can be initiated in case of provision of co-financing of insurance premium by the state budget or another source.				
Institutional capacity	There are insurance specialists, but there will be need for short-term training and awareness raising.				
Adequacy for current climate	The importance of insurance is becoming even more significant under climate change.				

[34] http://www.rae.ru/meo/?section=content&op=show_article&article_id=7141

Size of beneficiaries group	About 340 thousand farmers in the Republic of Armenia and 55,325 farmers in Armavir province[35].

Windbreaks as climate change adaptation tool	
Introduction	Increasing of air temperature, reduction of precipitations and irrigation water reserves, increased frequency of droughts, winds and sandstorms as a result of climate change require application of agricultural melioration systems with long-term stable impact and relatively low cost. In plane areas of the country it is recommended to establish windbreaks, as such systems. The latter reduce the speed of wind, keep the snow in the fields, increase soil humidity, improve the microclimate, protect sowing from drought and promote increasing of yield. Multi-year observations have shown that in case of existence of windbreaks the crop yield increases by 10-25% in comparison with open fields.
Technology characteristics	Windbreaks are established by planting of 3-4 lines of trees with total width of up to 15 meters. Depending on tree species there can be used a planting scheme with 2.5-4-meter distance between the lines and 2-3 meters between the plants. Depending on peculiarities of the terrain each windbreak can stretch 200-600 meters along the width and 1,000-1,200 meters along the length of fields. 10-15 wide corridors are left for agricultural machinery and vehicles. If after harvesting the area is used for grazing of cattle, then the width of corridors can be up to 20-25 meters. Preference is given to tree species with higher density of canopy (poplar, beech, elm, apple, plum, pear, sweet cherry, etc.). There is used a tree planting scheme in case of which penetration of wind becomes more difficult. Farms in Armenia are small and the number of these on relatively small areas can reach several dozens. Thus by consent of beneficiaries for the purpose of establishing of windbreaks there can also be used fruit trees well adapted to given climate conditions.
Costs, including	
cost to implement adaptation options	The surface of windbreaks on each 100 hectares of territory of RA can be 1,600m * 15m=24,000m^2 or 2.4 ha. If the scheme of planting of windbreak consisting of 4 lines is taken as 3.75m * 3m, then the number of trees will be 2,133. Total costs related to planting and maintenance during the first year, depending of tree species, can reach AMD 1.5 million. In 3 years the height of trees will exceed 3 meters, gradually ensuring protection of fields.
cost of not modifying the project	If the project is not modified, then based on winter wheat example, with yield of 3 tons/ha, price of AMD 140,000 per ton, in case of 7% yield loss, the total loss for 100 ha will be AMD 2.94 million.
Potential development impacts, benefits	

[35] https://www.e-gov.am/u_files/file/decrees/kar/2010/12/10_1756_1.pdf

Economic	About AMD 30 thousand reduction of annual losses per hectare.
Social	Beautiful landscape, cleaner air, recreation zones.
Environmental	Reduction of GHG emissions, prevention of wind erosion and humidity loss.
Status	After land privatization and as a result of mass tree felling due to energy crisis of 1990s the windbreaks have mostly been destroyed.
Barriers	Inadequate perception of the importance of windbreaks by farmers.
Acceptability to local stakeholders	It will become more acceptable in case of implementation of pilot projects and consulting.
Endorsement by experts	The technology is applied in almost all countries of the world.
Timeframe	2016-2019
Institutional capacity	There are sufficient number of professionals and scientific potential for launching of the project in 2016. There is sufficient number of seedlings in nurseries of Hayantar (Armenian Forest) SNCO. In the future there will be need for expansion of nurseries.
Adequacy for current climate	The project corresponds with current climate and becomes increasingly more important under climate change.
Size of beneficiaries group	Over 185 thousand farmers in all provinces of RA.

Construction of temporary shelters and facilities for stockbreeders	
Introduction	Under continental climate of Armenia, characterized by hot summers and cold winters, thermo-insulated eco-shelters and buildings constructed with local cheap and accessible construction materials that can be constructed fast and adaptable to climate change are becoming especially important for cattle breeders and young animals in distant alpine pastures. For that purpose, it is recommended using straw bales and local construction materials (boulders, clay, sand, etc.).
Technology characteristics	Modern technology of housing construction using straw is based on use of best characteristics of this natural material. Well dried straw of wheat, oar or rye pressed into bales becomes an excellent construction material. Studying of several types of straw houses shows that straw bales can be used for construction of both high quality homes and cheap shelters for cattle breeders in distant pastures. Construction of straw eco-shelters is also the best means for housing construction in seismic zone and fast and cheap means for meeting of housing needs of population in disaster zone[36].
Costs, including	
cost to implement adaptation options	In case of construction of 60-70 m^2 straw shelter by and for the families of cattle breeders in distant pastures, using second-hand construction materials (doors, windows, roof, etc.) 1m^2 will cost about AMD 3-4 thousand. Such shelter can be used for 25-30 years. Heating of such buildings will require 40 kW/hour per 1m^2,

[36] http://proekt-sam.ru/proektdoma/dom-iz-solomy.html

	annually, while concrete buildings require 240, stone buildings – 160 and buildings constructed using gas silicate blocks – 90 kW/hour[37]. The temperature in straw buildings is relatively stable, the air is beneficial and ecologically safe.
cost of not modifying the project	Currently used options, including tents, stone shelters, etc., are quite expensive, and even in summer months require heating using manure or wood, as well as renovation each spring. In addition to above-mentioned advantages, the straw bale house is also twice as cheap as the other ones.
Potential development impacts, benefits	
Economic	Costs related to straw house are about 2 folds lower than those of stone house. Construction of such shelter is simple and most of construction works can be implemented independently.
Social	Relatively cheap and fast solution for housing issue, reduction of construction and maintenance costs, healthiness.
Environmental	This type of buildings is usually called eco-house, since these have the highest level of compliance with ecological norms, are resistant from seismic perspective and easily adapt to climate change. In addition, the burning of straw and stubble has become a real environmental problem. Purposeful use of these will reduce emissions.
Status	In the past straw and clay mixture bricks have been used for construction of houses in Armenia, straw has been especially popular as a construction material among Molokans (members of Russian sect) in Stepanavan, Tashir, Sevan and other regions.
Barriers	One of the potential barriers is the perception that such buildings are fire prone and easily accessible for rodents. In reality the base of straw bale house and 60-80 cm of the bottom of walls are constructed using stone, a mesh is attached to the exterior of walls, after which these are plastered or lined used a cheap fire-proof material. The interior of the walls is also trimmed and plastered. Straw bales are also used for the roof, which is then lined with waterproof construction materials. Humidity is the biggest threat for this construction materials, thus it has to be protected from water penetration.
Acceptability to local stakeholders	There may be need for overcoming the resistance of conservative groups, since this is an unusual and simple technology. But the advantages are extremely obvious and it can be accepted within a short period. There need to be implemented pilot projects using grant funds to overcome the barriers.
Endorsement by experts	Construction of straw houses has become popular in Western Europe, Belarus, Ukraine and Russia. Especially in rural areas, this is the best means for adaptation to climate change and construction of an ecofriendly shelter. In Armenia this technology can be applied in distant pastures and disaster zone.
Timeframe	Depending on surface, construction of straw houses in distant

[37] http://www.zs-z.ru/zagorodnoe-stroitelstvo/domostroenie/texnologii-stroitelstva/ognestojkij-dom-iz-solomyi.html

	pastures can take 5-10 days. It is advisable to conduct construction after baling of well dried straw, while before that there can be conducted construction of the base and carcass.
Institutional capacity	One of the most important advantages of the project is its simplicity and absence of need for additional institutional capacity. Currently there are multiple designs and consulting materials on the Internet to obtain necessary information and knowledge regarding this technology.
Adequacy for current climate	The recommended technology fully corresponds with any change of climate.
Size of beneficiaries group	Each year in Armenia around 4,000 families take their cattle to distant pastures and live there for about 5 months. Taken into consideration that the average number of members in such families is 3.5, the number of direct beneficiaries may reach up to 14,000 people.

Diversification of agriculture	
Introduction	Impact of climate change is more significant in the communities of Armenia located at the elevations of up to 600 m. Especially the increasing of mean air temperature and shortage of irrigation water increase the risks related with crop cultivation. Thus it is necessary to make climate risks more manageable by increasing the areas of thermophilic crops and introduction of water saving irrigation technologies. Present project suggests adaptation to climate change and mitigation of socio-economic consequences via diversification of agricultural production in lower communities of Meghri region of Syunik province and Noyemberyan region of Tavush province of RA.
Technology characteristics	Diversification of agricultural activities of the residents of communities involved in the project. It is planned to increase the area of intensive orchard of persimmon, pomegranate, olive, fig and other subtropical fruits. Application of anti-hail nets and local drip and jet irrigation low cost and water saving systems. Zorakan and Haghtanak communities of Noyemberyan region of Tavush province of RA have been considered as locations for project implementation. Similar project can also be implemented in Bagratashen, Deghdzavan, Debedavan, Ptghavan, Voskevan, Koti, Barekamavan communities of the same region, as well as Meghri, Agarak, Alvank, Shvanidzor, Nrnadzor, Lehvaz, Vardanidzor and other communities of Meghri region of Syunik province of RA.
Costs, including	
cost to implement adaptation options	In the first phase there is recommended implementing a project on introduction of subtropical horticulture technologies: 5 years * 10 ha * 1.1 million/ha = AMD 55 million or AMD 11 million annually. An alternative adaptation option is the increased procurement of peach thanks to reset of Ayrum cannery factory and promotion of exports.

cost of not modifying the project	In case of not modifying the project each year farmers will lose about 5-10% of expected income as a result of climate change.
Potential development impacts, benefits	
Economic	Costs, employment, investments, etc. – development of production of subtropical fruits in mentioned communities will in average increase expected incomes per hectare 2.5-3 fold.
Social	Incomes, education, healthcare, etc. – the incomes of rural population will increase, production of fruits becomes more knowledge-based industry and there can be applied progressive technologies.
Environmental	Local pollution, GHG emission, etc. – planting of orchards prevents soil erosion and increases the potential for carbon sequestration
Status	
Barriers	▪ High demand for irrigation water, ▪ Farmers do not take seriously the consequences of climate change and are not ready to make investments.
Acceptability to local stakeholders	Acceptable for rural residents, processing industry and environmentalists.
Endorsement by experts	Both local and international practices indicate that the project will be efficient. As for new fruit species and varieties, these have been tested locally and are well adapted. Simply currently these have small production volumes and do not have industrial importance.
Timeframe	2017-2020
Institutional capacity	There will be need for organizing trainings to educate local specialists, especially in terms of fruit cultivation and fruit processing technologies.
Adequacy for current climate	Corresponds with current climate and can be better adapted to climate change.
Size of beneficiaries group	300 owners of orchards or 1,100 people together with families only in 2 communities + processors, middlemen, traders, 120 people. Together with 20 communities that have the same conditions the number of consumers will be more than 24 thousand people

Local melioration and low-volume drip irrigation for newly planted orchards	
Introduction	Due to lack of irrigation water and thin layer of humus about 12 thousand hectares of territories of RA with dry subtropical and continental climate remain unusable, and under climate change the zone of these is becoming increasingly larger. Whereas even in case of desert it is possible to conduct local melioration within the contour accessible only for the roots of the tree, and plant orchards of thermophilic fruit trees using drip irrigation. In Armenia there are such territories in Ararat, Armavir, Aragatsotn, Kotayk, Tavush and Syunik provinces, use of which can help to ensure climate change adaptation and will have economic, social and environmental significance.

Technology characteristics	Removing of stones, sand, soil without humus from the tree stem zone and melioration with carried fertile soil, conduction of watering and nourishing of seedlings or group of seedlings using a drip irrigation system with pipes attached to small barrels on the territories with dry subtropical and severe continental climate.
Costs, including	
cost to implement adaptation options	Depending on melioration needs of the location, distance of water sources and fruit type the cost of planting of 1 ha of orchard and installation of drip irrigation system with small barrels will be about AMD 2.5-3 million. Maintenance of one hectare of apricot and peach orchard requires AMD 400 thousand per year. After the maintenance AMD 40 thousand is needed for harvesting of 1 ton. This cost increases evenly depending on the harvest of given years. Profit from realization of harvest of one-hectare apricot orchard is AMD 7 million (in case of harvest of 30 tons). The average income is around AMD 5 million.
cost of not modifying the project	In case of not modifying the project, due to climate change and low fertility the size of such lands increases every year, and the annual environmental and economic loss will be around AMD 1.5 million per hectare.
Potential development impacts, benefits	
Economic	Provision of annual income of at least AMD 2 million from fruit orchard and increased level of food security.
Social	Reduction of rural poverty and emigration as a result of increased incomes and employment.
Environmental	Improved environmental conditions, carbon sequestration and synthesis of oxygen, prevention of wind erosion, application of water saving technologies.
Status	There is an experience of use of fallow soils via application of similar technologies on small areas. Terrace and precipitation accumulation technologies have applied at larger extent.
Barriers	Absence of traditions, inefficiency of pilot projects and trainings, lack of funds.
Acceptability to local stakeholders	In early spring mentioned territories are used as low productivity pastures. Turning these into cultivated and irrigated lands may be unacceptable for cattle breeders.
Endorsement by experts	Positive experience of Israel and other Middle Eastern countries, as well as positive reaction of specialists.
Timeframe	2016-2020
Institutional capacity	This adaptation option is simple and its implementation will require pilot projects, short trainings and serial production of non-metallic barrels, pipes and drips for that purpose.
Adequacy for current climate	It corresponds with the existing climate and climate change trends.
Size of beneficiaries group	Taken into consideration that 12-thousand-hectare orchard will provide income to 20 thousand families, the number of beneficiaries will be 60-70 thousand.

Planting of sea buckthorn forests as a means of land erosion prevention, regulation of river flows and source of additional income for locals	
Introduction	Planting of sea buckthorn seedlings in riparian zones of Lake Sevan and rivers, contributing to carbon sequestration, prevention of soil erosion, regulation of river flows and increased incomes of local population from realization of fresh and processed sea buckthorn berries. Similar project can also be implemented in other treeless areas of the country, on the banks of watercourses and gullies.
Technology characteristics	Sea buckthorn is propagated using cuttings, root thickets and grafting. Rooting material is planted using 3m X 2m scheme. 1,500 trees are planted per hectare. These bear fruit in 3-4 years. In average one tree produces 10-12 kg of fruit and in case of wholesale price of AMD 400/kg 1 hectare of plantation can provide about AMD 2.5 million net annual income. One sea buckthorn tree synthesizes 80-90 kg of oxygen per day and sequestrates 40-60 kg of carbon dioxide. One hectare of sea buckthorn plantation sequestrates 14.4 thousand carbon dioxide annually (40 kg * 1,500 trees * 240 days = 14.4 thousand tons). From climate change adaptation perspective, the advantages of this technology are related with higher level of drought and freezing tolerance of sea buckthorn with other agricultural crops, it is almost not vulnerable to diseases and pests, ensures stable harvest and promotes diversification of incomes of rural population.
Costs, including	
cost to implement adaptation options	Depending on melioration conditions of the locations total costs related with all technological processes of planting for the first year can be around AMD 750-850 thousand per hectare. Before bearing of fruits, during next 4 years the average annual cost will be AMD 250 thousand or AMD 1 million for 4 years. Thus costs related with planting and maintenance before fruit bearing will be AMD 1.8 million.
cost of not modifying the project	To determine the cost of not modifying the project preference has been given to benefit transfer method[38]. According to that methods in case of non-implementation of the project there will be lost the directly used benefits, such as timber, firewood, fruits and other useful products. Indirectly used benefits include agricultural productivity, watershed management, prevention of erosion, carbon sequestration, and development of scenic landscape.
Potential development impacts, benefits	
Economic	Within 3 years after the beginning of fruit bearing the investments are returned and there are only left maintenance and harvesting costs (AMD 250 thousand per ha), thus the annual net income per

[38] Environmental damage and responsibility, assessment of the economic value: methodologies, structure, criteria and application. Caucasus Regional Environmental Center, 2014, page 18

	ha is AMD 2.5 million.
Social	Mitigation of the risk of reduction of incomes of rural population as a result of climate change and provision of about 60 man-days of employment per hectare, with daily minimum salary of AMD 7,000.
Environmental	Carbon sequestration, prevention of soil erosion regulation of water flow, development of scenic landscape.
Status	There are sea buckthorn plantations in Armenia, particularly in the riparian zone of Lake Sevan, mostly in scrub form, which are almost not maintained, while rural population sells part of the harvest to local processing companies.
Barriers	Areas proposed for development of sea buckthorn plantations are mostly on the balance of Sevan National Park and there will be need to coordinate land use.
Acceptability to local stakeholders	Development of sea buckthorn plantations is beneficial for Sevan National Park, population of neighboring communities and entities involved in tourism. During the designing of plantation areas, it will be necessary to take into consideration the interests of cattle breeders. For that purpose, it will be necessary to leave corridors so cattle can reach the water.
Endorsement by experts	Similar projects have been implemented in other countries and the results have been positive. Altay region of Russia has the best practice in development of cultivated plantations of sea buckthorn and introduction of new varieties, especially in terms of propagation of high fertility varieties without thorns.[39]
Timeframe	One year for planting and 4 years of maintenance activities. For the purpose of testing and localization of varieties it is advisable to import cuttings and root stock of high fertility varieties from Altay region of Russia.
Institutional capacity	There is almost no experience in sea buckthorn cultivation technologies in Armenia. Nevertheless, there can be conducted education or training of professionals in Armenian National Agrarian University and Gavar Agricultural College.
Adequacy for current climate	Sea buckthorn adapts well especially in sandy and even saline soils. It is frost-hardy and is not vulnerable to climate change. Climate change trends in Armenia are mostly related with increasing of air temperature and reduction of river water flow. Sea buckthorn plantations adapt to these changes, while at the same time promoting mitigation of negative impacts of climate change.
Size of beneficiaries group	The existing experience shows that population of rural communities of Sevan basin receive significant income from selling berries of wild sea buckthorn and there is being developed production of sea buckthorn oil, juices and preserves. Currently about 450 (4,800 people) families from 15 rural communities

39 http://barnaul.ucoz.com/publ/nash_barnaul/les_parki/oblepikha_krushinovidnaja_dereza_gnec_mlechnik_hippophae_rhamnoides_l/10-1-0-158

	located around Sevan basin are involved in harvesting and selling of sea buckthorn berries. In case of expanding of sea buckthorn plantations, the number of beneficiaries will exceed 5,000.

Fruit drying community clusters	
Introduction	Diversification, cooperation and integration are an important means of climate change adaptation of agriculture. These options can be best displayed in case of development of fruit drying community clusters. It will provide an opportunity not only for better organized resistance to climate change, but also to adapt to these changes and apply resource-effective technologies.
Technology characteristics	It is recommended developing modern solar fruit drying facilities based on community cooperation, fruit drying facilities with combined use of solar energy and natural gas cooling water (next to natural gas filling stations), as well as fruit drying facilities using IR drying equipment. Importance of such technologies is especially high from climate change adaptation perspective. First, as a result of climate change there will be increasing of air temperature, reduction of precipitations and agricultural crops and potential reduction of incomes of rural population. In additional there will increase the possibility of simultaneous and fast ripening of crops, as a result of which there will increase post-harvesting losses and pressure related to efficient storage and realization of produce. Thus, in order to avoid these risks and to adapt to climate change without shocks it is advisable to combine competitive advantages of communities implementing similar type of agriculture and post-harvesting activities. For that purpose, it is suggested introducing the technology of development of intercommunity clusters for development of fruit drying production in modern solar drying facilities, fruit drying facilities with combined use of solar energy and natural gas cooling water (next to natural gas filling stations), as well as fruit drying facilities using IR drying equipment.
Costs, including	
cost to implement adaptation options	As a result of installation of double-tariff electric meters in such fruit drying facilities the average annual consumption of electricity decreases by 8%. Thanks to 2 folds shortening of ventilation (vapor removing) pipe of fruit drying facilities the drying process accelerates by 20%, and as a result energy consumption (gas, electricity) also decreases by 20%. Thanks to application of a new method of packaging/storage of finished produce in nitrogen atmosphere there is avoided the need for use of sulfur and SO2 emissions.
cost of not modifying the project	Development of dried fruits production is limited due to low productivity and high costs and there increase the losses of crops ripening simultaneously due to climate change.
Potential development impacts, benefits	
Economic	Annual saving is 25-30% and the productivity increases by 65-70%.

Social	Incomes of beneficiaries are increasing, and there is provided additional employment, while healthy and safe food is produced.
Environmental	Thanks to refusing from use of sulfur (as a fumigant) there is prevented emission on SO2 in the atmosphere. Waste (hilt, peel, seeds, fruit puree) inevitably generated as a result of primary processing of raw materials are used as forage when fresh. Kernel of apricot seed is used for local production of desserts. Solid seeds and other agricultural waste are used as compost.
Status	Currently more than 240 solar fruit drying facilities exist in 9 provinces of RA (about 60% of which are located in Armavir and Ararat provinces). Production of dried fruits and vegetables is among the most effective processing sectors, but drying of fruits and vegetables is still conducted using conventional solar drying method.
Barriers	Lack of trust in cooperation, difficulties of realization and lack of funds. Local market is saturated, while there is not enough output for exporting, thus in case of increasing of production volumes it has to be exported, including to Russia and Belarus. Currently the volume of export to these countries is very small.
Acceptability to local stakeholders	Acceptable for all stakeholders.
Endorsement by experts	New technologies have been piloted in Ararat, Armavir and Tavush provinces.
Timeframe	2016-2017
Institutional capacity	There is need for construction of new fruit drying facilities, acquisition of drying ovens with IR radiation, organization of pilot production and training of specialists.
Adequacy for current climate	The technology corresponds with current climate conditions, and especially with climate change trends.
Size of beneficiaries group	Currently there are 5,500 producers of dried fruits in Armenia. In case of introduction of resource-saving technologies and development of cooperation the number can increase 4 folds.

Technology Fact Sheets – Water

Distribution of cultivation areas of agricultural crops in accordance with water supply and demand	
Introduction	There are 450 thousand ha of irrigated land in Armenia, of which according to State Committee of Water Economy and published statistical data currently there are irrigated 134 thousand ha. According to expert assessments there are more of these, constituting 180 thousand ha. In 2007 there have been developed irrigation norms and regimes for agricultural crops. Decree N 654-N of RA Government has approved the program of necessary measures to be implemented in communities with excess water demand. State subsidies for irrigation of lands with excess water demand in Kotayk, Ararat, Armavir and Aragatsotn provinces has been AMD 185 million in 2009. But the lands with excess water demand are still under

	danger.
Technology characteristics	It is recommended conducting diversification of agricultural crops based on available water supply and water demand for irrigation of crops in agricultural lands. This implies cultivation of crops with high water demand in areas with rich water resources and humid soils, and to cultivate drought-resistant crops with low demand for irrigation water in dry regions with scarce water resources. To combine soil and water resources maps, to identify agricultural lands with lack of water resources and excess water demand. To select drought-resistant crops demanded by Armenian economy, for cultivation in these regions.
Costs, including	
cost to implement adaptation options	Combining of quantitative and qualitative maps of water resources with qualitative maps of soils – USD 20,000-100,000, Market research for selection of new crops – USD 70,000-120,000, Awareness raising and training of farmers – USD 200,000, Assistance to farmers for transition to new crops and selling of these – USD 600,000 – 1 million.
cost of not modifying the project	Inefficient use of water resources, draining of water sources, low level of fertility, land degradation.
Potential development impacts, benefits	
Economic	Decreased quantity of irrigation water, Expanding of lands used for agriculture, Increased fertility
Social	Increased incomes, improved social conditions, food security of population.
Environmental	Protection of water ecosystems, prevention of land erosion threat, maintenance of water resources within the watershed
Status	In some lands with excess water demand there have been introduced drip irrigation systems, but these measures are not an integrated solution. No large-scale diversification projects are implemented in the country. In agricultural land plots there are traditionally cultivated crops that have been cultivated for years, without the assessment of efficiency of these and economic benefits of transition to other crops.
Barriers	Absence of sectoral policy Low level of awareness of rural residents, farmers, Lack of trust and fear towards novelties, Lack of funds.
Acceptability to local stakeholders	In principle, the method is acceptable for local stakeholders, but it is difficult for implementation.
Endorsement by experts	Currently the method develops intensively in Central Asian countries, where crops with high water demand are replaced with more drought-resistant ones. It is accepted and applied especially in countries with lack of water resources.
Timeframe	Continuous
Institutional capacity	Sectoral study and adoption of clear policy,

	Transfer of information and knowledge to farmers, Changing of the behavior of rural residents, farmers
Adequacy for current climate	The issue exists under current climate conditions, but will become even more acute as a result of impact of climate change on water resources.
Size of beneficiaries group	All population of Armenia

Creation of circulatory water system for fisheries	
Introduction	Ararat Valley with its strategic importance for the country from the perspective of groundwater resources is currently overloaded with more than 250 fisheries, which use groundwater of the Valley for their operations (more than 450 wells are operated). Renewable groundwater reserves of Ararat Valley are 1,226 million m^3, while fisheries have been provided with water use permissions for the volume of 1,496 million m^3. As a result, the water resources of Ararat artesian basin are under threat of draining. In addition, 6,200 ha of agricultural land of 200 farms of Ararat and Armavir province remain without irrigation. In case of not being cultivated in the future these will degrade and soil will lose the accumulated carbon and in the future it will be much more expensive to return these lands into agricultural turnover.
Technology characteristics	It is recommended installing closed or semi-closed water circulation systems in the fisheries. Closed systems pump the whole volume of used water to the fisheries after treating it with mechanical and biological filters and enriching with oxygen. In this case the demand for fresh water is 6-8%, to restore the water losses during the treatment process. The process is the same in semi-closed circulation systems, but the level of water reuse is 70%, and 30% is replenished by fresh water.
Costs, including	
cost to implement adaptation options	USD 15-25 thousand per unit, depending of the volume of used water
cost of not modifying the project	Draining of groundwater resources of Ararat artesian basin, contraction of agricultural lands
Potential development impacts, benefits	
Economic	Reduction of water use payments, Increased fertility and stability of agricultural land Food security
Social	Increased incomes of farms, improved social conditions
Environmental	Effective use of groundwater resources, Protection of water ecosystems, Prevention of land degradation threat
Status	In accordance with decrees of RA Government
Barriers	Lack of willingness of fisheries' owners, Low level of oversight, Lack of finances.

Acceptability to local stakeholders	Among local stakeholders the method is acceptable for rural communities. For business sector – not yet.
Endorsement by experts	The method is accepted and applied around the world.
Timeframe	2015-2020
Institutional capacity	Transfer of knowledge for introduction of the system Awareness raising of businessmen and behavior change
Adequacy for current climate	The issue exists under current climate conditions, but will become even more acute as a result of impact of climate change on water resources.
Size of beneficiaries group	Whole population of Armenia

Saving of water resources within potable water supply systems via reduction of flow losses and introduction of monitoring system	
Introduction	Today the level of losses in potable water supply system of Armenia is assessed more than 80%. These include commercial and technical losses. Currently water supply companies are not able (financially, technically and professionally) to fully implement activities related with revelation and analysis of flow losses. Communities serviced by LSGBs are even less potent to implement these activities. As a result, despite the obligation of operators regarding gradual reduction of flow losses, these still remain at the same level, or even increase in some places. In about 570 settlements of Armenia, mostly rural ones, water supply is conducted from own sources and water supply systems are managed by LSGBs. In these settlements water resources are used inefficiently, water demand norms are exceeded few times. Often due to worn-out condition of network there are constantly used new sources, leading to draining of the old ones. Inefficient use of water resources becomes a behavioral norm.
Technology characteristics	It is recommended establishing a specialized group or service for identification, registration and analysis of water supply flow losses, which will be equipped with necessary software, devices, technics and specialists. This is an organizational change, leading to transfer of the responsibility for identification of flow losses from water supply companies, which are not interested or do not have required resources to identify losses under current low level of payments for use of resources, to private companies. The latter will identify flow losses and provide respective information to water supply companies, which will be obliged to eliminate these irrespective of the nature or size. It will be right if this service is provided by a private company, since in case of provision by operators there will be no conflict between the identifying and managing parties and in many cases the operation will not be interested in revelation of flow losses. In case of a private one there will be used a mandatory

	registration mechanism. In these settlements it is recommended importing water metering system by installing meters on the entering lines of residents.
Costs, including	
cost to implement adaptation options	Equipment for identification of flow losses – USD 500-700 thousand Training of specialists – USD 5,000-7,000 Installation of water meters – AMD 20 million (for 500,000 people)
cost of not modifying the project	Overuse of water resources due to flow losses, draining of water sources, deterioration of potable water quality, public health threats
Potential development impacts, benefits	
Economic	Reduction of water losses and squanders, creation of new jobs, development of private business
Social	Potential reduction of water fees as a result of reduced flow losses, protection of water quality, public health.
Environmental	Protection of water resources from draining, saving of water and energy resources.
Status	Currently, operators providing water supply services implement some activities aimed at revelation and eradication of flow losses, but these are not complete. Water registration system is installed in all settlements served by operators, as a result of which there has reduced water intake from sources and has increased water supply duration.
Barriers	Operators will not want to transfer this function to private parties; there will be need for creation of regulation mechanisms. Population of communities subsisting on systems maintained independently, which do not pay for water use or pay negligible amounts, may be against installation of water meters.
Acceptability to local stakeholders	Operators of water supply system may be against the entrance of private companies into any part of the system. It will be acceptable for LSGBs, but residents of some of the settlements (which have 24-hour free of charge water supply or pay negligible amounts) may be against it.
Endorsement by experts	In developed countries technical flow losses may reach 15-20%, and commercial losses are almost 0%. System of registration of used water is installed in almost all countries of the world, but registration methods are different: installation of meters – volume of actually consumed water; water use norm per resident; based on pipe diameter, etc. Depending on national traditions of population of the country, level of self-governance and consciousness, treatment of natural resources, there are applied different methods.
Timeframe	3-5 years
Institutional capacity	Establishing of regulatory mechanisms, Transfer of knowledge, Involvement of private business, Awareness raising and behavior change of population

Adequacy for current climate	The issue exists under current climate conditions, but will become even more acute as a result of impact of climate change on water resources.
Size of beneficiaries group	Whole population of Armenia

Installation of compact wastewater treatment plants	
Introduction	In Armenia there is not conducted complete treatment of neither municipal nor industrial wastewater, and as a result wastewater is discharged into surface water objects, irrigation channels, land areas without treatment, thus polluting, degrading ecosystems, damaging human health. In countryside recreation, tourism, catering objects located in the upper streams of rivers, as a result of absence of wastewater treatment process the damage is mostly caused to water ecosystems. Areas located on lower streams of such rivers are mostly used as disorganized recreation zones, where people have direct contact with polluted river. Installation of local compact treatment plants in such objects will enable not only to exclude pollution of water ecosystems, but also to use treated wastewater for irrigation or technical purposes.
Technology characteristics	Factory manufactured block type compact plant for conventional wastewater treatment. It ensures deep biological treatment of wastewater before discharging into river or using for other purposes. Treated wastewater can be stored in special reservoirs together with rain water, for future use in irrigation, watering of green areas (lawns, playgrounds, athletic fields), excluding the need for irrigation system.
Costs, including	
cost to implement adaptation options	Unit prices vary depending on volume of wastewater: 5 people – 2,000 euros 50 people – 15,000 euros 100 people – 22,000 euros Annual operational costs can vary between 300-1,200 euros, depending on the plant capacity. According to sanitary strategy of Armenia (developed in 2014) 29% of population can be provided with water removal and wastewater treatment local solutions, and this will partially be done using compact plants. Assessment of the exact number of necessary plants can be done after additional studies.
cost of not modifying the project	Pollution of water and land resources, disruption of human health, food security.
Potential development impacts, benefits	
Economic	It is 2-5 folds more effective than mechanical systems in terms of keeping green areas moist, minimum operational costs, especially in terms of electricity.
Social	Improving of sanitary conditions of the environment, public

	healthcare, ensuring food security. Possibility of using of treated wastewater as irrigation or technical water.
Environmental	Protection of water and terrestrial ecosystems, landscapes from pollution and degradation, reduction of methane emissions
Status	4 compact treatment plants have been installed and are operating in Teghut mine, Agarak hospital, Sotk site (for treatment of municipal wastewater).
Barriers	Lack of finances Low level of fines and penalties for discharging of untreated wastewater.
Acceptability to local stakeholders	The concept is acceptable for everyone, but there is lack of willingness to make investments.
Endorsement by experts	This is a globally accepted method. It is widely applied.
Timeframe	3-6 months, depending on capacity
Institutional capacity	Founding of organizations installing, regulating and operating the treatment plants.
Adequacy for current climate	The recommended methodology is also applicable under current climate.
Size of beneficiaries group	45-55% of population of the country.

Economy of water resources - introduction of irrigation systems using artificial raining equipment	
Introduction	Over 90% of irrigated lands in Armenia are irrigated using surface irrigation, and as a result, losses in that system occasionally reach 75%. Recently implemented projects on improving of irrigation systems are aimed at energy saving via transition from use of pumps to gravity systems. These include 2014-2017 Increase Efficiency of Irrigation Systems Project (EBRD) that has two components – transition from mechanical to gravity irrigation and reconstruction of drainage channels of pump stations. Since irrigation water supply is mostly conducted via rivers, water intake from rivers gradually increases towards the headwaters and there is a lack of water in downstream areas, there is disrupted balance of river ecosystems. Taking into consideration that downstream areas of most of the rivers pass through settlements, where untreated wastewater is discharged, often in downstream areas of rivers there is only wastewater (the negative effect of this is well noticeable on the example of rivers flowing into Lake Sevan).
Technology characteristics	It is recommended introducing irrigation water saving technologies, particularly micro-raining method provided for local watering of soil in crop development zone and enables supply of water directly to feed surfaces of crops. This technology has many alternatives, all of which are based on water pulverization via raining equipment.
Costs, including	
cost to implement adaptation options	2,000 euros per hectare for devices and equipment.
cost of not modifying the	Inefficient use of water resources, depletion of water springs, low

project	level of yield.
Potential development impacts, benefits	
Economic	Reduction of irrigation water quantity by 40-60% Increasing of yield by 20-40% Irrigation of lands inaccessible for channels
Social	Increasing of yield - 20-40% Increased incomes, improved social conditions Excluding of irrigation with polluted water, ensuring food security of population.
Environmental	Protection of water ecosystems, Prevention of the risk of soil erosion and increasing of ground water level
Status	As a result of implementation of several pilot projects in certain parts and farms of Armenia and Artsakh there have been installed irrigation systems with raining equipment, which are successfully operated.
Barriers	Low quality of irrigation water (this system requires high quality irrigation water, with low concentration of suspended particles). Absence of local standards of irrigation water quality, which allows use of water of any quality (including untreated wastewater) for irrigation purposes. Lack of finances.
Acceptability to local stakeholders	The method is acceptable for local stakeholders.
Endorsement by experts	The method is accepted and applied especially in countries with lack of water resources.
Timeframe	Continuous
Institutional capacity	Establishment of irrigation water standard Knowledge transfer for operation of the system Awareness raising and behavior change of population
Adequacy for current climate	This issue exists under current climate, and will become even more acute as a result of climate change impact on water resources.
Size of beneficiaries group	Whole population of Armenia

Spreading and expansion of drip irrigation system	
Introduction	Irrigated farming in Armenia is irrigated using channels, of which inter-farm and intra-farm channels are mostly ground surface. Water losses within irrigation system are 60-75%. Recently implemented projects on improving of irrigation systems are aimed at energy saving via transition from use of pumps to gravity systems. Since irrigation water supply is mostly conducted via rivers, water intake from rivers gradually increases towards the headwaters and there is a lack of water in down streams, there is disrupted the balance of river ecosystems. Taking into consideration that downstream areas of most of the rivers pass through settlements,

	where untreated wastewater is discharged, often in downstream areas of rivers there is only wastewater (the negative effect of this is well noticeable on the example of rivers flowing into Lake Sevan). Transition to drip irrigation system will enable not only to reduce flow losses of the system, but will also ensure reduction of irrigation expenses and increasing of yield.
Technology characteristics	Drip irrigation is based on direct supply of water to the root system of plant. The system is provided for local watering of soil in crop development zone, via drip dispensers with small portions. Drip irrigation enables saving of water, fertilizers, pipelines, energy and labor expenses. In addition, drip irrigation has several important advantages, such as early crop, prevention of soil erosion, decreased probability of spreading of diseases and weeds.
Costs, including	
cost to implement adaptation options	USD 5,000-7,000 for irrigation of 1 ha of land.
cost of not modifying the project	Large losses of water in irrigation system, insufficiency of irrigation water, low productivity of crops, fall of yields
Potential development impacts, benefits	
Economic	Reduction of irrigation expenses by 30-50% Yield increasing by 20-50% Irrigation of lands inaccessible for channels
Social	Yield increasing by 20-50% Increased incomes, improved social conditions Excluding of irrigation with polluted water, ensuring food security of population.
Environmental	Protection of water ecosystems, Prevention of the risk of soil erosion and increasing of ground water level
Status	As a result of implementation of several pilot projects (Millennium Challenge Account) in certain parts and farms of Armenia there have been installed drip irrigation systems, which are successfully operated.
Barriers	Low quality of irrigation water (this system requires high quality irrigation waters, with low concentration of suspended particles). Absence of local standards of irrigation water quality, which allows using water of any quality (including untreated wastewater) for irrigation purposes. Lack of finances.
Acceptability to local stakeholders	The method is acceptable for local stakeholders.
Endorsement by experts	The method is accepted and applied especially in countries with lack of water resources.
Timeframe	Continuous
Institutional capacity	Establishment of irrigation water standard Knowledge transfer

	Awareness raising and behavior change of population
Adequacy for current climate	This issue exists under current climate, and will become even more acute as a result of climate change impact on water resources.
Size of beneficiaries group	Whole population of Armenia

Application of wastewater natural and hybrid treatment systems	
Introduction	Thanks to credit investments currently there are constructed 5 wastewater treatment plants in Armenia, which conduct only mechanical treatment (lack of finances has not enabled construction of biological treatment structures). But full treatment of wastewater is also prevented by the circumstances thoroughly analyzed within the frameworks of Support to Development of Wastewater Removal and Treatment National Strategy in Armenia implemented in 2014. As a result of implementation of the Project there have been presented recommendations, particularly: ✓ Transition from group systems of wastewater treatment to local, which will enable leaving water resources of given settlement, basin (in case of considering treated wastewater as water resources) within the territory of settlement/basin and use using these for own needs, ✓ Application new, modern, relatively cheap treatment technologies, ✓ Application of natural treatment systems. Development of the process of full treatment of wastewater (mechanical and biological) will enable not only reuse of treated wastewater, but also using sludge produced as a result of biological treatment as a fertilizer or for the purpose of production of methane.
Technology characteristics	Depending on climate conditions, surfaces of available lands, volume and quality of produced wastewater, level of treatment, there are combined certain elements of natural and conventional treatment systems. The system can consist of an artificially aerated pond, where air is provided by fans and wastewater is aerated, leading to degrading of organic compounds. Then suspended particles subside in sedimentation pond, creating sludge. Wastewater cleaned from suspended particles flows to a pond with natural aeration, where is undergoes additional treatment using water plants. This water can then be used for irrigation of orchards, parks, lawns, etc. Sludge produced in sedimentation ponds is moved to sludge bed, where it is dried and removed either for using as a fertilizer or to landfill. Part of sludge is occasionally transported to aerated pond to accelerate the biological process.
Costs, including	
cost to implement adaptation options	Cost of implementation depends on the volume of treated water. In case of hybrid system treatment of 1 m^3 of wastewater will require USD 250-400. Operational costs of the system are quite

	low, around USD 0.08 for treatment of 1 m^3 wastewater.
cost of not modifying the project	Pollution of water and land resources, disruption of food security of population
Potential development impacts, benefits	
Economic	Construction costs of hybrid systems are 4-5 times lower in comparison with conventional treatment plants, and operational costs – dozens of times.
Social	Improving of sanitary conditions of the environment, protection of health and ensuring food security of population. Possibility of using of treated wastewater as irrigation water and processed sludge as fertilizer at a lower cost.
Environmental	Protection of surface and groundwater sources, agricultural land, water and terrestrial ecosystems, landscapes from pollution and degradation, reduction of methane emissions.
Status	A treatment plants based on hybrid technologies is constructed in Parakar community of Armavir province of RA, the capacity of which is 11.7 liters/second (the technology has been developed and designed by Jinj LLC). There are similar designs for other settlements too. Application of natural treatment technology (constructed wetlands) is planned for Tandzut village of the same province within the framework of WASTEnet regional project (Black Sea Cross-Border Cooperation).
Barriers	Lack of financing Absence of legal and regulatory mechanisms, particularly, absence of legal regulation with regards to wastewater treatment and removal, strict standards of wastewater treatment, absence of quality norms of irrigation water, etc.
Acceptability to local stakeholders	Local stakeholders (community leadership, population, organizations operating the system) accept it with difficulty, since there is not enough experience in Armenia. But in Parakar community it is completely accepted.
Endorsement by experts	There is quite extensive international experience; the method is widespread in Eastern and Central European countries, USA, Canada and Turkey.
Timeframe	12-18 months, depending on capacity
Institutional capacity	There will be need for transfer of additional knowledge to specialists of the sector and decision makers.
Adequacy for current climate	Recommended methodology is applicable under current climate too.
Size of beneficiaries group	Population of small communities of Armenia – 30-48% of total population.

Protection of water sources via construction of underflow water intakes	
Introduction	Recently as a result of moving horizontally higher within the gravitation system of potable water sources there are capped smaller and seasonal springs. As a rule, this water has low mineralization, since feeding is short, and qualitative

	characteristics of these are close to distilled water, but it does not satisfy potable water quality. On the other hand, springs are put into pipes immediately in headwaters, thus disturbing landscapes and ecosystems of given area. Besides, this system is very expensive, since sometimes the length of water supply pipelines reaches dozens of kilometers. And to ensure feeding from river there has to be constructed a potable water treatment plant and conducted treatment using coagulants, which are imported to Armenia and are quite expensive. It is suggested to conduct more comprehensive studies during the selection of springs and to consider the possibility of construction of natural underflow water intakes or underflow water intakes with artificial feeding.
Technology characteristics	Natural underflow water intake consists of underground drainage pipes located on a depth of 3-5 m, on a distance of up to 7 meters from river banks (depending on soil type), and are covered by a backfilling of inverse filter. It is foreseen for infiltration of water into pipes from underground water horizons. Characteristics of underflow water intakes (depth of installation of pipes, diameter, water intake outlet) depends on several factors, including the river power, slope, geological characteristics, etc. Artificial underflow water intakes have the same structure. In this case the filtering layers are developed artificially, by selection of respective location along the riverbed.
Costs, including	
cost to implement adaptation options	Implementation cost depends on the volume of required water. In case of outlet of 15 liter/s, the estimated value of construction of natural underflow water intake is USD 125,000 and USD 175,000, for the artificial.
cost of not modifying the project	The cost of construction of water supply systems increases 3-5 times.
Potential development impacts, benefits	
Economic	Saving of credit amounts, saving of financial resources of the companies. Calculations indicate that construction of natural river water intakes is 4-5 times cheaper than direct intake of water from river and treatment in treatment plant and supply to population. Water intake from springs using underflow water intake is 2-3 time cheaper than direct capping of springs (normally water springs are at a great distance from settlements and there is need for construction of long water pipelines). Financial calculations of construction of underflow water intakes is based on design calculations made within the framework of several project implemented in Armenia and construction and operational costs of existing underflow water intake systems (Artik, Vanadzor, Sevan and Tsaghkunk)
Social	Provision of fixed volume of high quality potable water to population, protection of public health.

Environmental	Protection of surface and ground water springs from depletion, protection of landscapes and ecosystems
Status	Armenia has successful examples developed and designed by Jinj LLC. There are natural underflow water intakes in Artik and Sevan cities (areas served by Armwater CJSC), and water intakes with artificial feeding – for water supply of Tsaghkunk village.
Barriers	There is no need for making policy changes to apply this policy. Main barrier is the skepticism towards the new method, as well as lack of knowledge of design organizations about this method (to apply the method there also need to be made very fine calculations, taking into consideration all parameters).
Acceptability to local stakeholders	Local stakeholders (community leadership, population, organizations operating the system) do not always accept it, since there is not enough experience in Armenia. But in communities, where it has been applied, it is completely accepted.
Endorsement by experts	The international practice is quite comprehensive, especially in countries, where potable water supply is conducted from surface water resources, particularly rivers.
Timeframe	8-18 months, depending on capacity
Institutional capacity	There will be needed transfer of additional knowledge to specialists of design institutes and private organizations of sector.
Adequacy for current climate	Recommended methodology is also applicable under current climate.
Size of beneficiaries group	Beneficiaries can include population of settlements both feeding from local springs and located on the territory serviced by water supply companies currently operating in Armenia.

Improving of ground water reserves management tools	
Introduction	One of the main tools of water resource management is development of reliable information regarding water supply. Groundwater reserves of Armenia have been confirmed in 1970-80s. But due to recent economic development – construction of small HPPs, rapid development of mining and fisheries, exploitation of new water springs for drinking and irrigation – there has not been conducted quantitative and qualitative monitoring of groundwater reserves. Results of previous studies have been used as bases for provision of permission for water use from these springs, which becomes a reason for emergence of conflicts between different types of water users or leads to depletion of water sources as a result of changing of water quantity of sources. Detailed study of groundwater sources and re-confirming of groundwater reserves can be a good tool not only for regulation of water supply and demand, but will also sharpen the veracity of forecasts on climate change impact, making correction in climate change scenarios.
Technology characteristics	✓ Specification of potential zones of feeding of groundwater sources,

	✓ Determination of monitoring spots and furnishing with modern devices and equipment, ✓ Monitoring and data analysis, ✓ Updating of groundwater water sources' map, development of a cadastre.
Costs, including	
cost to implement adaptation options	Total cost of project implementation can reach up to 18 million euros, including: Studies – 8 million euros Equipment – 6 million euros Cadastre development – 4 million euros
cost of not modifying the project	Depletion of sources, emergence of conflicts between water users, corruption risks in the process of provision of water use permissions.
Potential development impacts, benefits	
Economic	Reduction of water use expenditures, correct business planning.
Social	Adjusting of targeted water use priorities for the benefit of use for drinking and household needs, protection of public health.
Environmental	Sustainable use of groundwater resources, excluding of depletion of water sources, protection of landscapes in water sources feeding zones.
Status	Modern equipment for assessment of groundwater resources is limited and monitoring studies are conducted from selected water sources, depending on demand.
Barriers	Lack of devices and equipment, Lack of respective high-grade specialists, Lack of finances
Acceptability to local stakeholders	It is acceptable for all stakeholders, but not feasible from economic perspective (due to need for large financial investments).
Endorsement by experts	Corresponds with international practice
Timeframe	5-8 years
Institutional capacity	Training of specialists on working with modern devices and equipment
Adequacy for current climate	There is need for implementation under current climate too.
Size of beneficiaries group	Businesses, different types of water users

Construction of small water reservoirs at community level	
Introduction	As a result of climate change non-irrigated farming is considered highly risky due to frequent droughts, thus becoming a reason for increasing of poverty in highland villages. Due to lack of irrigation water the yield of crops drops severely, most of agricultural lands remain uncultivated. As a result, the lands are eroded, soil loses accumulated carbon and in the future it will be much more difficult (there will be need for more expensive measures) to return these lands to agricultural

	turnover. River flows, as well as precipitations, are distributed unevenly in Armenia, both in terms of territories and seasons. With this regards it is important to store water resources available in watery seasons, for future use. Construction of large reservoirs on rivers is related with environmental risks and in some cases, also with the need for resettlement of people. On the other hand, construction of large reservoirs, as well as water transportation system (to deliver it to existing irrigation system) require large financial investments, which is not feasible given current economic situation in the country. It is recommended to construct community level small water reservoirs to provide water for community irrigation needs.
Technology characteristics	Construction of small water reservoirs in alpine zones, for communities located in the end of irrigation system, that have non-irrigated agricultural lands, using natural ruptures and gulches located close to communities to collect the water from seasonal rivers, melting snow, floods and rain, for the purpose of future irrigation of agricultural lands.
Costs, including	
cost to implement adaptation options	For the construction of small reservoirs with the capacity of 100,000 m^3 there will be required 208,000-300,000 euros, including the cost of designing and hydraulic nodes.
cost of not modifying the project	Dependence of yield agricultural crops on climate conditions and management of irrigation water distribution, low level of social conditions of population, poverty increasing.
Potential development impacts, benefits	
Economic	Construction of water reservoirs, low cost of construction of the system of water transportation to communities, creation of jobs.
Social	Accessibility of irrigation water, low cost of free of charge irrigation water, increased incomes of population and improved social conditions.
Environmental	Protection of natural water and terrestrial ecosystems, landscapes, creation of favorable microclimate on the community territory.
Status	In Armenia there are mostly constructed large water reservoirs that store river flow and violate the ecological balance of rivers. There are almost no community level small water reservoirs.
Barriers	Lack of financing Absence of quantitative assessment of community water resources and management system of these
Acceptability to local stakeholders	It will become acceptable for local stakeholders after certain explanatory activities and calculation and presentation of quantities of existing water resources, as well as provision of financial support.
Endorsement by experts	Construction of community level small water reservoirs (which accumulate the water from seasonal rivers, melting snow, floods and rain) gain a new momentum globally, since these require

	smaller investments (both for construction of water reservoir and water transportation), water resources of given basin are not moved to other basins, there decreases the dependence of community on other water users.
Timeframe	Up to 1 years
Institutional capacity	Capacity development for management of water stored at community level
Adequacy for current climate	It is applicable under current climate conditions
Size of beneficiaries group	30% of population of Armenia

Annex II: List of stakeholders involved and their contacts

Institutions involved in stakeholder consultation process

Institution	Representative	Contacts
Public Administration Bodies		
Environmental Project Implementation Unit State Institution www.mnp.am/?p=291; www.epiu.am/	Rubik Shahazizyan Edik Voskanyan	+374 94 251709 rshahazizyan@yahoo.com +374 94 384151
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Annex III: TNA team contacts

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