EU REGIONAL PROJECT
IDENTIFICATION AND IMPLEMENTATION OF ADAPTATION RESPONSE TO CLIMATE CHANGE IMPACT FOR CONSERVATION AND SUSTAINABLE USE OF AGRO-BIODIVERSITY IN ARID AND SEMI-ARID ECOSYSTEMS OF ARMENIA

R E P O R T
PROVISION OF ASSISTANCE IN ELABORATION OF VULNERABILITY PROFILES FOR AGRO-BIO RESOURCES AND COMMUNITY VULNERABILITY PROFILES
2012

1. GENERAL PROGRESS OF WORKS

Climate change specialist for the REC-Caucasus project “Identification and implementation of adaptation response to climate change impact for conservation and sustainable use of agro-biodiversity in arid and semi-arid ecosystems of Armenia” commenced the activities in October 2011 as a part of the team of national experts. During the assignment period the climate change expert carried out the following activities within the framework of the project:

- Participation in group meetings and discussions regarding selection of the project; areas taking into account the proposals made by the steering committee members;
- Identification of sources of information on project areas and climate related issues;
- Collection of baseline data of climate for the project areas;
- Participation to field work with an aim to get additional data on the project areas;
- Participation in development of respective section of the project reports;
- Participation in the VII Annual International Conference of REC Caucasus “Climate Change Adaptation – Challenge and Opportunity for the Caucasus” held on 10-11 November 2011 in Tbilisi, Georgia, participation in development of presentation providing information on current project being implemented in Armenia as well as demonstrating activities carried out and progress achieved;
- Provision of assistance in elaboration of vulnerability profiles for agro-bio resources and community vulnerability profiles.

The first project report has been developed in November of 2011 with revisions made in December of 2011 and January 2012. Current report summarizes the activities undertaken as a part of the assignment and presents key considerations for preparation of vulnerability profiles for the project areas.

Overall, the project on “Identification and Implementation of Adaption Response to Climate Change Impact for Conservation and Sustainable Use of Agrobiodiversity in Arid and Semi-arid Ecosystems of South Caucasus” funded by European Commission has an objective to build adaptive capacities in the South Caucasus countries to ensure resilience of agro-biodiversity of especially vulnerable arid and semi-arid ecosystems and local livelihoods to climate change. The specific objective of the project include provision of support in development and implementation of coping mechanisms to improve resilience of local communities to future climate change through introduction of sustainable agricultural practices in selected regions.

The project also envisaged involvement of an international consultant to assist the local teams in three south Caucasus countries with their respective tasks in regard to agro-biodiversity and climate change.

2. REVIEW OF AVAILABLE DATA ON CLIMATE CHANGE IN PROJECT AREA

Background

The Republic of Armenia lies in the north-east of the Armenian Highland at the turn of Caucasus and Western Asia. It borders with Georgia in the north, Azerbaijan in the east, Turkey in the west and south-west and with Iran in the south. The length of the RA state borders is 1479 km. The RA territory is 29743 km^2. The greatest extension of the territory from south to north is 360 km and 200 km from west to east.

Armenia is a mountainous country. The 76.5% of its territory is situated on the altitudes of 1000-2500 m above sea level. Due to vertical alternation, 10 landscape zones have been formed in Armenia - from semi-desert to snowy highlands, including 6 climate patterns - from arid sub-tropical to frosty highlands. Armenia is a country of climate contradictions and has almost all subtypes of climate – from arid subtropical to cold high mountainous, but for the most part it is a semiarid country. These natural conditions have enabled the existing biodiversity. The territory of Armenia is inhabited by 3600 plant species (which is almost half of the whole Caucasian flora), around 450 species of vertebrate animals and 17000 species of invertebrates. The significant part of biodiversity is represented by endemic and rare species. To preserve the biodiversity, specially protected areas of nature have been created, including 3 reserves, 2 national parks and 26 sanctuaries. According to the land balance data of 2006, the territory of the country is divided into the following categories: 71.6% - agricultural lands, 12.5% - forests (10.4% - covered with forest), 7.4% - specially protected nature areas, 0.9% - water surface, 5.4% - settlements, industry and communications territory, 1.3% - other areas. Approximately 80% of the land area is exposed to desertification, of which 26% faces extreme desertification and 27% high desertification.

Armenia’s territory is notable by its developed and irregular hydrological system typical to mountainous countries. It accommodates around 9500 small and medium rivers, the total length of which is 25 thousand km. The longest rivers are: Araks (1072 km), Vorotan (179 km), Debed (178km) and Hrazdan (146 km). The average annual flow of surface waters is about 6.8 km^3. The flow of ground waters is approximately 4.07 km^3, exploited approved reserves (1200 km^3). The density of rivers network varies significantly across the country (0-2.5 km/km^2). The greatest lake of Armenia is Sevan – one of the largest high-mountain fresh-water lakes. Presently, the level of the lake is 1898 m, the surface area – 1257 km^2, the volume – 33.4 km^3. Armenia also has 100 small mountainous lakes, with the total volume of 0.8 km^3.

The territory of the republic is characterized by high seismicity and intensive exogenous processes, contributing to landslide occurrence and development of erosion. The frequency and magnitude of hazardous hydro-meteorological phenomena also contribute to emergence of hazards and incur significant losses for the population and economy. As is stated in the National Action Plan to Combat Desertification (2002), 81.9% of the current territory of Armenia is prone to various degrees of desertification, including 26.8% - to extremely high, 24.6% - high, 19.6% - medium, and 8.8% - low degrees. Additional concern is caused by projected intensification of the mentioned phenomena due to the forecasted global climate change.

As a mountainous country with arid climatic conditions, Armenia, with its entire territory, is vulnerable to global climate change. Armenia is among the most sensitive countries in the Europe and Central Asia region in regard to climate change. As it was already noted the wide range of altitudinal variation and climate zones in Armenia has produced great plant diversity. The country is extremely rich in crop wild relatives, landraces as well as different breeding varieties of cultivated plants that offer a rich pool of gene resources for utilization in agriculture at present and in the future. However the existing system of protected areas does not fully represent the biological and landscape diversity of Armenia, in particular arid and semi-arid ecosystems as well as majority of steppe and meadow ecosystems are nor adequately covered and representing in the protected areas network. Thus, many of these resources are at risk of loss due to lack of awareness, growing human pressure, environmental disturbances and climate change. Increased temperatures and reduced precipitation accelerate the desertification processes and will have a negative impact on public health and sectors, which depend on the climate. Declining water resources will have a direct impact on agriculture (reduced possibilities for irrigation, worsened conditions for dry farming, reduced crop yields), and will result in reduction of hydroelectricity production and scarcity of water. The forecasted higher frequency of extreme climatic phenomena, as a result of climate change, will have a negative impact on public health, property, agriculture and infrastructures. Climate change will result in changes to natural ecosystems, which will also reflect on biodiversity and forest, alpine, sub-alpine and wetland ecosystems of Armenia.

Information on climate

Overall, the climate of Armenia is formed under influence of dominating western-eastern humid air masses, which are active in spring and summer on one side, and with intrusions of northern cold and southern hot and dry air masses that prevail during winter and summer. Some impact is also made by intrusion of eastern air masses (especially in winter season). All such air masses are significantly deformed in the mountainous ranges of the country. Moving up to mountainous highlands such air masses form precipitation, while moving down along the slopes they get warmer and the relative humidity of air reduces. In a result two drastically different agro-climatic zones have been formed in the territory of the country. The first zone is represented by relatively humid forests with mild winters – the forested areas of Lori, Tavush and Syunik marzes. The second zone is characterized with dry continental climate and is represented by all the rest marzes of the republic.

The climate of Armenia is highly variable, even on small territories, due to the country's complex relief. Almost all types of climatic patterns can be observed in Armenia - from dry sub-tropical to frosty highlands. In the southern plain regions the climate is arid and extremely continental. In the northern mountainous regions the climate is milder and damper. The average annual temperature is 5.5°C. The highest average range of temperature is 12-14°C (in Alaverdi and Meghri). Negative average annual temperatures are recorded at the altitude of 2500 m and higher. Summer is temperate. The average temperature in July is 16.7°C, although in Ararat valley it varies between 24-26°C. The absolute maximum temperature is recorded in Artashat (43°C), whilst the absolute maximum temperature for Yerevan is 42°C. Winter is cold. January is the coldest month of winter with an average temperature of -6.7°C. The absolute minimum temperature is recorded in Paghakn (-42°C). Winter is temperate in northeastern and south-eastern regions of the country.

The average annual precipitation in Armenia is 592 mm ranging from 114 mm in the semi-desert zone to about 1000 mm in the high mountains. The most arid regions are Ararat valley and southern region. The annual precipitation here usually varies within 200-250 mm. The highest annual precipitation - up to 1000mm - is observed in high-altitude mountain regions. In Ararat valley the average precipitation during summer does not exceed 32-36 mm.

The project area is located in two transboundary marzes: Ararat and Vayots Dzor. The map of Armenia with project area is demonstrated in the figure 1.

Figure 1. Map of project area

Climatic map of the Armenia with the project area marked with red circle is presented in figure 2.

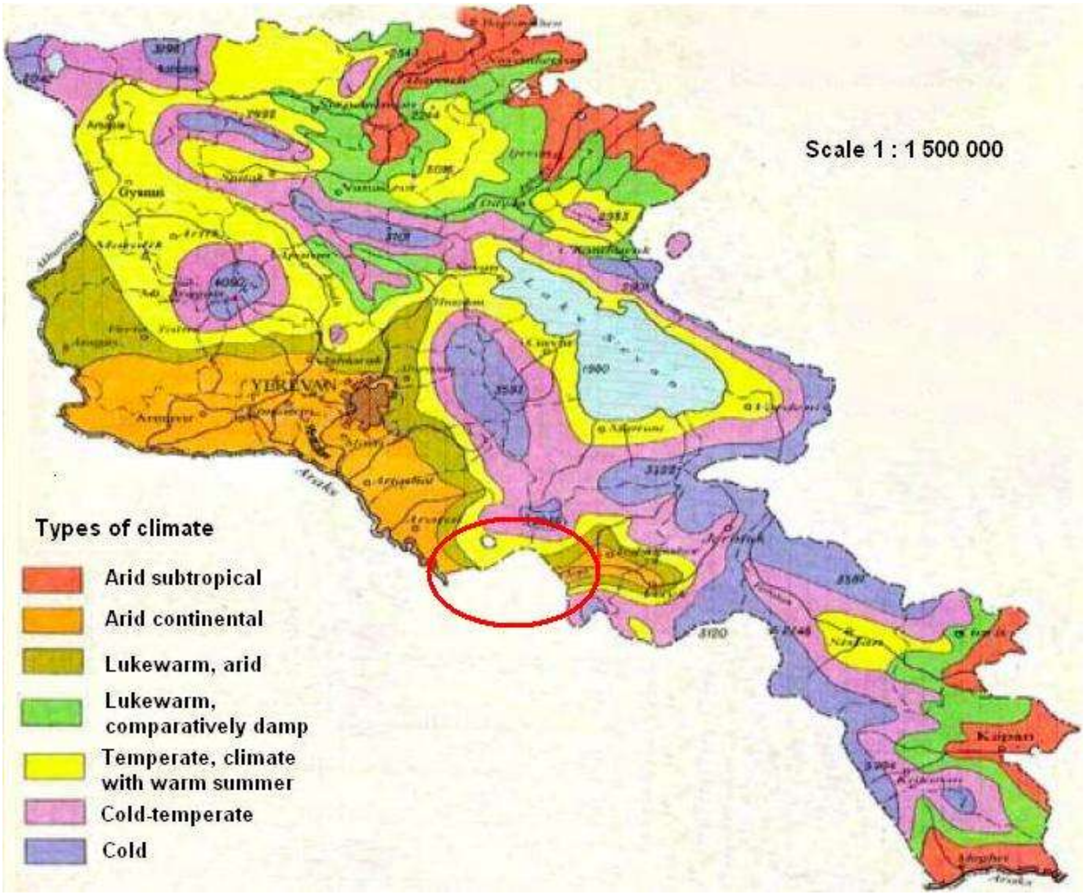

Figure 2. Climatic map of Armenia

Ararat marz is situated in the south-western part of the Republic of Armenia. In the north the marz borders the capital Yerevan, Armavir marz and Kotayk marz, in the east it borders Gegharkunik marz, in the south-west –Vayots Dzor marz and in the south it borders the state border of Turkey. The territory of the Ararat marz is 2096 km^2, or about 7% of the territory of the Republic of Armenia. There are 97 communities in the marz, of which 4 urban and 93 rural. The climate of Ararat marz is continental with hot sunny summers and cold winters. The marz is considered as one of the most arid regions of the country. The average temperature for July in Ararat Valley it varies in the range of 24-26°C. The absolute maximum temperature in the republic is 43°C, recorded in Artashat, capital of Ararat marz. The average annual quantity of precipitation in Ararat valley is 200-250mm, while during the entire summer the quantity of precipitation on average does not exceed 32-36mm.

Data on air temperature registered at Yeraskh station are presented in the table 1 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Yeraskh	-3.4	-0.5	6.4	13.5	18.2	22.6	26.6	26.1	21.4	13.9	6.6	-0.3	12.6

Data on average minimum air temperature registered at Yeraskh station are presented in the table 2 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Yeraskh	-9.0	-6.6	-0.6	6.0	11.0	14.3	18.5	17.2	12.2	5.3	-0.1	-6.4	5.2

Data on average maximum air temperature registered at Yeraskh station are presented in the table 3 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Yeraskh	1.1	4.1	12.7	19.6	24.4	28.8	32.6	32.7	28.7	22.0	13.0	4.5	18.7

Data on absolute minimum air temperature registered at Yeraskh station are presented in the table 4 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Yeraskh	-27	-28	-27	-6	1	4	9	8	1	-5	-16	-25	-28

Data on absolute maximum air temperature registered at Yeraskh station are presented in the table 5 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Yeraskh	20	23	28	33	36	39	41	42	39	32	27	22	42

Data on average values of absolute minimum air temperature registered at Ararat station are presented in the table 6 below (data for Yeraskh station is not available, so the data was taken for next most close station to project area - Ararat station):

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Ararat	-14.9	-12.6	-6.0	0.3	6.2	10.4	14.2	13.7	7.0	0.1	-5.9	-11.1	-17.2

Data on average values of absolute maximum air temperature registered at Ararat station are presented in the table 7 below (data for Yeraskh station is not available, so the data was taken for next most close station to project area - Ararat station):

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Ararat	8.8	13.0	20.8	26.8	31.1	35.1	38.2	38.0	34.6	27.9	20.1	12.7	39.1

Data on first and last frost as well as duration of no-frost period registered at Ararat station are presented in the table 8 below (data for Yeraskh station is not available, so the data was taken for next most close station to project area - Ararat station):

Station	Last frost			First frost			Duration of no-frost period (days)		
	average	earliest	latest	average	earliest	latest	average	earliest	latest
Ararat	29 III	11 III	24 IV	2 XI	9 X	28 XI	217	183	251

Data on average monthly and annual temperature of soil registered at Ararat station are presented in the table 9 below (data for Yeraskh station is not available, so the data was taken for next most close station to project area - Ararat station):

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Yeraskh	-3	1	8	16	22	28	33	32	25	15	6	0	15

Data on average values of minimum and absolute minimum temperatures of soil registered at Ararat station are presented in the table 10 below (data for Yeraskh station is not available, so the data was taken for next most close station to project area - Ararat station):

Charac-terictic	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
average	-9	-6	-2	4	9	13	17	16	10	4	-2	-6	4
absolute	-30	-30	-22	-10	-2	2	6	6	-4	-8	-14	-32	-32

Data on average values of maximum and absolute maximum temperatures of soil registered at Ararat station are presented in the table 11 below (data for Yeraskh station is not available, so the data was taken for next most close station to project area - Ararat station):

Charac-terictic	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
average	7	13	26	36	45	54	59	58	49	35	22	10	35
absolute	28	40	48	59	64	70	70	69	65	52	40	28	70

Data on soil freezing depth (cm) registered at Ararat station are presented in the table 12 below (data for Yeraskh station is not available, so the data was taken for next most close station to project area - Ararat station):

Station	Average					Maximum					Maximum, during winter		
	XI	XII	I	II	III	XI	XII	I	II	III	Average	Absolute maximum	Absolute minimum
Ararat	-	9	14	-	-	20	20	37	24	-	15	37 (1989)	2 (2011)

The main details on precipitation and snow cover available for various elevations in Ararat marz are provided in the below Table 13 (the project area is located at elevations 800-900m above sea level):

Criteria	Elevation above sea level		
	800m	1000m	1200m
Annual precipitation (mm)	200-250	250-300	300-400
Precipitation in vegetation season (mm)	50-100	100-150	150-200
Number of days with stable snow cover	-	66-73	70-82

In recent decades the intensity and frequency of hazardous hydro-meteorological phenomena has increased. Among the natural hazards, Armenia is mostly affected by droughts, early spring frosts, heat/cold waves, hailstorms, mudflows, landslides, storms, fogs and forest fires. Table 14 presents data on natural hazards registered in Ararat Marz.

Marz	Dry conditions (0-low, 5-high)	Drought (0-low, 5-high)	Seasonal flooding (0-low, 5-high)	Hailstorm (0-low, 5-high)	Early frosts (0-low, 5-high)
Ararat	4	5	2	4	5

Vayots Dzor marz is situated in southern part of the Republic of Armenia. In the south borders with Nakhijevan, in the north it borders with Gegharkunik marz, in the east – Syunik marz and in the west – Ararat marz. The territory of the Vayots Dzor marz is 2308 km^2, or about 7.8% of the territory of the Republic of Armenia. There are 55 communities in the marz, of which 3 urban and 52 rural.

The area of the marz is considered unique due to its exceptionally rich biodiversity and diverse landscapes. The Vayots dzor climate on the whole is arid, continental, with cold or moderate cold winters and hot or warm summers. In the lowland parts of the marz, where the project areas are located, the climate is arid, with large fluctuations of temperature and precipitation of up to 400mm. The temperature of the air in the lowland parts can reach up to + 40°C in summer and - 35°C in winter. Medium elevated areas located at the altitudes of 1400-2800m have typical mountainous-steppe and mountainous-forest landscape. Mountainous-steppe zones are distinguished with longlasting mild winters and precipitation of 500-600mm. Forested areas are scattered, the climate is mild, dry, winters are mild and the amount of annual precipitation comprises 700-800 mm. High-mountainous zone is characterized by alpine meadows located on the steep slopes of the mountains. Climate in this zone is cold; precipitation comprises 800-900 mm.

Data on air temperature registered at Areni station are presented in the table 15 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	-2.6	-0.1	5.7	12.1	17.1	21.9	26.1	25.9	21.1	13.9	6.7	0.1	12.3

Data on average minimum air temperature registered at Areni station are presented in the table 16 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	-6.7	-4.8	0.3	5.8	10.5	14.4	18.8	18.3	13.1	6.6	1.3	-4.4	6.1

Data on average maximum air temperature registered at Areni station are presented in the table 17 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	2.5	5.2	11.6	18.5	23.7	20.0	33.1	32.9	28.7	21.1	12.9	4.8	18.7

Data on absolute minimum air temperature registered at Areni station are presented in the table 18 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	-24	-23	-22	-8	1	2	8	9	3	-5	-14	-22	-24

Data on absolute maximum air temperature registered at Areni station are presented in the table 19 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	18	19	27	34	35	38	41	42	39	33	26	19	42

Data on average values of absolute minimum air temperature registered at Areni station are presented in the table 20 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	-12.9	-11.3	-6.5	0.0	5.7	9.8	14.0	13.5	8.4	1.3	-4.4	-10.1	-15.3

Data on average values of absolute maximum air temperature registered at Areni station are presented in the table 21 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	8.9	12.4	19.2	25.6	30.0	34.9	38.0	38.1	34.6	28.3	20.1	12.3	38.9

Data on first and last frost as well as duration of no-frost period registered at Areni station are presented in the table 22 below:

Station	Last frost			First frost			Duration of no-frost period (days)		
	average	earliest	latest	average	earliest	latest	average	earliest	latest
Areni	28 III	1 III	22 IV	8 XI	3 X	3 XII	224	190	258

Data on average monthly and annual temperature of soil registered at Areni station are presented in the table 23 below:

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Areni	-3	0	8	15	23	30	35	34	26	16	7	0	16

Data on average values of minimum and absolute minimum temperatures of soil registered at Areni station are presented in the table 24 below:

Charac-terictic	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
average	-9	-6	-1	4	9	13	18	17	11	4	-1	-6	4
absolute	-33	-33	-24	-10	-2	0	5	8	-1	-9	-13	-26	-33

Data on average values of maximum and absolute maximum temperatures of soil registered at Areni station are presented in the table 25:

Charac-terictic	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
average	7	13	26	36	46	56	62	60	52	35	21	10	35
absolute	30	38	50	60	67	72	72	73	69	55	40	32	73

Data on soil freezing depth (cm) registered at Yeghegnadzor station are presented in the table 26 below (data for Areni station is not available, so the data was taken for next most close station to project area - Yeghegnadzor station):

Station	Average					Maximum					Maximum, during winter		
	XI	XII	I	II	III	XI	XII	I	II	III	Average	Absolute maximum	Absolute minimum
Yegheg-nadzor	8	17	29	18	-	12	45	79	47	4	31	79 (1964)	8 (1989)

The main details on precipitation and snow cover available for various elevations in Vayots Dzor marz are provided in the below Table 27 (the project area is located at elevations 1100-1200m above sea level):

Criteria	Elevation above sea level		
	1200m	1400m	1600m
Annual precipitation (mm)	350-450	450-500	450-550
Precipitation in vegetation season (mm)	200-250	230-300	300-350
Number of days with stable snow cover	50-70	65-70	74-84

Table 28 presents data on natural hazards registered in Vayots Dzor Marz.

Marz	Dry conditions (0-low, 5-high)	Drought (0-low, 5-high)	Seasonal flooding (0-low, 5-high)	Hailstorm (0-low, 5-high)	Early frosts (0-low, 5-high)
Vayots Dzor	2	3	4	2	2

Observed changes in climate and projections

The results of various studies carried out based on meteorological observation data show that Armenia has been warming during the last decades. The anomalies of annual air temperature and total precipitation for 1935-2007 over Armenia estimated with respect to the base period 1961-1990 are presented in figures 3 and 4 respectively.

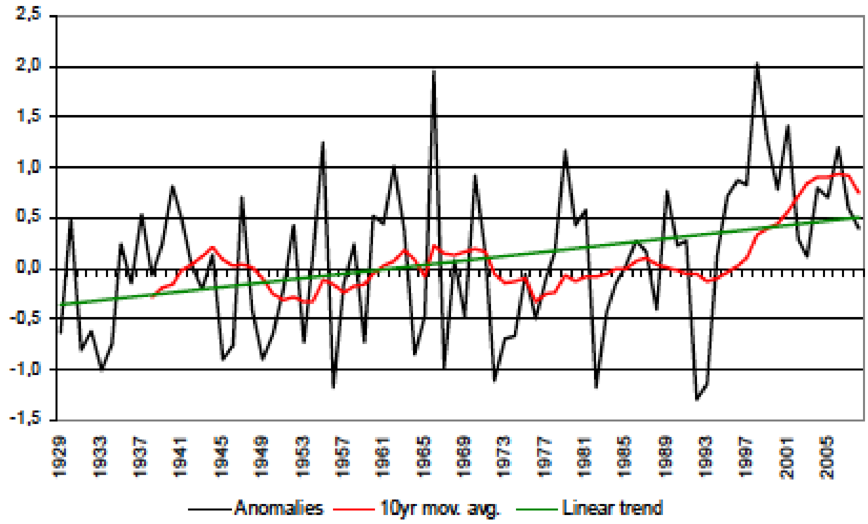

Figure 3. Observed annual air temperature anomalies compared to 1961-1990 baseline mean (black line), their decadal moving averages (red line) and linear trends (green line)

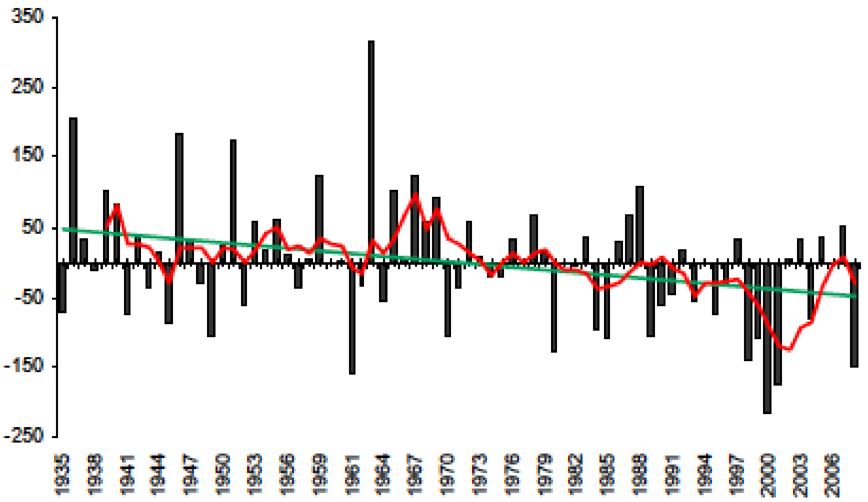

Figure 4. Observed precipitation anomalies compared to 1961-1990 baseline mean (black line), their decadal moving averages (red line) and linear trends (green line)

During the last 80 years the annual air temperature has been increased by 0.85°C and the precipitation has been reduced by 6%. However, it should be noted that the changes of temperature and precipitation vary from region to region and from season to season. Thus, during the period 1935-2007, in summer months (June, July, August) the temperature has increased by 1°C, whereas in winter (December, January, February) the increase is not statistically significant – about 0.04°C. The changes in temperature in summer and winter seasons are shown in figures 5 and 6.

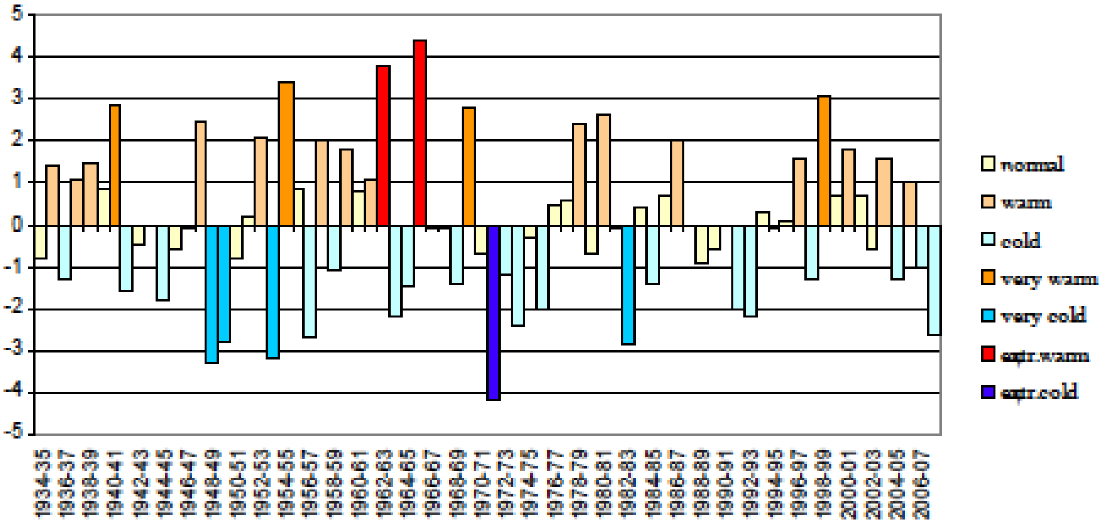

Figure 5. Observed winter temperature anomalies with respect to 1961-1990 normal

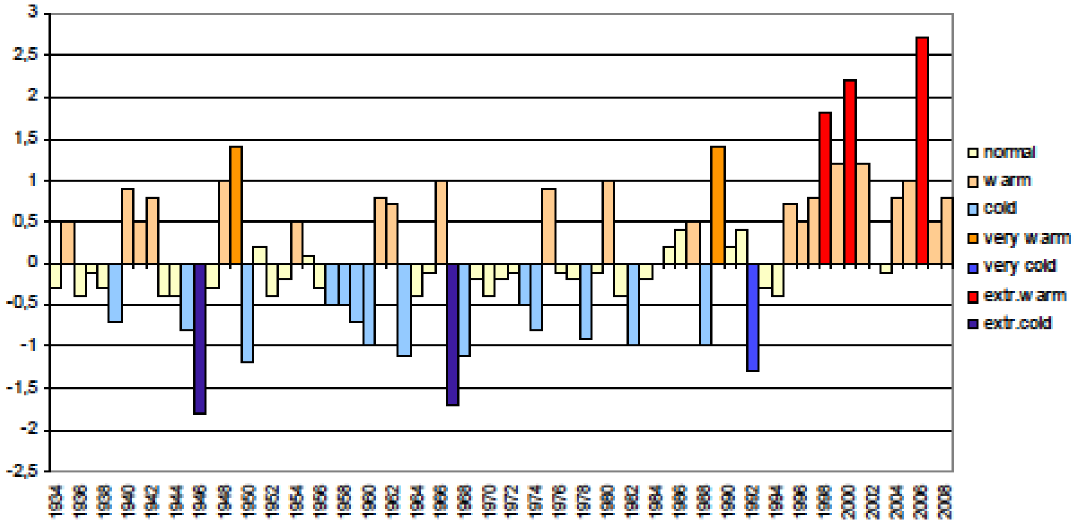

Figure 6. Observed summer temperature anomalies with respect to 1961-1990 normal

Persistent positive anomalies of summer temperature have been reported during last 14 years (except 2003), and summer of 2006 was the hottest in Armenia during the period 1929-2007.

Forecast for the extreme climatic indices SU25 and TR20 assessed for 2020 and 2050 is based on PRECIS RCM forecast and RCliMDex 1.0 software. Data on extreme climatic indices (average values for 2020-2050 in comparison with 1935-2005) is presented in table 29 (data for Yerevan and Armavir are compatible for Ararat Valley).

Table 29. Extreme climatic indices (PRECIS)

Station	SU 25	TR 20
Armavir	12	37
Yerevan	12	36

The forecasts for Armenia show a significant and consistent increase in temperatures projected for the three time slices: 2030, 2070 and 2100. Analyses were made through PRECIS climate model, and the results obtained for the period 2071-2100 (see figure 7) were compared with the classical climate distribution (see figure 8).

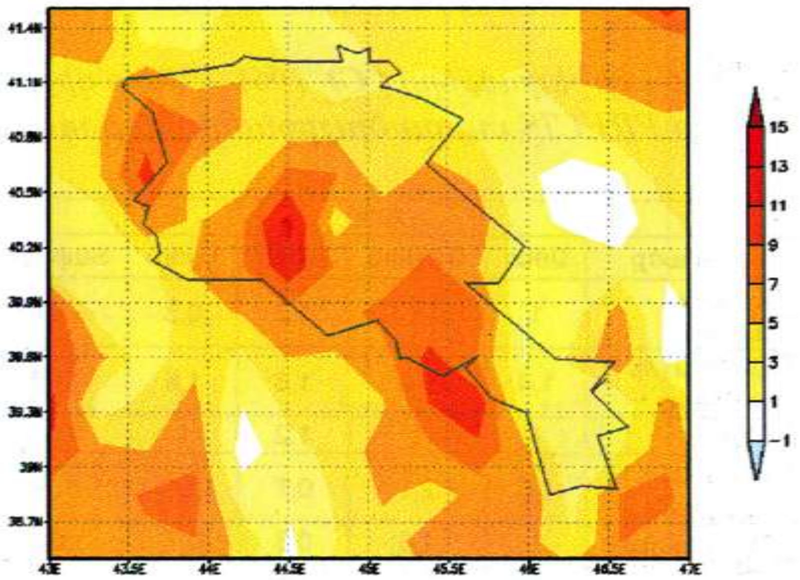

Figure 7. Forecasted changes in air temperature by 2100
in accordance with PRECIS regional model

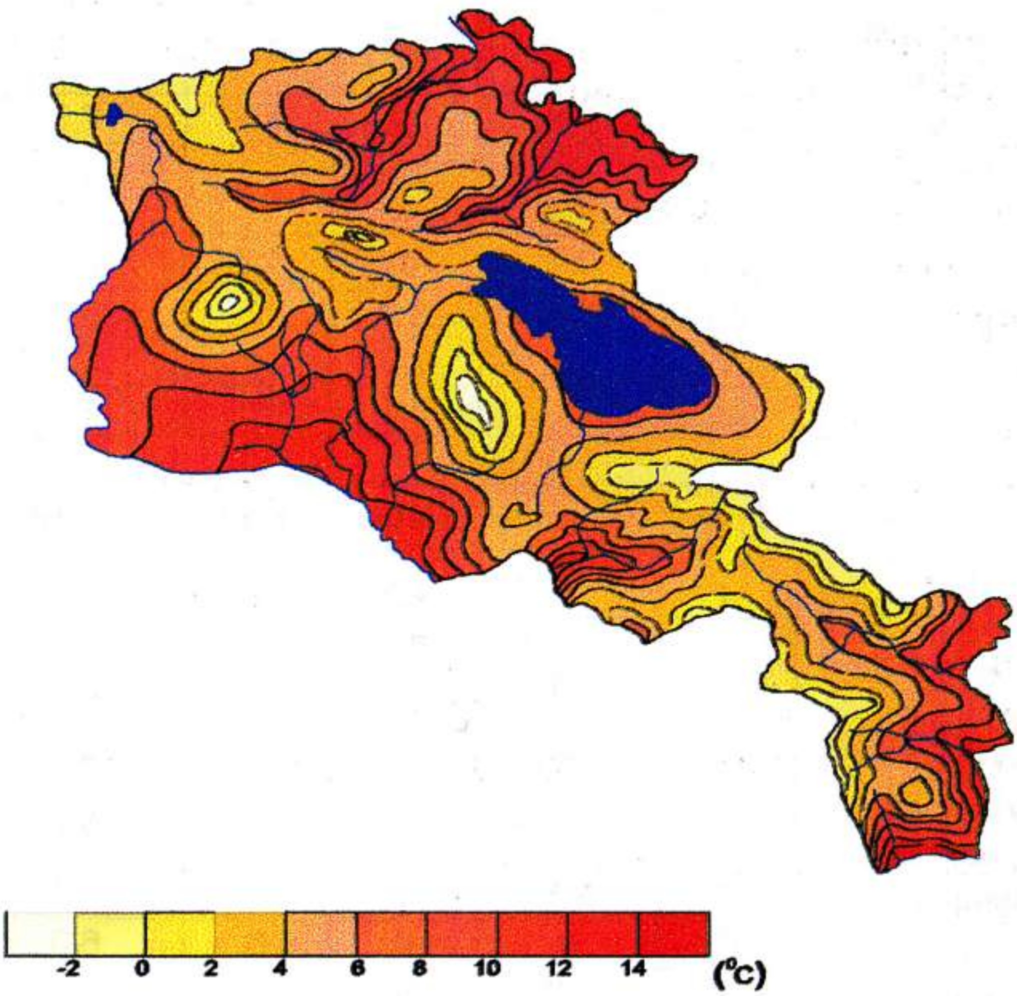

Figure 8. Average annual temperature for 1961-1990

Results of the forecast of the change in air temperature are presented in table 30. The increase of air temperature shall be maximal in summer season (about 5-9°C warmer). There are regional variations within Armenia. West and central region, particularly Ararat Valley shall experience higher warming than rest of the country during all the seasons. Temperature over southern part of Armenia (Suniats highland) shall become mildly warmer. Annual mean surface temperature anomalies for 2071-2100 compared to baseline climatology have essentially same features as the ones described for seasonal mean anomalies. The central and western regions of Armenia shall experience more warming than the rest of the region in the country. Annual temperatures will rise by 4-7°C by the end of 21st century.

Table 30. Changes in seasonal and annual temperatures (°C) compared to 1961-1990 baseline average (PRECIS model under A2 scenario)

Area	Winter	Spring	Summer	Autumn	Annual
2030					
Ararat valley	1.05	1.6	0.32	0.7	0.96
Vayk	1.05	1.78	1.78	1.05	1.4
2070					
Ararat valley	2.5	3.6	1.0	1.7	1.7
Vayk	2.5	3.9	3.9	2. 5	3.2
2100					
Ararat valley	2-6	4-7	1-3	2-4	2.5 - 5
Vayk	5-7	5-7	5-7	5-7	5-7

Figure 9 presents annual distribution of precipitation in Armenia according to the model, and from comparison with the climatic norms for precipitation (see figure 10) it is obvious that significant deviations of precipitation, compared to the climatic norms, are expected in Armenia as a result of global warming.

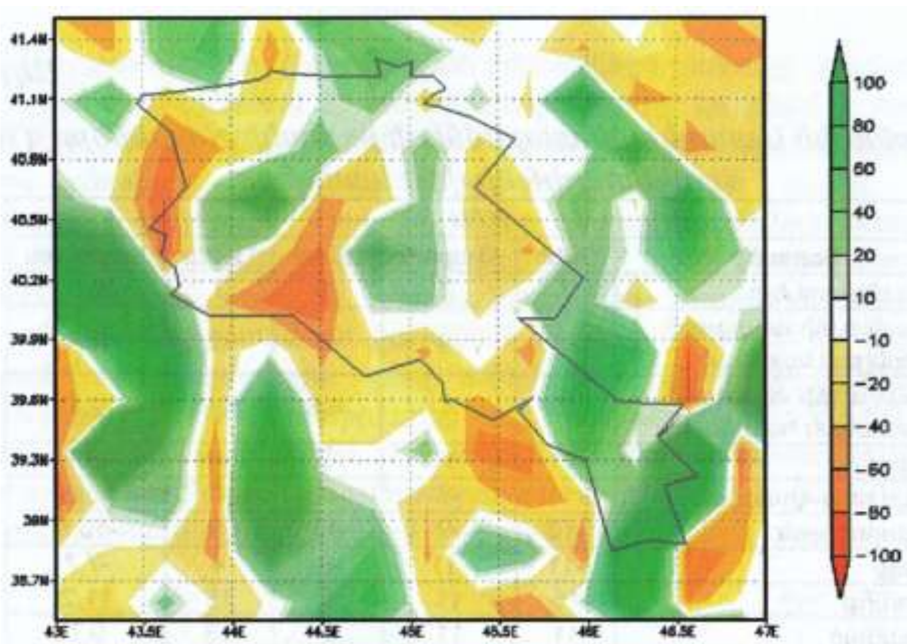

Figure 9. Forecasted changes in precipitation by 2100
in accordance with PRECIS regional model

Precipitation will reduce drastically in the entire region, especially in summertime. Spatial changes of precipitation are different: decreasing in lowlands and Ararat valley, and increasing in foothills and the eastern part of the Lake Sevan basin. The modeled change in annual precipitation for the period till 2030 was generally less than 10%, which is an insignificant change compared to the large inter-annual variability of precipitation. However, given the large standard deviation the results for annual precipitation should be interpreted with the high caution.

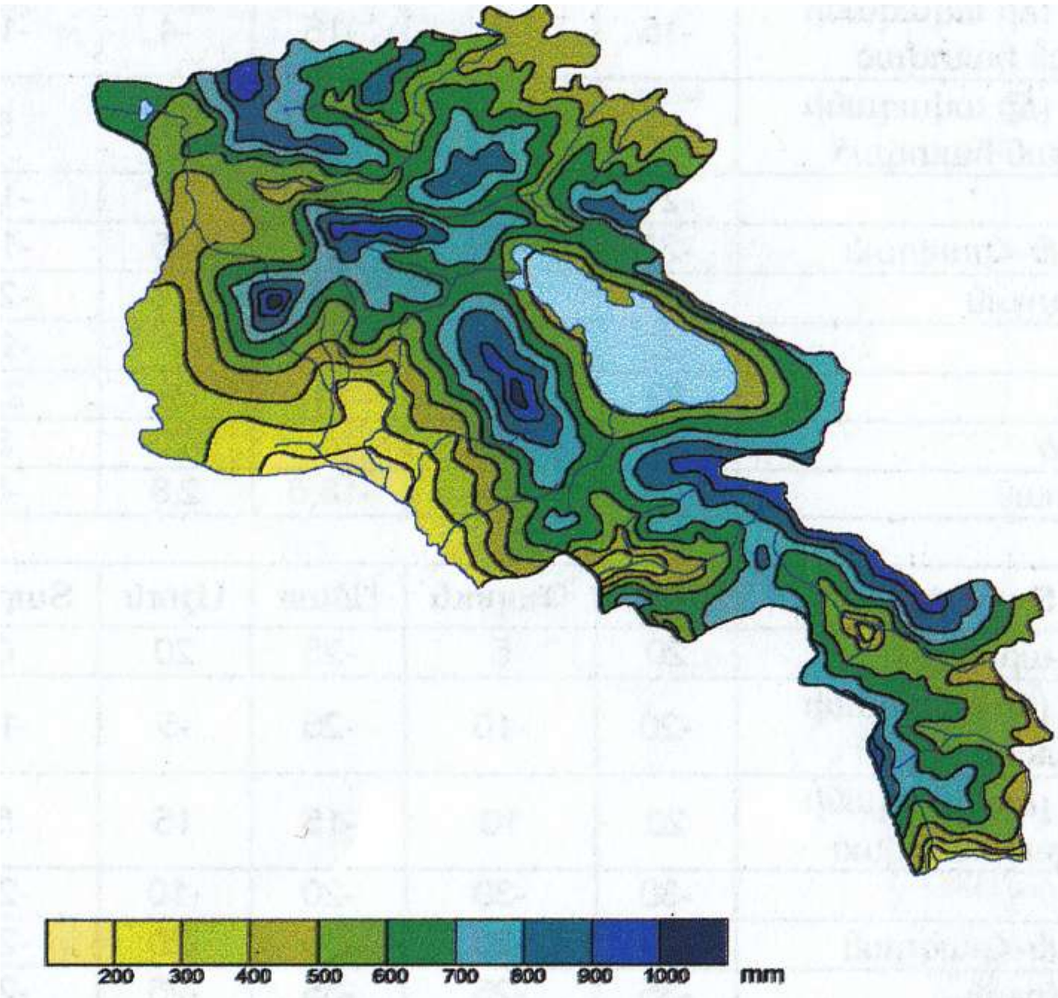

Figure 10. Average annual precipitation for 1961-1990

According to the PRECIS results, in the period of 2071-2100, the total soil moisture in Armenia will increase during spring months (March, April, May) compared to the average (1961-1990), and in summertime the total soil moisture may possibly decrease. These results are in line with precipitation forecasts and the fact that snow melt will start earlier due to the increase in spring temperatures. The relative air humidity, according to the model, will reduce in the same period in all seasons of the year except autumn, compared to the average for 1961-1990 (table 31).

Table 31. Deviations of seasonal and annual precipitation (%) compared to the average for 1961-1990 (PRECIS model under A2 scenario)

Area	Winter	Spring	Summer	Autumn	Annual
2030					

Ararat valley	-13	-9	-13	-9	-11
Vayk	-11	-11	-9	+4	-7
2070					
Ararat valley	-25	-18	-25	-18	-22
Vayk	-22	-22	-18	+7	-13
2100					
Ararat valley	-35	-25	-35	-25	-18
Vayk	-30	-30	-25	+10	+30

In autumn, the humidity will reduce negligibly in the central regions, and a relative increase in humidity may be observed in northeastern and southern regions. In spring, the air will be 4-8% drier in the central regions and 2-4% drier in northeastern and southern regions of the country. The maximal reduction of humidity is anticipated in winter and summer (10-14%). Annual relative humidity shall reduce by 5-10% and more.

Lower precipitation levels combine with higher average temperatures to increase evaporation rates and reduce winter snowpack and spring run-off: as a result less water reaches streams and rivers. For a number of Armenia's rivers the greatest cause of reduced flow will be less accumulation of snow and ice, with lower winter precipitation and slightly higher winter temperatures. Snowmelt is responsible for 20 - 40 % of total river flow in the country, with most important sources of snow and ice accumulating at 1800 - 2800 meters above sea level. In terms of declining river flow due to reduced snowmelt, Armenia's most vulnerable river basins located in the project marzes are Arpa, Azat and Hrazdan. Armenia's total river flow is projected to drop 7 % by 2030 and 24 % by 2100.

Climate change in Armenia has been pronounced by more frequent and severe weather events, such as droughts, spring frosts, hails, floods, mudflows, winds and forest fires. During the past decade extreme weather events have been recorded to accelerate.

3. IMPACTS AND CONSEQUENCES OF CLIMATE CHANGE FOR AGRICULTURE

The agriculture in Armenia is one of the most important and at the same time one of the most vulnerable sectors in the national economy and societal welfare. It along with agro-processing accounts for much of the country's employment and export earnings. The share of agriculture has accounted for approximately 20% of the country's GDP on average in the recent years, which creates favorable preconditions for the gradual increase of the level of the country's food security. Meantime, is should be noted that Armenia is characterized by high risk of agricultural operations due to relatively scarce land and water resources, as well as high probability of different extreme events such as frosts, hails, floods, heat waves, landslides and droughts which affect agricultural production and sustainable development in general.

The usable agricultural lands make a bit more than 70% of the country's total area, with arable lands making only about 15%. The current market-based economy includes more about 340,000 individual farm households with an average landholding of around 1.4 hectares, which are especially susceptible to economic risks and external stresses.

The ownership structure with predominant small size parcels sets limits for the commercial production, leads to increase in production costs, prevents application of appropriate agro-technical rules and intensive technologies and causes soil erosion. The major land users in agriculture are the farms, which have 75.9% of arable land, perennials - 74.7% and grassland - 44.9%. More than 98% of the agricultural gross production is carried out by the private sector.

Half of Armenia's arable land requires irrigation; with climate change more land will fall under this category but less river water will be available. Crops, which are more vulnerable to drought than pastures and far more likely to require irrigation, represent 14% of GDP. A 25% reduction in river flow is projected to result in a 15-34% reduction in the productivity of irrigated cropland, with an average estimated reduction of 24%. The expected loss in yield for grapes would be 21% and for winter wheat, 25%. Total losses to the agricultural sector would amount to 65 to 145 billion AMD, or US$180 to 405 million (with an average impact of 105 billion AMD or US$293 million); this would be a loss of 2-5% of GDP (3% on average).

Depending on policy choices, reductions in agricultural production could also impact on Armenia's food production industry and thereby have a wider-reaching effect on the economy. If agricultural losses result in losses to the food production industry of the same scale – 13 to 34% reduction – the additional decrease to GDP would range from 1.5-3.4%.

Due to clear understanding that the possible negative consequences of global warming would adversely affect not only the climate-dependent sectors but also the entire economy of our country, the climate change challenges and undertaking mitigations actions are becoming priorities for the country's policy and are being considered in the light of the food security and self-sufficiency in major food products.

The following possible consequences are expected in agricultural sector if the climate change scenario (increase in air temperature by 2^{o}C and reduction of precipitation for 10%) takes place:

- change of the borders of natural climatic zones;
- significant change of the biota;
- change of the mode of the rivers' runoff, and quantitative indicators of water resources;
- change of agriculture potential of the county and its regions;
- change in amount of precipitation and soil moisture content due to aridization of climate.

A significant reduction of efficiency of the agricultural sector is possible, in particular:

- humidity of soil will decrease for 10-30%, depending on the vegetation period and elevation of the particular area;
- natural moisture provision of various agricultural crops will decrease by 7-13%, moisture deficit in soil will increase by 25-50mm;
- efficiency of crop production in Armenia can be reduced by 8-14%, productivity of crops, cultivated in arid zones will be reduced by 10-14%, and by 7-10% for moderate zones,
- productivity of cereals will be reduced on the average by 9-13%, vegetable crops – by 7-14%, potato – by 8-10%, and horticultures – by 5-8%;

- productivity of more heat-tolerant grapes can rise by 8-10%;
- reduction of pasture areas as a whole and of their productivity by 4-10%;
- expansion of the areas of low-yield pastures of the semi-desert belt by 17%;
- reduction of the areas of most valuable and high-yield pastures of sub-alpine belt by 19% and alpine belt - by 22%, and productivity of mountain grasslands by 7-10%
- increase of the share of poisonous, prickly and weed plants in structure of vegetation pastures, reduction in their productivity, reduction of forage quality, reduction of number of livestock by 30% and dairy cattle production by 28-33%.

In general, vulnerability assessment undertaken in the country has revealed a series of obstacles preventing precise quantitative estimation of the impact of global warming and economic losses caused by weather and climate related disasters. However, the following difficulties have been faces while collecting the baseline data for analysis of vulnerability:

- lack of corresponding data collection system;
- lack of proper system for damage valuation and compensation that creates constrains in economic impact assessment; the impact of climate change on Armenia's economy is difficult to calculate in money terms, because of data limitations and concerns with accuracy;
- lack of research data for precise assessment of impact of climate change on farming systems;
- lack of data, expertise and skills to apply cost-benefit analyze models;
- lack of explicit guidelines, methodologies and models;
- lack of finer resolution models for the small size country with diverse topography and vertical zoning.

Access to the best available data and information on climate variability and impacts will facilitate dynamic, long-term national planning and application of adaptation mechanism for sustainable food and livelihood security.

A number of adaptation measures targeted on reducing the adverse effects of climate have been identified a result of climate change impact assessment on agriculture:

- improving genetic potential of crops and animals, such as introduction of new high-yielding frost resistant and drought tolerant, salt resistant (for salinized lands) crops varieties, including old traditional varieties, improvement of the breed structure of herd, introduction of more valuable species and varieties of forage crops, crop diversification;
- land reclamation, in particular increase soil water keeping capacity, prevention of the secondary salinization, expansion of zones of crop production, restoration of degraded pastures, pastures watering, increase of productivity of pastures vegetative cover, optimization of utilization of reserve lands;
- introduction of appropriate agricultural practices including conservation tillage, mulching, revision of fertilization rates, regulation of the photo- and micro-climate, revision of sowing time for winter crops;
- irrigation measures, such as expansion of irrigated lands, building of new irrigation schemes, drop irrigation systems enlargement to cope with water shortage;
- insurance for agricultural operations, that helps to empower rural people against climate change risks.

4. KEY CONSIDERATIONS FOR DEVELOPMENT OF VULNERABILITY PROFILE

4.1 Assessing vulnerability

Vulnerability is the degree to which a system is likely to experience harm due to exposure to a hazard. Vulnerability can de defined as a function of exposure, sensitivity, and adaptive or coping capacity (as is schematically presented in the figure 12).

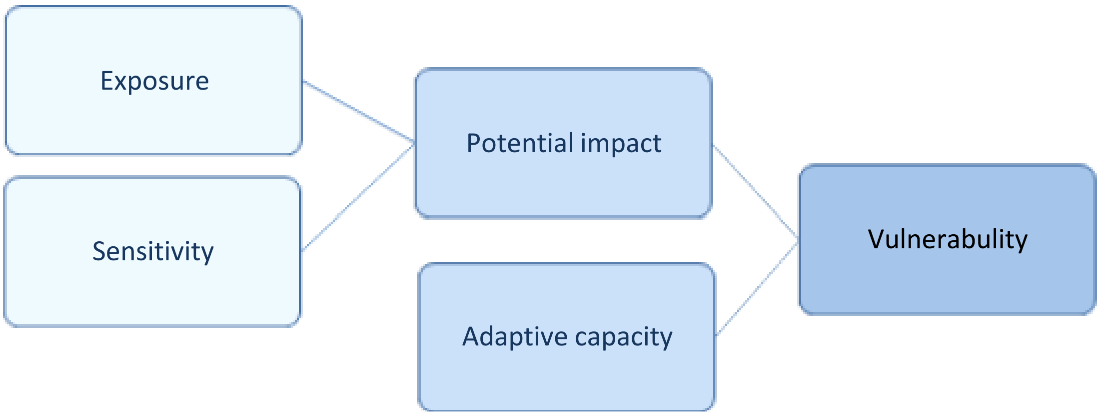

Figure 12. Schematic framework for defining vulnerability1

Exposure is a fairly straightforward concept: it is determined by the type, magnitude, timing and speed of climate events and variation to which a system is exposed (e.g., changing in minimum winter temperatures, flood events, etc.). But the impact of a climate shock or change also depends on how sensitive a system is to that shock. The impact of a flood, for example, will depend on several factors, such as: whether people are living in the flood plain, whether waste dump sites or plants/storages of toxic substances located in the flood plain, whether the local community have sufficient organizational and financial resources to prevent the spread of waterborne diseases, help people access shelter, and quickly rebuild damaged infrastructure, thereby reducing post-disaster loss of life and promoting faster recovery, etc. Similar analysis can be done for other natural emergencies, such as droughts, frosts, etc.

Sensitivity depends on how stressed the current system is. A system or a population already close to its limits will suffer great damages even from small shocks. These might include communities lacking administrative and financial resources, poor farmers/households without any savings, congested and poorly maintained infrastructure, water basins with depleted resources, communities with unhealthy population etc. The exposure and sensitivity together determine the potential impacts confronting a community or a system—the impacts without considering adaptation. Meantime, it should be noted that vulnerability also depends on the capacity of a community or a system to adapt and to cope. The ability to adapt is a function of organizational skills, access to the appropriate information and ability to use it, as well as the access to financial resources. In some cases distinction between sensitivity and adaptive capacity can be quite uncertain. Sensitivity can be the degree to which a system is affected (positively or negatively) in its current form by a climate trend, climate variability, or climate shock. Adaptive capacity, on the other hand, is dynamic and affects future sensitivity.

In practice, it may well be that the same factors that determine current sensitivity also determine the extent of adaptive capacity. A poor farmer/household, will be sensitive to shocks, experiencing large impacts from even small shocks. Such farmer/community will also have less adaptive capacity due to its lack of resources to finance relocation or protective infrastructure (e.g. small dykes, irrigation systems, etc.). The above approach on "exposure-sensitivity-adaptive capacity" can help to identify the combination of factors that strengthen or reduce the impact of climate change. This approach can be applied to particular farmers or communities or sector by sector, as is presented in the below list providing analysis for various vulnerability criteria for agricultural sector:

- **Exposure:** The project marzes are located across a wide range of agro-ecological zones that differ significantly in their access to rain-fed and irrigated water. Climate change will leave these areas exposed due to increased temperature, reduced annual rainfall, or reduced water when needed for plant growth. An increase in the intensity and frequency of extreme events, such as droughts and hails, will limit the capacity to grow productive crops. It is likely that the areas now considered marginal in their capacity to produce viable crops will be the most vulnerable to climate change.
- **Sensitivity:** The projects areas are selected in a way, so that these communities, located in the arid zones, will be more sensitive to the impacts of climate change than others. This sensitivity can be attributed to a number of factors, including heat stress, susceptibility to pests and diseases, seasonal rainfall patterns delivering rain when it is not needed, frequency of frost days and very hot days, frequent drought years. These communities depend on the economic viability of the agricultural sector and so will likely suffer from the impacts of the climate change. In nearest future these communities can become even more dependent of availability of irrigation water and increased use of fertilizers to maintain current production rates.
- **Adaptive capacity:** The small individual farms relies strongly on the ability to obtain a good annual return from their agricultural activities, as in most cases this is the only income source for their households, thus such farms will have limited options to adapt to the impacts of climate change. In may cases they will be driven to shift existing cropping pattern and introduce drought tolerant varieties of crops in order to cope with unfavorable natural conditions and increase adaptive capacity of their agricultural activities taking into account increased temperature and reduced soil moisture conditions. In addition, improved water use efficiency and better soil management can also contribute to increase in capacity to adapt to small changes in climate. Adaptation measures may also include production of crops with increased drought tolerance and shorter vegetation season, improved protection from pests and diseases, use of water saving irrigation technologies (e.g. on-farm drip-irrigation systems, etc.). All these measures will allow improving the capacity to increase yield and reducing the losses in bad years.

3.2 Adaptation planning

Adaptation planning first of all requires identification and assessment of potential hazards and risks. Such assessment should be based on the current climate, identifying current vulnerabilities and knowledge or other gaps. Key steps for identification and assessment of risks are briefly summarized in the below list:

- **Establish scope and objectives:** Formulate the issue and the scope of assessment; define the objectives of the exercise and the broad context for the decision; identify climate scenarios; and define the geographic areas and key stakeholders (including sectors and communities) to whom the assessment is targeted;

- **Identify the hazards:** Start with a screening exercise to identify the main hazards, including what could happen given climate scenarios and their causes;
- **Analyze hazards:** Consider each major hazard identified in the previous step and existing safeguards or controls, including policy and management responses. Assess the consequences to the community or sector based on existing data, and make a judgment about the likelihood of those consequences having place. Determine the level of risk
- **Assess risks:** Rank the risks, screening out minor risks and prioritizing major risks for further analysis. Describe uncertainties associated with each of the risk factors;
- **Analyze options to manage risk (including their costs and benefits):** assess various options hat could be applies to manage the risks identifies, prevent them or mitigate their consequences;
- **Develop adaptation measures:** Develop a list of prioritized actions/measures including a review of costs and associated benefits, to adapt to identified vulnerabilities and risks. Ensure that adaptation planning addresses consequences of changing climate, as well as increased variability and extremes;
- **Implement adaptation measures:** Determine what institutional capacity exists and what is needed to support implementation at local level, assess financing needs and resources available, clarify what information is available, whether the information gaps exist and how to address them, etc;
- **Periodic review of adaptation measures:** Establish monitoring and evaluation process to periodically reassess the risks and priorities once additional information becomes available or if relevant event occurs.

Approach applied for adaptation planning should be flexible and applicable at a local community level. The leader of community and its key members should be able to obtain the needed guidance, informational inputs and support both at marz and national levels. Also, the actions should be taken by the community shall not be costly, so as the community can still deal with those within their budget, otherwise there should be an opportunity provided to get additional resources from higher levels. Another important factor is stakeholder engagement, which is critical for multiple reasons: stakeholders such as local farmers, water engineers (representatives of water user's associations), utility managers, or public health staff possess greater knowledge of stress points and vulnerability that may be difficult to access otherwise. They are also critical for making assessments and recommendations on the ground. In addition, stakeholder involvement in the planning process increases the chance that they will support the development and implementation of an adaptation plan. The main approaches to effective engagement of stakeholders are listed below:

- Key stakeholders include administration of local communities, organizations dealing with local utilities (such as roads, irrigation systems, water supply and wastewater facilities etc.), local agricultural processing units, etc;
- Engagement of key stakeholders on a community level is vital for:
    - understanding how climate change may impact their own communities;

- identifying practical adaptation strategies;
- gaining understanding and support for implementing those strategies;

- Engagement of stakeholders often begins with an event designed to raise awareness in climate impacts and adaptation. Among the actions applied to ensure efficiency of this process a plan for engagement of stakeholders can be necessary;

- Understanding the general goals and concerns of stakeholders is important for understanding the way in which climate change could affect these areas, and therefore developing a better approach to address impacts and suggest appropriate adaptation strategies;

- Regular communications and meetings are required for sustained stakeholder engagement. This can be time consuming and costly process; therefore, adequate staff time and funding are essential for successful and sustainable stakeholder involvement.

Further, the adaptation planning needs to be mainstreamed into the daily operations of decision-makers, as this will ensure that climate stress is integrated in considerations of the multitude of other stresses that human and natural systems must cope with. It also helps to avoid taking unrealistic, inefficient, and potentially ineffective actions. Main steps of the adaptation planning process are presented in the below list:

- **Take the loss:** Simply do nothing, if there is no capacity to respond, or the cost of adaptation is too high;

- **Share the loss:** involve additional financial resources (from marz, state budget or insurance, if any) for reconstruction and rehabilitation activities;

- **Manage the threat:** undertake the treat control measures, such as establishment of new cropping patters, application of water saving technologies, shift to new drought-tolerant agricultural crops, improvement of forecasting systems to give advance warning of hazards and impacts, development of contingency and disaster plans;

- **Take measures to prevent effects:** Structural and technological changes needing more investment cover increase in availability of irrigation water through increased reservoir capacity, water diversion, increase of water use efficiency, upgrade of water systems. Regulatory, and institutional changes cover change in traditional land use practices, provision of training and guidance to farmers, review of design standards, etc.

- **Land use change:** Change land use pattern in the areas that become unsuitable for agricultural production, e.g. substitute existing cropping patter with more drought tolerant crops, turn the land used for arable crops to the pastures, etc.

- **Research:** Research new technologies and methods of adaptation, improve availability of information on frequency and magnitude of extreme events, develop better regional indicators for climate change.

- **Education and awareness:** increase public awareness to encourage people to take individual action and to accept change to public policies (e.g. landscape protection, biodiversity conservation).

3.3 Adaptation measures

Adaptation is essential to protect and enhance rural livelihoods in the project areas. Meantime, the adaptation is also critical to supply food markets, as yields can decline from the damaging physical impacts of climate change. Farms play a crucial role in rural poverty reduction, employment, economic growth, and food security. Different types of farms have varying advantages and disadvantages in adapting to the challenges posed by climate change. Broadly, the ability to adapt to a changing climate depends on the elements of a functioning agricultural system:

- timely climate information and weather forecasts, and skills required for their interpretation;
- locally relevant agricultural research in techniques and crop varieties;
- training in new technologies and knowledge-based farming practices;
- availability of agricultural services, including seeds and machinery, and affordable finance for provision of such services;
- infrastructure for water storage and irrigation;
- physical infrastructure and logistical support for storing, transporting, and distributing farm outputs; and
- strong linkages with local and marz markets for agricultural goods, as well with processing units.

In the project areas the largest type of farms is the small family farm, which produces for the commercial market but at a small scale. These farms make up the bulk of agricultural income and output in the project areas. These farms may be highly vulnerable to climate change given their size, the farmers' limited technical knowledge, and poor access to public and private information and financial services. Small farmers in particular will face climate change as yet one more stress compounding many others, including fragmented holdings, marginal land, poor environmental management, increasing demand for standardized and safety-controlled products, aging of the farmers and outmigration of the young generation, high cost for fertilizers and agricultural services.

Adaptation is also crucial from biodiversity conservation perspective to address changes expected under certain climate change scenarios. Looking from the perspective of biodiversity preservation, reduction of great stresses of habitat destruction and fragmentation, the following adaptation option can be suggested:

- **Protected areas**
  - Identify ecosystems, species, and processes particularly sensitive to climate change;
  - Design areas to protect species, habitat, and ecosystems;
  - Evaluate and improve management and monitoring capabilities.
- **Conservation networks**
  - Create a network of protected areas endowed with buffer zones and connected through corridors that allow species to move along different altitudes and latitudes;
  - Use landscape management to allow movement through mostly anthropogenic landscapes.
- **Participation in management**
  - Involve local people in the management of protected areas;
  - Improve locals' livelihoods by decreasing their dependence on natural resources and provide incentives for people to value and sustain ecosystem services.
- **Supporting policies**

- Develop policies and plans for specific geographical areas, sectors, and agencies, including legal provision and economic instruments.
- **Monitoring**
  - Key element of any adaptive management;
  - A long-term observation network can be established to detect effects of climate change.
- **Minimize non-climate change related stresses**
  - Minimize pollution and minimize pressures from land-use changes, development, and tourism.

3.4 Prerequisites for successful adaptation

Adaptation to challenges of climate change demands technologies to monitor and measure conditions in the productive environment, institutions to facilitate change, and policies that encourage the reforms. In this respect, a number of sustainable, appropriately chosen adaptation initiatives would yield measurable benefits regardless of climate factors. Policies and technologies for more efficient distribution and on farm use of water have economic and adaptation outcomes, as they enable farmers to cope with reduced water availability and drought events.

Meantime, it should be well understood, that adaptation is a national effort not limited to individual farmers or communities. For example, increased water-use efficiency will not be implemented without adoption of irrigation technologies and management strategies. But institutional components are equally important: water-user associations might aid in knowledge sharing, and advisory services can equip farmers with waste-reducing techniques. At the policy level, government or respective state agency can invest in advisory services and awareness campaigns, while setting water prices to give users incentives to reduce waste and thereby lower state spending on subsidies.

Three main prerequisites to ensure successful adaptation and minimal losses from climate change, irrespective of climate change scenarios and risks, are presented below:

a. Institutional change: Support provided by key institutions offers communities at local level win-win opportunities for reducing vulnerability to climate risk and promoting development. Key institutions include: Hydro-meteorological Agency, Water Users Associations, respective units of regional governments, organizations providing agricultural support and research services, farmer associations, agro-processing facilities, financial institutions, NGOs and civil society. Key institutional approaches critical for efficient adaptation are summarizes in the below table 32:

Institution	Support in adaptation
Hydro-meteorological Agency	Provision of essential information for planning, understanding changing climate, providing farmers with long-term, seasonal, and daily weather forecasting for knowledge-based response farming; advance warning on extreme natural events
Water Users Associations	Maintain, rehabilitate, expand, and replace old and new irrigation facilities, which will be more important for water-stressed areas. Intermediary between managers of water resources/systems and farm users.
Agricultural Advisory Services	i. Interpret Hydromet output for practical advice to

including i. Agronomic Information ii. Financial Advice iii. Market Information	farmers; convey information on trends of climate change and risk; recommend and train in new and off-the shelf technologies and in new locally-adapted crops and varieties; demonstrate new farming practices; ii. Provide information on sources of finance for adaptive investments; iii. Provide information on market prices and channels. Key to ensure that services reach small family farms.
Agricultural Research Institutes	Bring knowledge of locally- relevant needs to research networks from local to international level, develop varieties and technologies suitable for changing climate and local communities.
Agricultural education through training sessions and distribution of publications	Important conduit for information about implications of climate change for farmers and community leaders, including adaptation measures and technologies and guidance on how and when to implement them. Key in move towards more knowledge-based rather than input-based farming.
Farmer Unions and Organizations	Share information about outcomes and challenges of adaptation, serve as locus for absorbing new information from and communicating farmer concerns to government bodies and private enterprises, allow shared investment in new machinery by small farmers.
NGOs and civil society	Provide information, funding, and institutional support at small scale for pilot adaptation efforts by farmers, offer microcredit to enable adoption, share knowledge of local experiences, advocate farmers' concerns.
Financial Services (banks, credit organizations, etc.)	Provide necessary finance for implementation of adaptations; reach out to small farmers with limited access to formal banks; mitigate risks of crop failure from unpredictable weather, unproven adaptations, market uncertainties.

b. Policy change: Non-distorting pricing for water and commodities, financial incentives to adopt technological innovations, access to modern inputs, reformed farm subsidies, risk insurance, tax incentives for private investments, strengthening of social safety, etc. Key policies that can be considered for adaptation are summarized in the table 33 below:

Policy actions	Importance for climate change adaptation
Non-distortionary water pricing	Reduce subsidies to increase incentives for better management of water resources, allocation of water, and efficiency of its use. Difficult because removing subsidies often meets political resistance.
Financial incentives for adoption of technological upgrades	Provide tax incentives for adoption of new technologies, e.g. farmers' purchase of machinery required for conservation tillage, planting of drought-resistant seedlings.
Access to modern approaches	Remove restrictions on imports of modern seeds and seedlings to allow farmers access to modern varieties (e.g., with increased drought resistance or longer maturation). Of course such seeds/plants should be approved by respective state entity (e.g. use of GMO seeds/plants shall not be allowed)

Policy actions	Importance for climate change adaptation
Risk insurance	Explore opportunities for developing system of weather insurance in case of harvest loss due to extreme weather events, etc.
Social safety strengthening	Provide targeted income support for poor and vulnerable segments of the population that may have difficulty affording food, who may live in areas where agriculture becomes unviable, may not be able to easily change livelihoods (elderly, sick).

c. Technology and management change: Conservation tillage for maintaining moisture levels, use of organic matter to protect field surfaces and help preserve moisture, diversification of crops to reduce vulnerability; adoption of drought-, flood-, heat-, and pest-resistant crops, modern planting and crop-rotation practices, integrated pest management, in conjunction with similarly knowledge-based weed control strategies; capacity for knowledge based farming, etc. Technological adaptation practices and investments for various climate, weather and agricultural phenomena are presented in the table 34 below:

Technological adaptation measures	**Climate / weather / agricultural phenomena** **A.** Drought; **B.** Need for soil moisture conservation (rain-fed); **C.** Need for water use efficiency (irrigated); **D.** Land degradation, soil infertility, erosion; **E.** Heat stress; **F**. Pest and disease control; **G.** Excess rain, flooding, storms
Land use	A,B,C,D,E,F,G
Farming systems (crops, livestock, trees)	A,B,C,D,E,F,G
Conservation tillage	A,B,C,D
Nutrient management, use of organic matter	A,B,D
Water use	A,B,C,D,E,F,G
Water harvesting techniques, storage, reduction of runoff	A,B,C,D,E
Drainage systems	D,F,G
Rehabilitation and modernization of irrigation infrastructure, canals	A,C, E,G
Develop new irrigation facilities	A,E
Cropping pattern and crop diversification	A,B,C,D,E,F,G
Use water-efficient crop varieties	A,C,D
Heat- and drought-resistant crops/varieties/hybrids	A,B,C,E
Switch to crops, varieties appropriate to temp, precipitation	A,C,D,E,F,G
Crop rotation (sequencing)	A,B,F
Timing of operations (planting, inputs, irrigation, harvest)	A,B,C,E,F,G
Response farming (using seasonal forecasts)	A,C,D,E,F
Integrated Pest Management	A,F

5. REFERENCES

Literature consulted:

- Activities of ArmStateHydromet in the Sphere of Climate Change, Yerevan, 2009
- Adapting to Climate Change in Europe and Central Asia, World Bank, Yerevan, Armenia, 2009
- Agricultural Sustainable Development Strategy of the Republic of Armenia (revised version), Ministry of Agriculture, 2006
- Agro-climatic resources of Armenia, RA Ministry of Emergency Situations, State Agency of Hydro-meteorology and Monitoring, Yerevan, 2011
- Atlas of the Republic of Armenia by the regions and Yerevan city, Map of the climate in the RA territory, Yerevan, Armenia, 2011
- Avagyan A., Review of national research, data and projects on climate change: Dimensions, impacts and mitigation and adaptation policies in Armenia, 2009
- Climate Change Newsletter - Armenia Number 3, 2009
- Climatic Directory, Volume I: Temperature of Air and Soil; ArmStateHydromet SNCO, Ministry of Emergency Situations, 2011
- Climate proofing study in Ararat marz of the Republic of Armenia, Climate Change Impact Assessment, UNDP, Yerevan, Armenia 2008
- First National Communication of the Republic of Armenia under the UNFCCC, Ministry of Nature Protection of the Republic of Armenia, UNDP/GEF Armenia, 1998
- Integration of Climate Change Risk Management into the UNDP's development assistance in Armenia, Technical Report Based on findings during the mission, Yerevan, Armenia, 2007
- Investigation of Regional Impact of Climate Change on South Caucasus Region, Tbilisi, 2011
- Main directions for agriculture section vulnerability reduction in conditions of global climate change, compiled by R. Nazaryan, T. Chitchyan, Yerevan, Armenia, 2008
- Marzes of the Republic of Armenia and Yerevan city in figures, Yerevan, Armenia, 2010
- McGuire, Patrick E. Elements of a National Strategy for Management and Use of Plant Genetic Resources in Armenia. Sustainable Agriculture in Central Asia and the Caucasus No. 3. ICARDA-CAC/FAO, 2009
- McSweeney, C., M. New, and G. Lizcano, Armenia, UNDP Climate Change Country Profiles, 2008
- Melkonyan H., Zoryan Z., Hayrapetyan K., et al. Estimation of Global Climate Change in the Republic of Armenia and Assessment of Vulnerability of Ecosystems. 2nd European Conference on Applied Climatology, Vienna, Austria, 1998
- Proceedings of VII Annual International Conference of REC Caucasus "Climate Change Adaptation – Challenge and Opportunity for the Caucasus", Tbilisi, Georgia, 10-11 November 2011
- Second National Communication on Climate Change, Ministry of Nature Protection of RA Yerevan (2010). "Lusabats" Publishing House. 132 p.
- Sustainable Development Program, Yerevan, Armenia, 2008

- The Second National Environmental Action Program of the Republic of Armenia, Yerevan, Republic of Armenia, 2008.
- The Socio-Economic Impact of Climate Change in the Republic of Armenia, publication supported by UNDP and developed by Stockholm Environmental Institute (USA), 2009
- Vulnerability of water resources in the Republic of Armenia under climate change, Yerevan, Armenia, 2009

Websites consulted:

http://www.armstat.am - National Statistical Service of the Republic of Armenia

http://www.minagro.am - RA Ministry of Agriculture

http://www.mnp.am - RA Ministry of Nature Protection

http://www.mta.gov.am - RA Ministry of Territorial Administration

http://vdzor.gov.am/ - RA Vayots Dzor Marzpetaran

http://ararat.gov.am/ - RA Ararat Marzpetaran

http://www.nature-ic.am - Climate Change Information Center of Armenia