COUNTRY REPORT
CLIMATE RISK MANAGEMENT IN ARMENIA

DECEMBER 2013

United Nations Development Programme

CRISIS PREVENTION & RECOVERY

Supported by **United Nations Development Programme (UNDP)**
Bureau for Crisis Prevention & Recovery (BCPR)
Under the **Climate Risk Management - Technical Assistance Support Project (CRM-TASP)**

This report was commissioned by the United Nations Development Programme's Bureau for Crisis Prevention and Recovery (BCPR) under the Climate Risk Management – Technical Assistance Support Project (CRM-TASP)

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Cite as: United Nations Development Programme (UNDP), Bureau for Crisis Prevention and Recovery (BCPR), 2013, *Climate Risk Management in Armenia,* New York, NY: UNDP BCPR

Published by:
United Nations Development Programme (UNDP), Bureau for Crisis Prevention and Recovery (BCPR), One UN Plaza, New York-10017

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FOREWORD

Climate change has the potential to exacerbate conflict, cause humanitarian crises, displace people and destroy livelihoods. Without concerted action, it could undermine development and the fight against poverty for millions of people across the globe.

For example, it is estimated that over 20 million people in the Mekong Delta, Viet Nam, and 20 million in Bangladesh could be forced to move as their homes are affected by saltwater incursion from rising sea levels. Entire populations of some low lying island states, such as Nauru or the Maldives may have to relocate. In countries like Honduras, where more than half the population relies on agriculture, climate induced risks, such as hurricane Mitch in 1998 which caused over two billion US dollars in agricultural losses, will continue to pose exceptional potential for damage. Similarly, climate risk assessments in Nicaragua show that changes in rainfall patterns, floods and drought could put human health at risk by increasing the prevalence of respiratory and water borne diseases and malnutrition.

Long-term incremental changes will mean that people everywhere must learn to adapt to new weather or rainfall patterns, or to shifts in the ecosystems upon which humans depend for food. Perhaps more worrying, however, is that climate variability and change will also bring unpredictable weather patterns that will result in more extreme weather events. Heat waves, droughts, floods, and violent storms could be more common in the decades to come. Climate change is "loading the dice" and making extreme weather events more likely. These disasters will undermine the sustainability of development and render some practices, such as certain types of agriculture, unsustainable; some places uninhabitable; and some livelihoods unliveable.

As climate change creates new risks, better analysis is needed to understand and address the new level of uncertainty. In order to plan for disasters, we need to understand how climate change will impact on economies, livelihoods and development. We need to understand how changes in temperature and precipitation, as well as the frequency and magnitude of future extreme weather will affect all sectors, including agriculture, water-use, human and animal health and the biodiversity of wetlands.

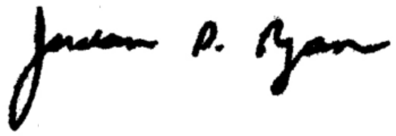
This report is a product of the *Climate Risk Management – Technical Assistance Support Project*, which is supported by UNDP's Bureau for Crisis Prevention and Recovery, and Bureau for Development Policy. This is one in a series of reports that examines high-risk countries and focuses on a specific socio-economic sector in each country. The series illustrates how people in different communities and across a range of socio-economic sectors may have to make adaptations to the way they generate income and cultivate livelihoods in the face of a changing climate. These reports present an evidence base for understanding how climatic risks are likely to unfold. They will help governments, development agencies and communities to identify underlying risks, including inappropriately designed policies and plans, as well as crucial capacity gaps.

This series is part of a growing body of climate change adaptation resources being developed by UNDP. The Climate Risk Management – Technical Assistance Support Project has formulated a range of climate risk management assessments and strategies that bring together disaster risk reduction and climate change adaptation practices. The project is designing a common framework to assist countries in developing the necessary capacity to manage climate-induced risks and to respond to emerging threats. The climate risk assessments discussed in this report and others in the series will feed into a set of country-level projects and regional initiatives that will inform the practice of climate risk management for decades to come.

Addressing climate change is one of UNDP's strategic priorities. There is strong demand for more information. People at all levels, from small communities to government departments, want to understand the potential impact of climate change and learn how they can develop strategies to reduce their own vulnerability. UNDP is addressing this demand and enabling communities and nations to devise evidence-based risk management solutions. UNDP recognises that climate change is a crucial challenge to sustainable development and the goal of building resilient nations.

As the full effect of climate change becomes apparent, it is assessments such as these that will become the lynchpin of national responses and adaptation strategies for many years to come. Like the threat from many disasters, there is still time to prepare for the worst impacts of climate change in developing countries if we expand our understanding now.

This knowledge must be combined with real preparedness and action at all levels. Only then will we be able to stave off the worst impacts of climate change in the most vulnerable and high-risk countries of our world.



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ACKNOWLEDGEMENTS

The Report *Climate Risk Management in Armenia* was commissioned under the Climate Risk Management – Technical Assistance Support Project (CRM-TASP), a joint initiative by the Bureau for Crisis Prevention and Recovery (BCPR) and the Bureau for Development Policy (BDP) in UNDP, and implemented by the Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) through a contract administered by Asian Disaster Preparedness Center.

The Project, its methodology and its analytical framework was conceptualized by Maxx Dilley, Disaster Partnerships Advisor, and Alain Lambert, Senior Policy Advisor, Disaster Risk Reduction and Recovery Team (DRRT), BCPR with key inputs from Kamal Kishore, Senior Programme Advisor, DRRT, BCPR and Bo Lim, Special CC Advisor, Environment and Energy Group (EEG), BDP.

Within BCPR, the Project implementation process has been supervised by Alain Lambert and Rajeev Issar who provided regular inputs to ensure the quality of the climate risk assessments and the identification of tangible risk reduction and adaptation options. From BDP, Mihoko Kumamoto and Jennifer Baumwoll provided their inputs and comments to refine the assessment and recommendations.

The CRM-TASP and climate risk assessment has benefitted immensely from the strategic guidance provided by Jo Scheuer, Global Coordinator, DRRT, BCPR and by Veerle Vandeweerd, Director, EEG, BDP.

The Project team would like to acknowledge and give special thanks to the main authors of the Report from RIMES, as well as Hamlet Melkonyan and Anahit Hovsepyan from Armenia State Hydrometeorological and Monitoring Service (ASHMMS).

For their valuable contribution to the project implementation and climate risk assessment process, the Project team and lead authors would like to acknowledge gratefully the unstinted support provided by colleagues from the UNDP Country Office in Armenia and officers from the national nodal department/agency, as well as national and regional stakeholders who participated in the process.

The climate risk assessments under the CRM-TASP have been undertaken with the financial support of the Government of Sweden.

LIST OF ABBREVIATIONS AND ACRONYMS

ADPC	Asian Disaster Preparedness Center
AMD	Armenian Dram
ARS	Armenian Rescue Service
ASHMMS	Armenian State Hydrometeorological and Monitoring Service (a State Non Commercial Organisation under the Ministry of Emergency Situations)
BCPR	Bureau for Crisis Prevention and Recovery
BDP	Bureau for Development Policy
BDP/EEG	Bureau for Development Policy's Energy and Environment Group
CCA	Climate Change Adaptation
CDM	Clean Development Mechanism
CO	Country Office
CRM	Climate Risk Management
CRM-TASP	Climate Risk Management Technical Assistance Support Project
DRR	Disaster Risk Reduction
DRRT	Disaster Risk Reduction and Recovery Team
ECMWF	European Centre for Medium-Range Weather Forecasts
EIMC	Environmental Impact Monitoring Centre
FAO	Food and Agriculture Organization
GCM	Global Climate Model
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
IRI	International Research Institute for Climate and Society (part of the Earth Institute, Columbia University)
IITM	Indian Institute of Tropical Meteorology
LRF	Long Range Forecasting
MAGICC/SCENGEN	Model for the Assessment of Greenhouse-gas Induced Climate Change/Regional Climate SCENario GENerator
MES	Ministry of Emergency Situations of the Republic of Armenia
MNP	Ministry of Nature Protection of the Republic of Armenia
MoA	Ministry of Agriculture of the Republic of Armenia
NCTS	National Center for Technical Security (under the Ministry of Emergency Situations)
NHMS	National Hydrometerological Services
NSS	National Statistical Service
NSSP	National Survey for Seismic Protection (under the Ministry of Emergency Situations)
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PRECIS	Regional Climate Model Developed by the Hadley Centre
RA	Republic of Armenia
RCM	Regional Climate Model
RIMES	Regional Integrated Multi-hazard Early Warning System for Africa and Asia
SCWM	State Committee of Water Management
SDP	Sustainable Development Programme
SEI	State Environmental Inspectorate
SNC	Second National Communication to UNFCCC of the Republic of Armenia
SRES	Special Report on Emissions Scenarios by IPCC
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization
WRI	World Resources Institute
WRMA	Water Resources Management Agency

EXECUTIVE SUMMARY

Armenia is a landlocked country in the South Caucasus with a population of 3.2 million. Armenia's GDP as of 2011 is in excess of US$ 11 billion. Its economy is based on agriculture (22 percent), services (39 percent) and industry, including construction (39 percent). As of 2010, 35 percent of the population lives below the poverty line and in rural areas the incidence of poverty is between 40 and 50 percent (NSS, 2011).

Armenia's industrial and construction sectors are connected to the global economy primarily through commodity exports and remittances. As such, external shocks have an amplified impact. For example, following several years of double-digit growth, the 2008/2009 global economic crisis precipitated a recession that reduced Armenia's GDP by 14 percent in 2009 alone.

Despite its per capita income of US$3,100, the Armenian economy is different from other lower middle income countries as the service sector's share is relatively modest, while the agriculture and agro-processing sectors constitute more than 30 percent of GDP. Of note, the agriculture sector alone commands 22 percent of GDP, yet it supports 47 percent of the population. The contribution of agriculture to the national economy and to the livelihoods of a large proportion of the population is significant due to the risks posed to the sector by climate variability.

In addition, although 67 percent of the population lives in urban areas, most of the urban population is engaged in the agriculture sector. Agriculture in Armenia is a source of employment, rural income, domestic food supply and raw materials for food processing industries. The share of food processing in the manufacturing sector is at 40 percent.

The agriculture sector in Armenia is predominantly composed of 340,000 small, mainly subsistent farms. The average land holding is about 1.4 hectares. Of the total 240,000 hectares of arable land, around 64 percent is under some form of irrigation. The irrigation system suffers from poor maintenance, conveyance losses and high pumping costs. Climate-driven shocks, including drought, hail storms, flash floods, floods, landslides and frost, seriously impact the agriculture sector with varying intensity. Between 2000 and 2010, Armenia experienced seven droughts. Major droughts in 2000, 2006 and 2010 combined with other hazardous events such as hail storms, early frosts and spring floods. These events caused a reduction in grain production by 50 percent, potato production by 35 percent and vegetable production by 65 percent. In turn, this led to a ten percent reduction in rural employment opportunities.

As almost 98 percent of agricultural activities, including the entire agro-processing sector, are undertaken by private sector entities through small-scale cultivation activities. The Government's role is limited to providing concessional loans and to distributing seeds. The climate risk is thus carried by small farmers.

The budgetary allocation for the agriculture and water resource sector stands at two percent for 2012. Most of the allocation covers the sector's operations, with little capital being invested in the development of the sector.

The 2009 economic crisis in combination with the 2010 drought highlighted the vulnerability of farmers to climate-based shocks. These events also contributed to the observed increase in poverty, from 28 percent to 35 percent, between 2008 and 2010.

The economic and climatic crisis had serious cascading effects on agricultural exports, which reduced to a level of seven percent, as well as precipitated increased imports by 17 percent and led to double-digit inflation rates. The inflation in turn affected urban households by reducing their purchasing power.

In response, the Government of Armenia developed a Strategy for Sustainable Agriculture and Rural Development 2010-2020. Analysis of this strategy reveals that no institutional mechanisms have been established, nor financial resources allocated, to integrate climate risk management instruments despite the existence of compelling evidence.

CRM-TASP analysis reveals that between 1998 and 2010 climate events caused a loss of US$ 2.8 billion with an annual average loss of around US$ 450 million. CRM-TASP analysis also reveals that there are options available to reduce climate risks substantially. The climate risk reduction options are not being implemented in Armenia due to lack of policy leadership, institutional mechanisms and other related capacities.

CRM-TASP recommends a proper evaluation of climate risks in order to direct climate risk mitigation policy and thus provide the economic rationale for adequate public investment. This will, in turn, significantly reduce climate risk related losses and enable the achievement of the development goals, such as a reduction in poverty, envisioned in the Strategy for Sustainable Agricultural and Rural Development 2010 to 2020.

1. INTRODUCTION

The climate risk management framework has been created to assist countries in developing the capacity to manage the risks associated with climate variability and change. It has been developed by the United Nations Development Programme (UNDP), through its Bureau for Crisis Prevention and Recovery (BCPR), which is responsible for assisting countries to develop the capacity to better manage disaster risks, and the Bureau for Development Policy's Energy and Environment Group (BDP/EEG), which is responsible for assisting countries to develop the capacity to adapt to climate change.

The Climate Risk Management Technical Assistance Support Project (CRM-TASP) facilitates the operation of a CRM framework by integrating Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) approaches. The Regional Integrated Multi-hazard Early Warning System for Africa and Asia (RIMES) with the Asian Disaster Preparedness Center (ADPC) have been tasked with implementing the CRM-TASP framework in assessing risk management priorities and incorporating capacity development needs into development planning.

1.1 Approach and methods

The CRM-TASP was initiated through an inception meeting organized for the UNDP focal points from the participating countries in Bangkok, Thailand in October 2008. In Armenia the project has been implemented in close cooperation with the Armenian State Hydrometeorological and Monitoring Service of the Ministry of Emergency Situations of the Republic of Armenia (ASHMMS) (see table 1.1).

The key stages in the project's implementation are stated briefly below.

During the last quarter of 2008 and first quarter of 2009 a consultancy was undertaken to prepare baseline information and preliminary analysis for the Armenia CRM-TASP report. A regional workshop concerning extreme weather events was organized by the Project, for stakeholders, in March 2009 at the Indian Institute of Tropical Meteorology (IITM) in Pune, India, in order to conduct analysis for the report. In addition, a mission, facilitated by ASHMMS, was undertaken in May 2009 by a team from ADPC and RIMES to consult national stakeholders and to gather additional information, following which the CRM-TASP report was further revised.

In February 2010, a consultation meeting was organized at UNDP to present the findings of the Armenia CRM-TASP draft report, and several comments for its improvement were received. Facilitated by ASHMMS, the team from ADPC and RIMES also took the opportunity to meet with several national agencies which use weather and climate information and also with the Armavir Marz administration in order to identify opportunities for improving the climate risk information system. The CRM-TASP report has been revised and updated subsequently, including information from the Second National Communication under the UNFCCC.

The final meeting was organized by UNDP in January 2011 involving major stakeholders, such as representatives of climate sensitive sectors. It was focused on the identification of climate risk management priorities for the key sectors and the development of proposals for addressing the identified needs.

Table 1.1: Project steps

Project Step & Purpose		Specific steps taken in Armenia
1. Initiation	Introduce CRM-TASP	• Country engagement facilitated by the UNDP country office (CO) in Armenia
2. Collaborative Analysis	Prepare baseline information and preliminary analysis	• Baseline information and preliminary analysis undertaken in collaboration with a local consultant • Training workshop on the analysis of extreme events organized in March 2009, at Indian Institute of Tropical Meteorology (IITM) in Pune, India in which ASHMMS specialists participated
3. Consultation with key agencies	Validation of research findings	• Mission undertaken in May 2009 by a team of RIMES professionals to consult national stakeholders and to gather additional information facilitated by ASHMMS, following which the CRM TASP report was revised further
4. Consultation Workshops	To share draft report and findings	• Consultation meeting organized at UNDP in February 2010 to present and discuss the findings of the Armenia CRM-TASP draft report • Team of RIMES professionals conducted additional stakeholder engagement to identify opportunities for improvements of the climate risk information system, including meetings with several weather and climate information national user agencies and stakeholders in Armavir Marz facilitated by ASHMMS • CRM-TASP report revised based on the Second National Communication under the UNFCCC and discussed at the CRM-TASP Final Workshop held in Yerevan, in February 2011
5. Documenta–tion & Report writing	Documentation and finalisation of CRM TASP report	• Final draft submitted in March 2012 • UNDP provided guidelines for revision of the draft, and the report was updated accordingly

1.2 Report structure

The report contains six chapters. Chapter 1 captures the steps and methods adopted (p. 11). In Chapter 2 the overall development context and trends in Armenia, as well as the rationale for the prioritization of climate sensitive issues, are described (pp. 13-18). Chapter 3 focuses on the geo-physical environment and the climate risk features of Armenia's past, present and future (pp. 19-26). An assessment of the climate-based threats to development in the context of past climate risks and a climate change projection is covered in Chapter 4 (pp. 27-36). Current Climate Risk Management processes, policies and institutional systems to address the threats identified in earlier chapters are discussed in Chapter 5 (pp. 37-47), while Chapter 6 (pp. 48-54) focuses on ownership of CRM within the Government, an assessment of capacity needs, and recommendations for future actions.

2. DEVELOPMENT PROFILE

This chapter analyses the development profile of Armenia including its key development conditions, the trends observed during recent decades, and the vision and strategies outlined in the national planning documents. The most critical sectors concerning climate sensitivity are also identified.

2.1 Current development conditions, trends and challenges

Armenia is a landlocked country in the South Caucasus. It is located between latitude 38 ^{o}51´ to 41^{o}18´ North and longitude 43^{o}29´ to 46^{o}37´ East. It has an area of 29,743 km^2; the length from the north-west border to the south-east border is 360 km and the maximum width from west to east is 200 km. It is bordered by the Republic of Georgia to the north, to the east and south-west by the Republic of Azerbaijan, to the west by Turkey and to the south by the Islamic Republic of Iran. Over 11.4 percent of the territory is forested, and 70.6 percent of the territory is used for agriculture (NSS, 2011).

The territory is divided into ten regions, or “marz”: Aragatsotn, Ararat, Armavir, Gegharkunik, Lori, Kotayk, Shirak, Syunik, Tavush, Vayots Dzor and the capital city Yerevan (which is not included in the marzes). Armenia’s population is approximately 3.2 million. The largest city is Yerevan, in which over a third (1.12 million) of Armenia’s population lives.

Armenia is a mountainous country with an average elevation of 1,800 metres. The tallest point is at 4,090 metres (Mount Aragats) and the lowest is 375 meters above sea level (Debed river). River systems in Armenia are part of the larger South Caucasian rivers, such as the Kura river in the north and Araks river in the south. Within Armenia, the Akhuryan river, in the north, is its longest at 186 km, followed by Araks river, which is 158 km long and the Debed river at 154 km. Lake Sevan, in the centre of Armenia, is its largest and most important body of water occupying an area of 1270 square km, or over 4.3 percent of the territory.

2.2 National development vision, objectives and priorities

The key document guiding development in Armenia is the Sustainable Development Programme (SDP), 2008. The SDP articulates the Government of Armenia’s strategy until 2021 and includes objectives to improve the living conditions of the population as well as to eliminate extreme poverty by bringing it down to 1.2 percent by 2012. It also aims to promote balanced economic growth and introduce a targeted local development policy in order to ensure the accelerated development of weak regions. The SDP aims to reduce the poverty incidence from 26.0 percent of the population in 2006, to 14.0 percent by 2012; to 10.1 percent by 2015; and to 6.8 percent by 2021.

The SDP targets regarding economic growth foresees three-fold increase in GDP by the end of the strategy’s timeframe in 2021.

Poverty and human development

Armenia has a predominantly urban population of over 2.09 million, which comprises 64 percent of the total population. The majority of the urban population is based in the capital Yerevan. The marzes of Argatsotn, Tavush, Armavir, Ararat and Vayots Dzor are predominantly rural, while in Shirak, Lori, Kotayk and Syunik marzes an urban population is prevails. The density of population in Yerevan is 4942 persons per square kilometre, while marzes are much more sparsely populated.

In 2009 the 34.1 percent of Armenians are classified as poor and 3.6 percent as extremely poor. The proportion of urban and rural poverty incidence is almost equal; 33.7 percent in urban areas, 34.9 percent in rural areas. Extreme poverty is high in urban areas, at 4.6 percent, compared to rural extreme poverty, which stands at 1.7 percent (NSS, 2010).

Access to electricity is almost universal. Nearly 95 percent of households can access processed drinking water on their property. Access is slightly less in rural areas, at 88 percent, as ten percent of residents receive water deliveries. Close to 100 percent of the population is literate and over three percent of the annual budget is allocated consistently for education.

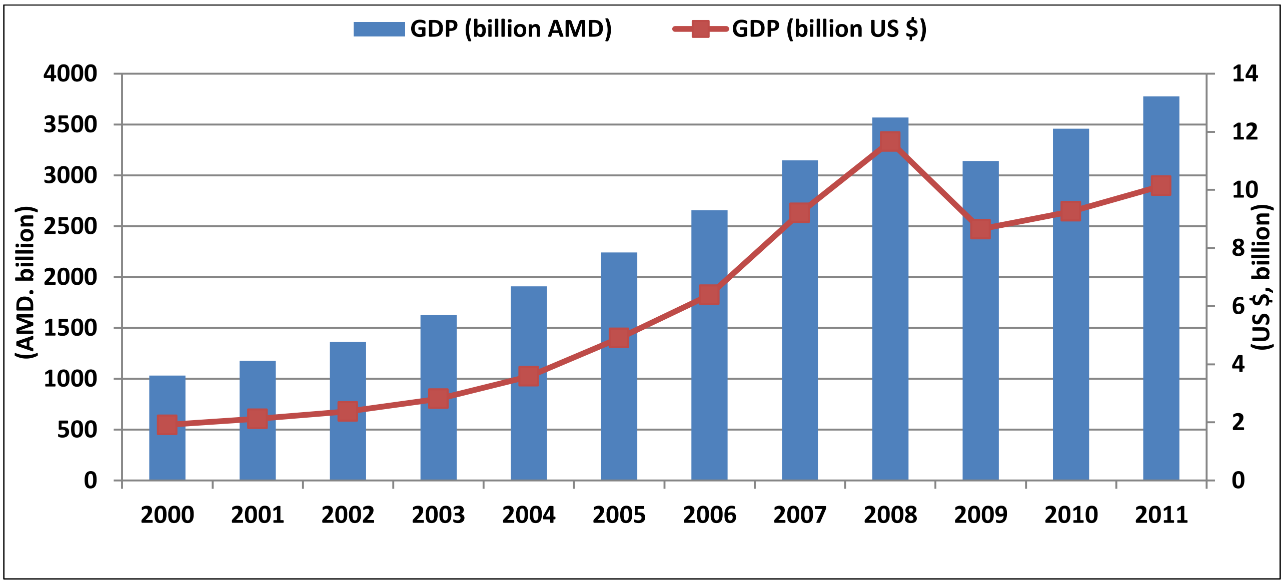
Economy

The Armenian economy has more than tripled in size since 2001. Between 2004 and 2008, the economy grew by an average of over 11 percent annually (see Table 2.1 and Figure 2.1). The global economic crisis, however, impacted Armenia severely due to its dependence of remittances particularly in the construction and services sectors.

Table 2.1: Gross Domestic Product and structure of GDP by sectors

	2000	2001	2004	2006	2008	2009	2010	2011
GDP (AMD, billion)	1031.3	1175.9	1907.9	2656.2	3568.2	3141.7	3460.2	3776.4
GDP (US$, billion)	1.9	2.1	3.6	6.4	11.7	8.6	9.3	10.1
GDP by economic activity (percent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture (percent) *	23.2	25.6	22.7	18.7	16.3	16.9	17.1	20.2
Industry (percent)	25.2	23.2	22.1	17.2	13.3	13.5	15.4	16.3
Construction (percent)	10.2	97.0	15.5	23.7	25.3	18.6	17.3	12.8
Services (percent)	32.3	31.8	31.3	31.9	33.7	40.4	39.0	39.8
Net taxes on products (percent)	9.1	9.7	8.4	8.5	11.4	10.6	11.2	10.9

** Includes hunting, forestry, fishing and fish farming* *Source: NSS RA, 2012*

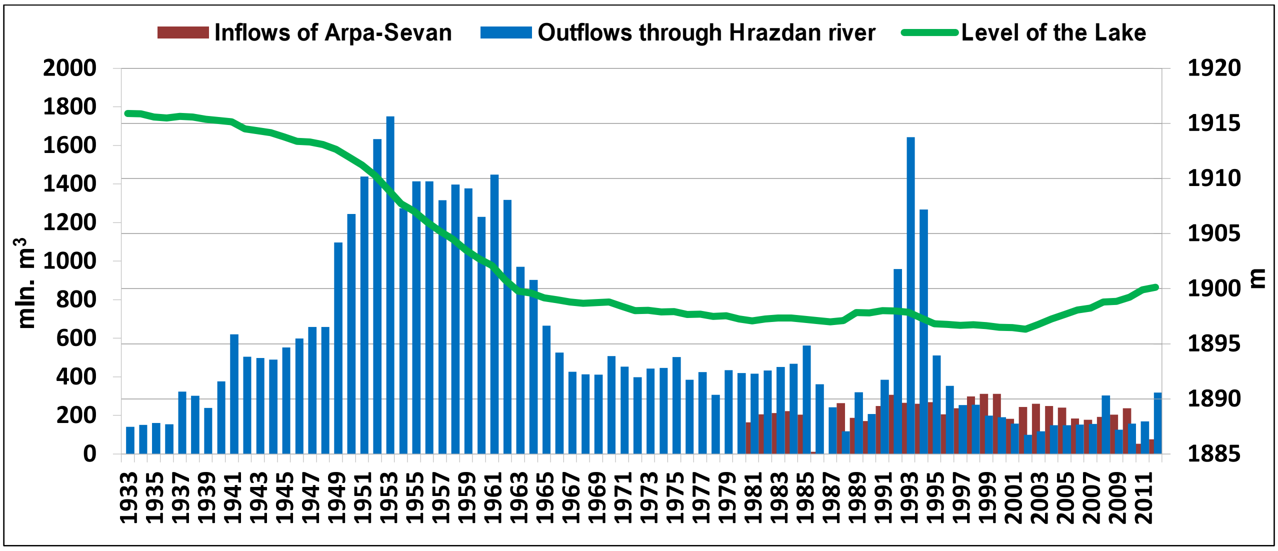


Source: NSS RA, 2012

Figure 2.1: Trends in Gross Domestic Product

Environment

Lake Sevan is the largest alpine lake in the Caucasus and its catchment area includes one-sixth of the country. It is considered as a key resource for Armenia's development, due to being a major water resource with economic and strategic implications. In the past, due to unsustainable extraction of water (see Figure 2.2), Lake Sevan's ecosystems and resources have been severely threatened.



Source: Rio+20 National Assessment Report. 2012

Figure 2.2: The dynamics of Lake Sevan's water level (m) and discharge 1933 to 2011

Initiatives by the Government coupled with favourable climate conditions in recent years have generated a reversal in the trend and a significant rise in inflows since 2001 (see Figure 2.2).

With regard to water resource management, priority issues are related to water supply and water removal services. In particular, the reduction of leakages in potable water supplies and irrigation systems; the introduction of water saving technologies; the improvement of water supply services; the restoration of wastewater treatment plants and the construction of new plants. (Rio+20 Report, 2012)

Forest fires are also a concern, due to the recent increase: from 5.6 hectares of forest land in 2002 to 810.6 hectares in 2010. They are perceived to be due to an increase in temperatures, as well as the practice of burning meadows and pastures in autumn. (Rio+20 Report, 2012)

Another area of concern relates to agricultural land use practices, which have resulted in diminished productivity and erosion, as well as the salination and alkalization of soils. Overexploitation and unbalanced use of pastures and hayfields have resulted in a depletion of animal feedstock and threaten biodiversity, thus causing further land degradation. (SDP, 2008)

Agriculture

Agriculture is one of the main sectors of the Armenian economy. Its economic contribution has decreased from a high of almost 35 percent in 1996 to a low of 18.6 percent in 2006. In 2011 agriculture contributed over 20 percent to GDP. The sector is the largest employer, and its contribution to the labour market has gradually increased: in 1996 it provided 40 percent of jobs, in 2004, 47 percent, and since then has stabilized at over 44 percent.

The total area of agricultural land stands at 1,391,377 hectares, 494,689 hectares of which are arable, 63,766 hectares are perennial plantation, 138,907 hectares are grassland and 694,015 hectares are pasture (FAO, 2001). A total of 154,600 hectares (or half of arable lands) are irrigated. However, 150,000 hectares of arable land are currently out of use.

Agriculture in Armenia is largely a private enterprise carried out by 340,000 farms, which contribute more than 97 percent to total production. The average land holding is 1.4 hectares, but the average arable farm size is smaller at 1.1 hectares. Most of the machinery is in poor condition, for example over 94 percent of tractors are at least ten years old and many require repair.

The area cultivated for crops is decreasing yearly, from 310 thousand hectares in 2006 to 284 thousand hectares in 2010. Over half of the cultivated areas are for food grains and legumes, and about 10 percent for vegetables, including potatoes.

The SDP targets a 1260 percent increase in the export of agricultural products by 2021 and encourages self-sufficiency by reducing the total imports over the same time frame to three percent from 7.5 percent in 2010 (see Table 2.2).

Table 2.2: Agriculture sector targets under SDP -indicators

Indicators	2010	2015	2021
Value Added, AMD billion, in current prices	697	982	1379
Percent of GDP	14.8	12.5	10.5
Average annual actual growth rates (percent)	5.74	3.44	2.64
Value added in agriculture, as a percent of GDP	68.1	64.3	60.1
Value added in non-agricultural sector, as a percent of GDP	31.9	35.7	39.9
Export and Import			
Export of agricultural products,(US$ million)	56.8	177.3	498.5
Percent of total exports	3.5	4.1	4.8
Import of agricultural products (US$ million)	386.1	506.1	542.5
Percent of total imports	7.5	5.2	3
Employment			
Employment in agriculture, as percent of total employment	80.3	78.5	76.6
Employment in non-agricultural sector, as percent of total employment	19.7	21.5	23.4

Source: RA, 2008

The SDP proposes intensive development to the agriculture sector via efficiency gains and exports. It notes that small farms will remain the basis of agricultural production, and that better access to markets and productivity increases as well as availability of credits will continue to be priorities in agrarian policy.

Agrarian policy will also simultaneously promote the development of large-scale commercial enterprises with a view to increasing the overall efficiency of agriculture. The SDP proposes large government investments in agricultural infrastructure; specifically in irrigation and the rural road network. It also proposes support to other areas such as land improvement; plant selection and seed farming; the promotion of advanced technologies; and strengthening agriculture extension services. The SDP supports the mitigation of natural risks in agricultural activities through the development of relevant infrastructure such as anti-hail stations and anti-flood measures, as well as through the development and introduction of an appropriate insurance system.

Agriculture strategies in Armenia also include the Poverty Reduction Strategy of Armenia, 2007; Food Security Concept of the Republic of Armenia, 2010; and the Republic of Armenia Sustainable Agriculture Development Strategy for 2010 to 2020. These documents call for the development of sustainable agriculture in Armenia as a high national priority. It is foreseen that a focus on sustainable agriculture will foster local production of food products, thus leading to increased food security and a higher potential for the export of food and agricultural products.

According to these strategies, agricultural output is envisioned to increase by 46 percent compared to annual production volumes between 2007 and 2009. Plans exist to increase cropped areas to 421,000 hectares by 2020, including grains, cereals, fruits, vegetables and fodder crops, which will exceed the 2009 figure by almost 39 percent. The strategy and implementation measures envision an extension of cattle breeding, while at the same time calling for the implementation of measures for the increased efficiency of resource use by reducing water losses and introducing other techniques, such as drip irrigation, high value agriculture, new management practices, organic agriculture, alternative crops and livestock breeds, and alternative breeding practices.

The Strategy for Sustainable Development of Agriculture 2010 to 2020 sets out the main directions for government policy. The strategy also outlines key priorities and programmes to address known challenges in the agriculture sector, including:

a) Deepen agrarian reforms and the development of agricultural cooperatives;
b) Increase food security, ensure food safety and at least a minimum level of self-sufficiency in terms of the main food commodities;
c) Increase the competitiveness of domestic agricultural products, replace imported foodstuffs; and develop export-oriented agriculture;
d) Implement zone-based specialisation and rationalise the allocation of production;
e) Increase the effectiveness and efficiency of land use;
f) Develop organic farming;
g) Develop crop production;
h) Develop livestock breeding;
i) Increase the domestic processing of primary agricultural products;
j) Develop technical and industrial services for agriculture and upgrade the equipment for production;
k) Develop agriculture infrastructure in rural communities;
l) Mitigate agricultural risks.

The Medium Term Expenditure Framework (2010) is another significant instrument that provides guidance for development programmes for the period from 2011 to 2013. It prioritises the implementation of programmes for the rehabilitation and development of agriculture, water, roads and energy infrastructure. Key priorities include:

a) Deepen agricultural reforms, enhance market infrastructures, and improve management;
b) Improve of the availability and reduce the cost of food products, ensure minimal levels of food safety and domestic self-sufficiency concerning basic food products;
c) Facilitate the introduction of a progressive agro-technical system in plant cultivation, seed production, seed selection, plant protection and quarantine measures;
d) Promote the development of agricultural product processing, agricultural servicing, and social infrastructures.

KEY MESSAGES (DEVELOPMENT PROFILE)

- Armenia is a mountainous country with an average elevation of 1800m and a population of 3.2 million. Two-thirds of the population live in urban settings and one-third in rural areas.

- About 35 percent of the population is living in poverty; in some regions it reaches 50 percent.

- The economic structure of Armenia is evenly balanced between agriculture, industry and services. The industry and services sectors depend on remittances and global export markets. Any fluctuations in the global economy directly impact Armenia's economy, and, as such, its vulnerability.

- Significant effort has been made to reverse environmental degradation, particularly of Lake Sevan.

- Considering poverty reduction as key target, the government of Armenia adopted a three-pronged Sustainable Development Programme (SDP) to guide development trajectories until 2021. The SDP promotes balanced economic growth and the diversification of the economy to ensure a sustained reduction in poverty.

- Agriculture is an important sector supporting 44 percent of the population; hence improving agricultural development is one of the focus areas for reducing poverty.

- The SDP development trajectories were impacted by the global economic crises coupled with severe weather events in Armenia

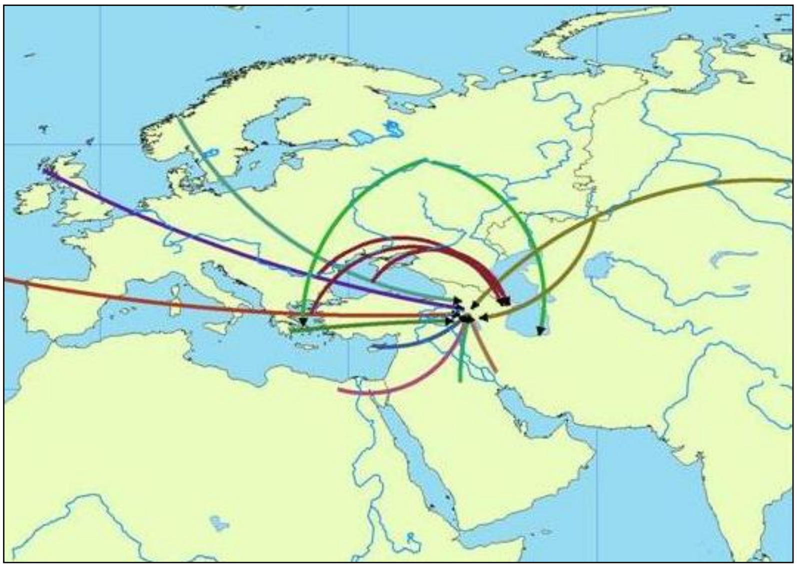
3. CLIMATE PROFILE

This Chapter provides an overview of current and future climate, as well as related trends at the national level.

3.1 National weather and climate context

Being a mountainous country (with altitudes ranging from 375 to 4090 meters above mean sea level) with a characteristic relief straddling two different physical-geographic regions, Armenia has a wide variety of climatic conditions and soils, ultimately manifested in its rich flora and fauna as well as a variety of landscapes and types of vegetation. There are six climatic zones from dry subtropical to high mountainous snowcaps and from warm humid to subtropical forests, as well as humid semi-desert steppes.

Atmospheric occurrences in the territory of Armenia are mainly contingent upon penetration of prevailing western and eastern air masses, with frequent infringement of arctic cold air masses from the north and hot air masses towards to Meridian from south, as shown in Figure 3.1.



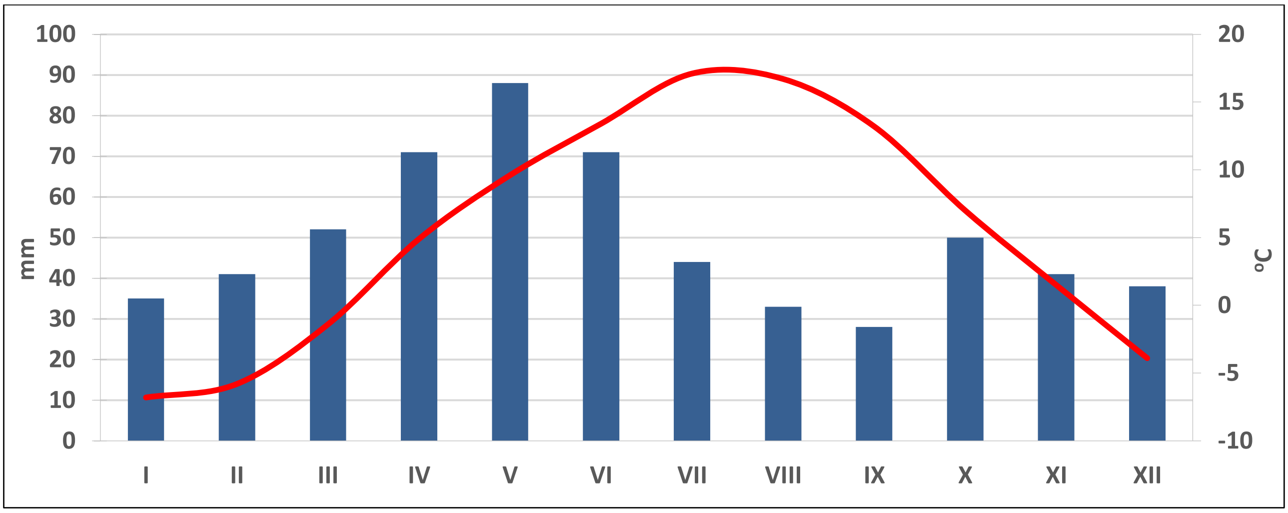
Source: ASHMMS

Figure 3.1: Main atmospheric circulation patterns influencing the weather conditions in Armenia

Rainfall

The average annual precipitation is 592mm, but it is distributed unevenly across the country. In the Ararat Valley and Meghri region, the total annual precipitation is about 200 to 250mm, while in the mountains and highlands it reaches 1000 to 1100mm. April/May and November are the rainiest periods of the year.

In the Ararat valley, during the entire summer, the quantity of precipitation, on average, does not exceed 32 to 36mm. In the mountainous regions, the snow cover is formed in the months of September and October, and snow melt occurs in July. In some years the height of snow cover exceeds 2m. In warmer regions the snow cover is formed in December and melts in March. Sustainable snow cover is formed in 15 to 20 percent of winters. In mountain passes, 31 stormy days are observed. Hail is recorded more frequently during May and June. The regions of Shirak, Lori and Aragatsotn, are mostly affected by hailstorms (on average six to eight days/per year).



Source: ASHMMS

Figure 3.2: Intra-annual variations of monthly mean temperature (red line) and precipitation (blue bars) across Armenia

Temperature

Mean temperature in Armenia fluctuates between -5°C and 17°C. The temperature varies between regions because of the mountainous terrain. An average temperature during June and August is 10°C in mountainous regions and 24 to 26°C in lowlands. The average air temperature during January depends on altitude, fluctuating from –13°C to 1°C. Figure 3.2 shows the intra-annual variation of temperature and precipitation in Armenia.

The highest average annual temperatures are observed in Alaverdi and Meghri (12 to 14°C). Summer in Armenia is moderate, the average temperature for July is 16.7^{0}C, and in Ararat Valley it varies between 24 and 26°C. The highest maximum temperature recorded in Armenia is 43.7°C in Meghri and Artashat and 42°C in Yerevan. The lowest minimum temperature recorded in Armenia is -42°C in Paghakn and Ashotsk.

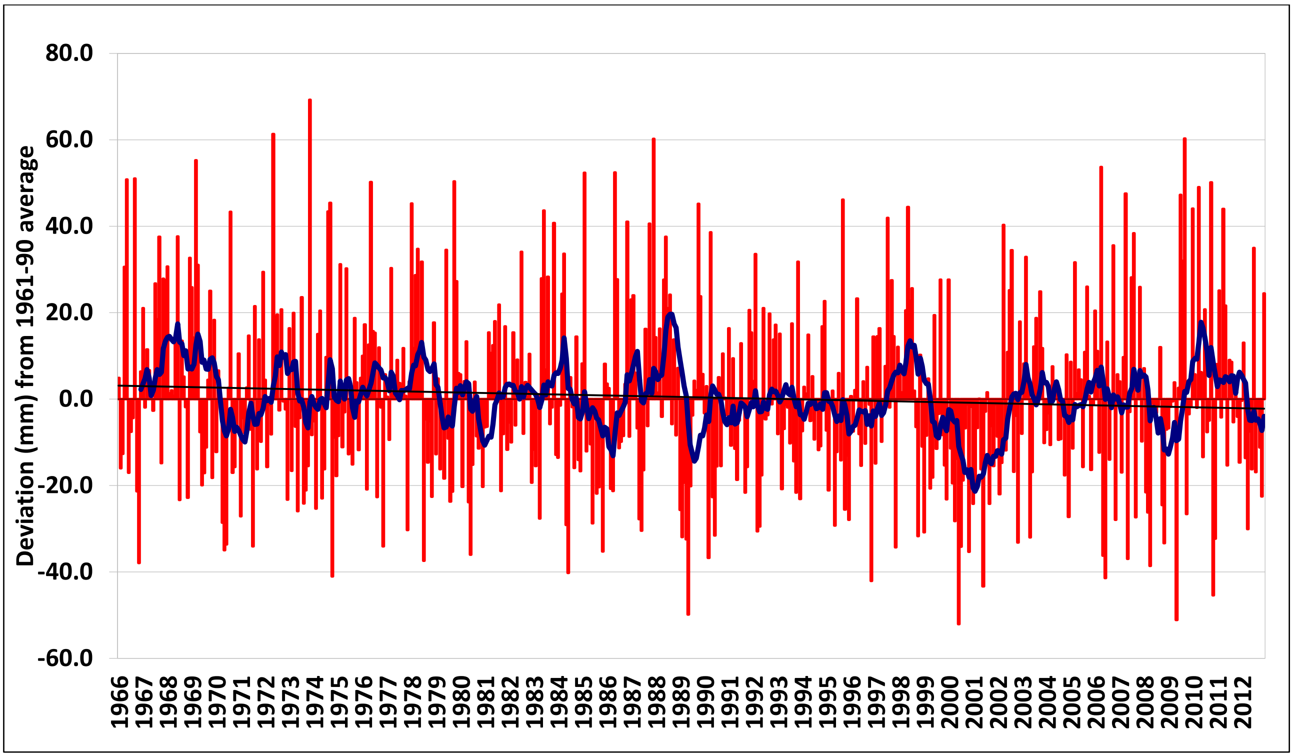
3.2 Climate variability and observed trends in climate variables and hazards

Climate drivers

Armenia due to its complex mountainous terrain and geographical location has several climate zones. The varying altitudes, from 375m to 4090m, have a strong influence over the climate. Another factor is the prevailing western and eastern processes which bring arctic cold air masses from the North and hot air masses from the South towards the Meridian.

Precipitation variability and trends

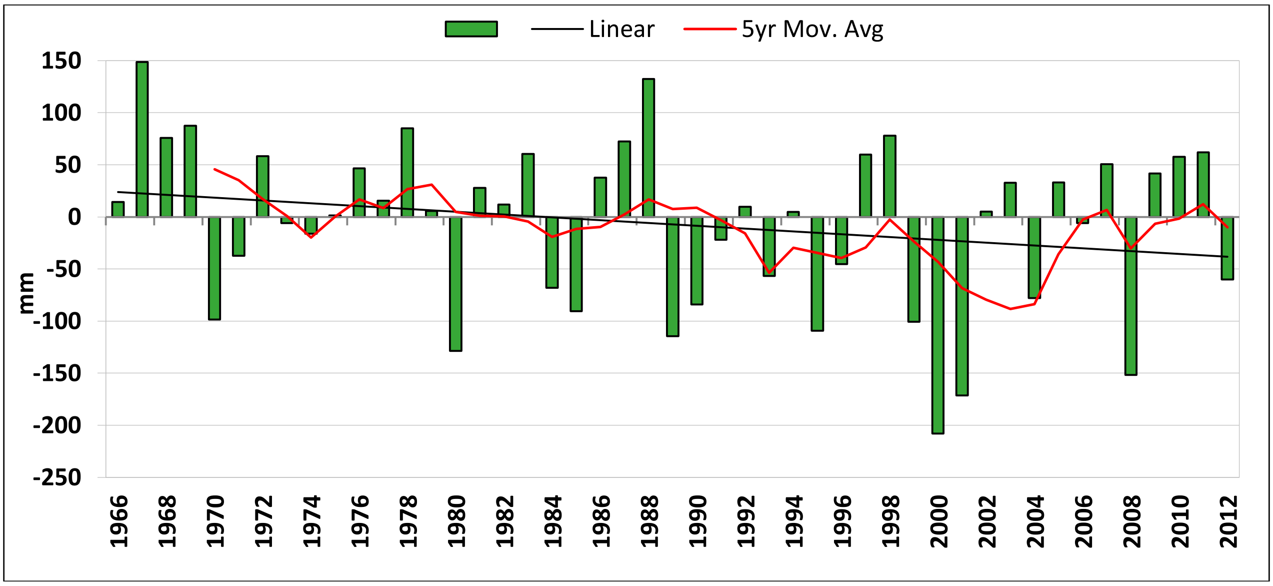
Inter-annual variability of precipitation over Armenia fluctuates between 60 and 165 percent (Figure 3.3). The monthly anomaly analysis indicates huge fluctuations over Armenia. For example, monthly precipitation anomalies in Yerevan vary within the range of 100 to 450 percent, and in Aragats between 100 and 250 percent.



Source: ASHMMS

Figure 3.3: Inter-annual variability of precipitation in Armenia

Analysis of trends shows that the changes of total precipitation have irregular spatial patterns and vary from season to season. The north-eastern and central regions (Ararat Valley) indicate a drying trend whereas southern areas, north western parts and the basin of the Lake Sevan region demonstrate increasing precipitation between 1935 and 2007 (MNP, 2009). The trend analysis for different locations (Gavar, Yerevan, Amasia, and Aragats stations) indicates that both increasing and decreasing trends persist in Armenia. Gavar indicates an increasing trend, while Yerevan, Amasia and Aragats reveal a decrease of precipitation. On average, across Armenia, a decline in precipitation of six percent has been observed over the last 80 years (Figure 3.4).

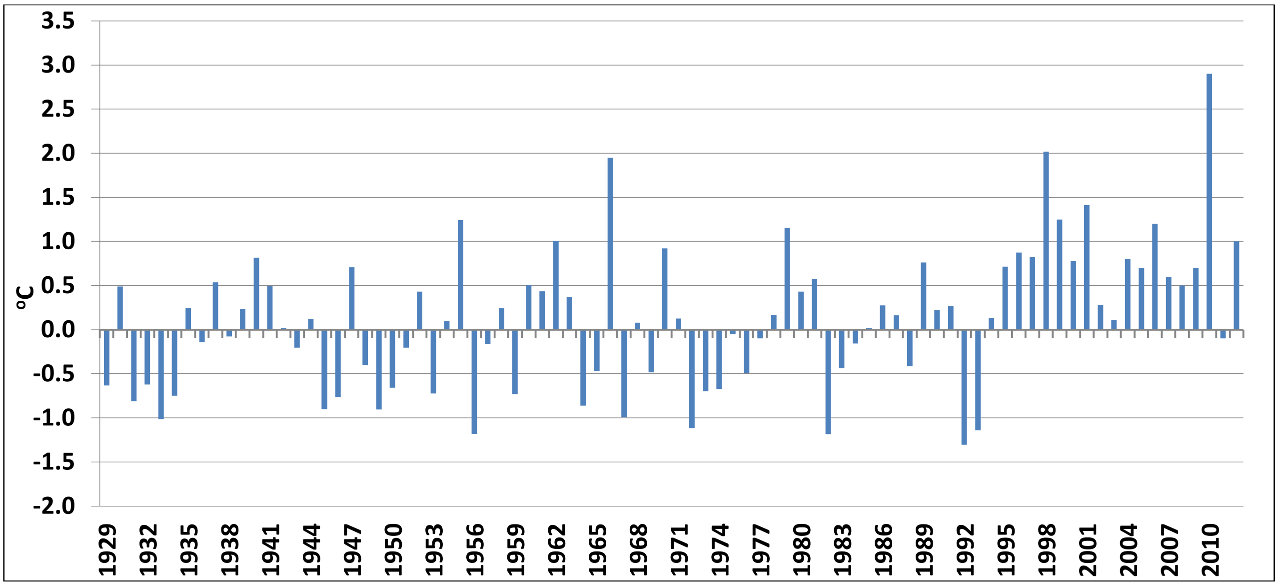


Source: ASHMMS

Figure 3.4: Precipitation anomalies (mm) with respect to 1961 to 1990 norm and trends

Temperature variability and trends

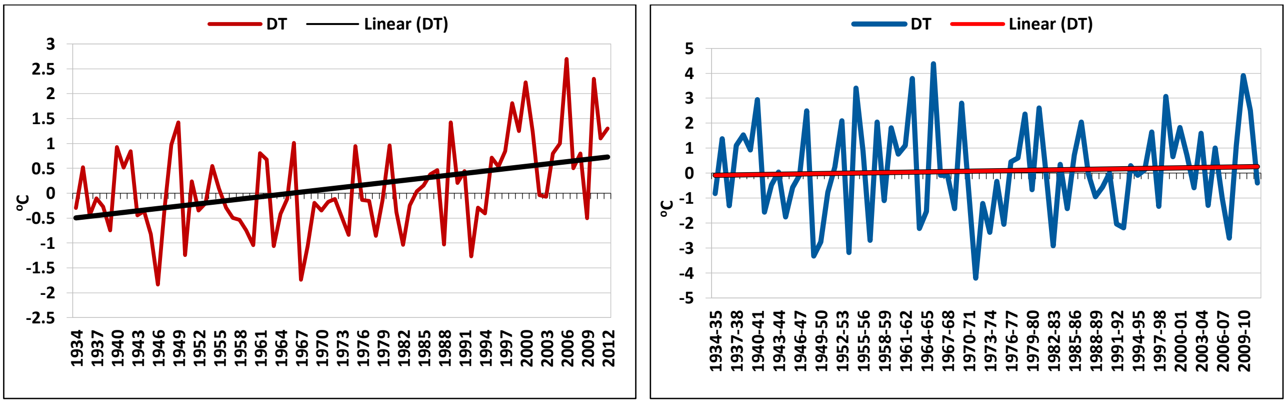
The inter-annual variability of annual average air temperatures between 1935and 2011 is presented in Figure 3.5. The year-to-year anomalies from the 1961 to 1990 average fluctuate between -1.5°C and 2.9°C.



Source: ASHMMS

Figure 3.5: Inter-annual variability of annual average temperatures in Armenia

The annual mean temperatures over Armenia between 1935 and 2012reveal an increase by 1.03°C. Starting from 1994, Armenia is experiencing persistent positive anomalies of summer average temperatures (ASHMMS, 2012). The trend varies for different seasons (Figure 3.6 a, b), for example summer (JJA) temperatures have increased significantly, by 1.2°C, compared to the marginal increase observed in winter (DJF), of 0.4°C.



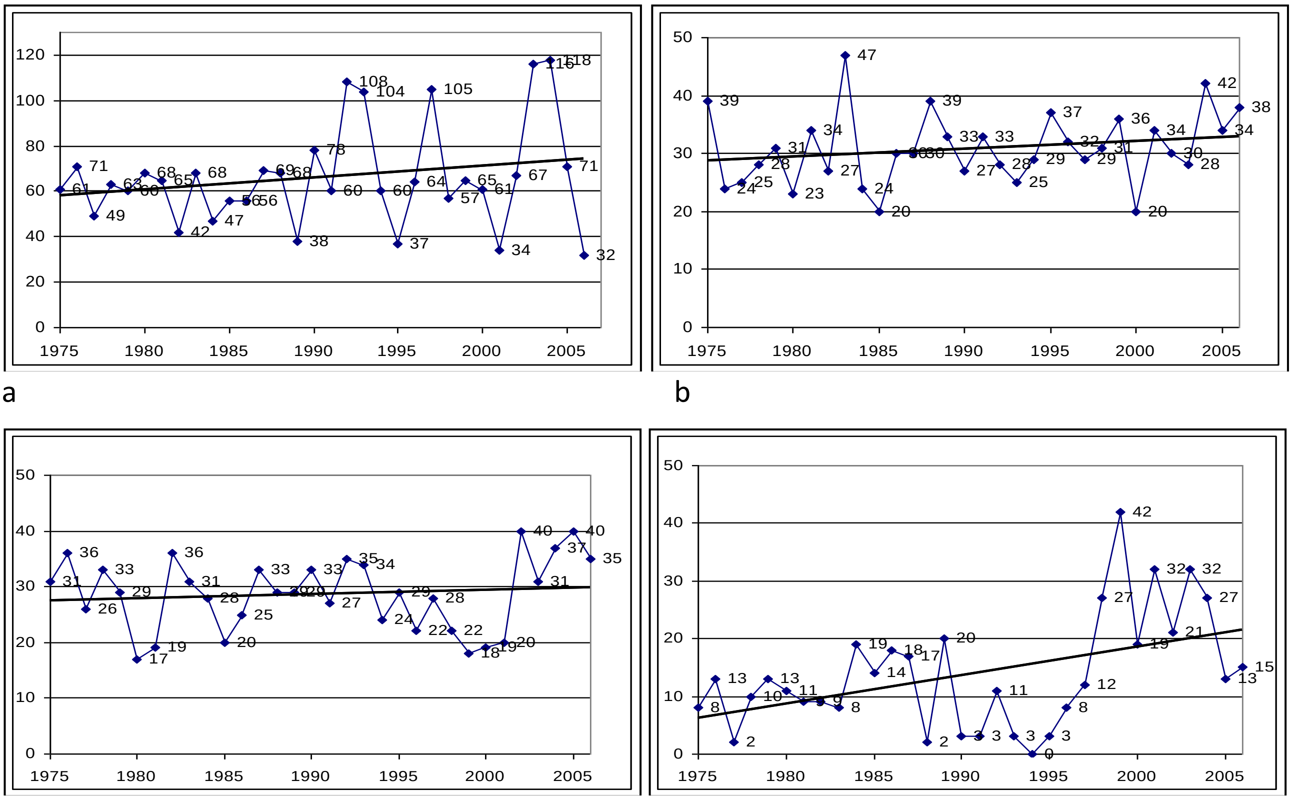
Source: Armenia's Second National Communication under the UNFCCC 2010

Figure 3.6: Trends of average summer (a) and winter (b) temperatures from 1935 to 2012 based on normal period 1961 to 1990

Changes in the frequency of extreme events

At present the assessment of the frequency of hydrometeorological hazardous events and the assessment of the damages caused by these events are conducted by different organizations, using different methodologies. Weather hazards are mostly observed by ASHMMS at meteorological stations, and the damages are estimated by other organizations applying various approaches and thresholds. Therefore, it is very important to develop a mechanism for applying a standard methodology for the assessment of extreme weather/climate events and their damages.

The analysis of weather extremes from 1975 to 2006 indicates that the number of days per year experiencing frost varies from 32 to 118 days; hail varies from 20 to 47; heavy rainfall varies from 17 to 40; strong wind varies from 2 to 42 (see Figure 3.7), and the total number of days with extreme events varies from 102 to 224.



a b c d *Source: ASHMMS, 2007*

Figure 3.7: Number of extreme hydrometeorological event days in Armenia, 1975 to 2005 – (a) frost, (b) hail, (c) heavy rainfall, (d) strong wind

The analysis of trends for the period 1975 to 2006 (see Figure 3.7) shows that all these hazards (frost, hail, strong wind and heavy rainfall) have an increasing tendency. The record number of days with hydrometeorological hazards was recorded in 2003 and 2004. Over the last thirty years the total number of hydrometeorological hazards increased by 1.2 cases per year, and during last two decades, it has increased by 1.8 cases per year) (ASHMMS, 2007). However this trend varies from region to region. For example, extreme daily maximum precipitation in Yerevan (medium altitude) didn't reveal significant change, while in Aragats (high altitude) it shows decreasing trend (see Figure 3.8).

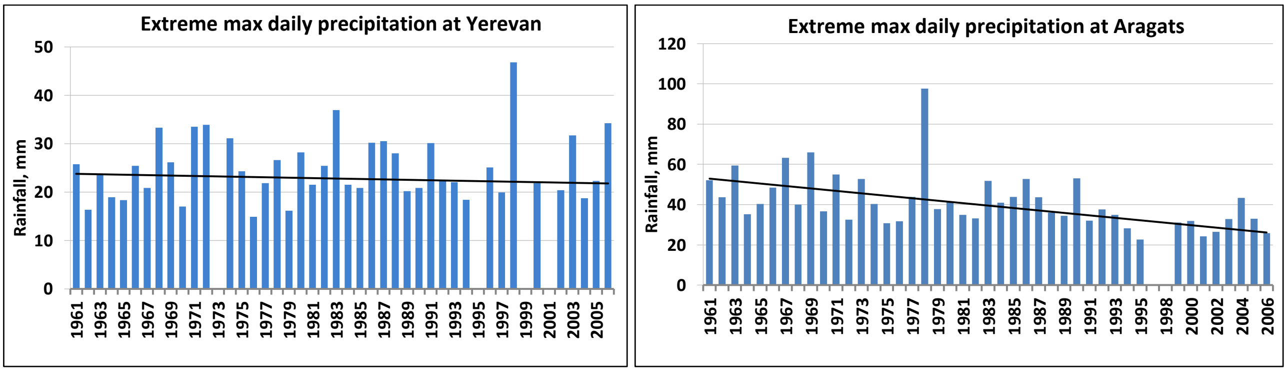
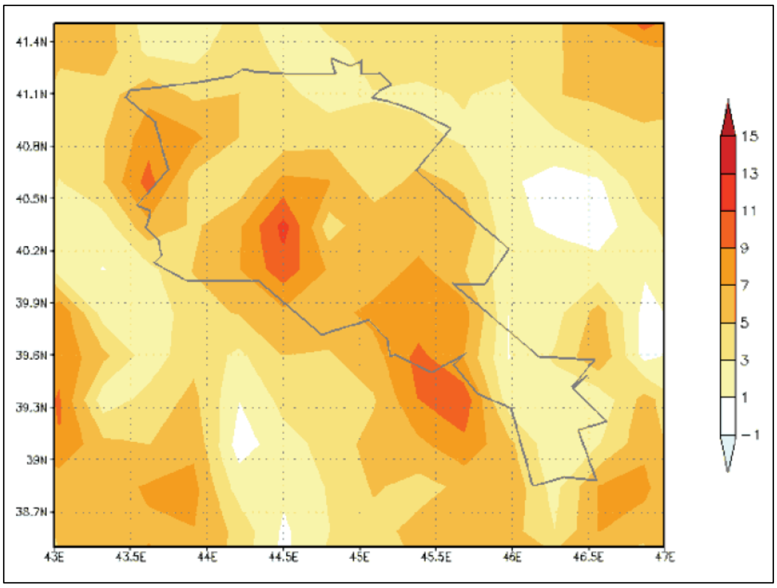


Figure 3.8: Trends of daily maximum precipitation at Yerevan and Aragats stations

3.3 Climate change projections

Temperature

MAGICC/SCENGEN model results for A2[1] indicates that annual mean temperature will rise 1.1 to 1.2 in 2030, 3.2 to 3.4 in 2070 and 5.3 to 5.7 in 2100 and the B2[2] scenario indicates the temperature rise will be 1.0 to 1.1 in 2030, 2.9 to 3.0 in 2070 and 4.8 to 5.1 in 2100. The PRECIS Regional Climate Model (RCM) projections indicate that the whole of Armenia will likely have higher temperatures (four to seven degrees Celsius) (see Figure 3.9). The seasonal analysis temperature projection December, January, February (DJF), March, April, May (MAM), June, July, August (JJA) and September, October, November (SON) indicates warming trends over Armenia with more warming in the west and central region. The summer season projection indicates that west and central regions will experience much higher temperature rises than other regions. Overall the temperature rise will be five to seven degrees Celsius during summer (MNP, 2010).



Source: Armenia's Second National Communication under the UNFCCC, 2010

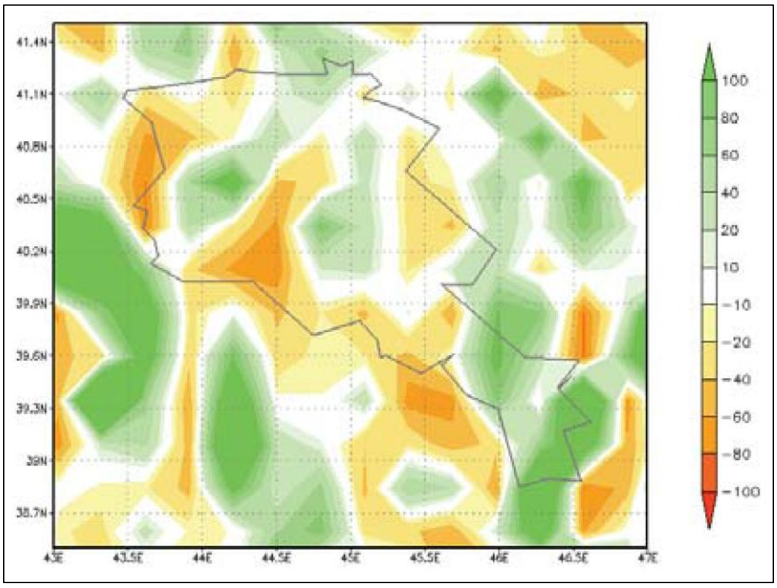
Figure 3.9: Annual average air temperature anomalies (°C) in 2071 to 2100 compared to the baseline values (1961 to 1990)

Precipitation

The MAGICC/SCENGEN model results for A2 indicates that annual precipitation deviation will be -2 to -6 percent in 2030, -6 to -17 percent in 2070 and -10 to -27 percent in 2100 and the B2 scenario indicates the deviation will be -2 to -6 percent in 2030, -3 to -15 percent in 2070 and -8 to -24 percent in 2100. The PRECIS Regional Climate Model projections indicate that precipitation deviation varies from region to region (see Figure 3.10). The annual precipitation anomaly over Armenia for 2071 to 2100 shows that the deviation is likely to be -80 percent to 80 percent. Overall the regional model results show that a decrease in precipitation is evident in the coming years. A summary of region wide seasonal average air temperature and precipitation projections for 2030, 2070 and 2100 is presented in Table 3.1 (MNP, 2010).

[1] The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines (IPCC, SRES 2001).

[2] The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels (IPCC SRES, 2001).



Source: Armenia's Second National Communication under the UNFCCC, 2010

Figure 3.10: Annual precipitation anomalies (percent) for 2071 to 2100 compared to the baseline values (1961 to 1990)

The PRECIS model revealed certain weaknesses in simulating precipitation across Armenia. It is advisable to commission additional climate change studies and develop of projections using different, regional and global models and applying downscaling techniques.

Table 3.1: Changes in seasonal and annual temperatures (°C) and precipitation (percent) compared to the average for 1961 to 1990, according to PRECIS model simulations under SRES A2 scenario

Region		Emissions Scenario A2																							
		Precipitation (percent)												Temperature (^{0}C)											
		2030				2070				2100				2030				2070				2100			
		W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F	W	Sp	S	F
Northeast		7	2	-9	7	15	4	-18	15	20	5	-25	20	1	1	1	0	3	3	3	1	3-5	3-5	4-5	1-3
Sevan Lake basin	Eastern	-7	-4	-9	-2	-15	-7	-18	-4	-20	-10	-25	-5	1	1	2	2	3	2	4	4	4-6	3-5	5-7	5-7
	Western	-7	4	-5	5	15	11	-11	11	20	10	-15	15												
Shirak		-11	-11	-7	-4	-21	-21	-15	7	-30	-30	-20	-10	1	1	1	1	3	3	3	3	3-5	3-5	3-6	4-6
Aparan-Hrazdan		-11	-7	-11	-7	-21	-15	-21	-15	-30	-20	-30	-20	2	2	1	1	4	5	2	3	4-7	6-8	2-4	4-6
Ararat Valley		-13	-9	-13	-9	-25	-18	-25	-18	-35	-25	-35	-25	1	2	0	1	3	4	1	2	2-6	4-7	1-3	2-4
Vayk		-11	-11	-9	4	-22	-22	-18	7	-30	-30	-25	10	1	2	2	1	3	4	4	3	5-7	5-7	5-7	5-7
Syunik		15	11	5	15	29	22	11	29	40	30	15	40	0	1	1	1	1	1	3	2	1-3	2-3	3-5	2-4
Aragatz		11	11	2	13	22	22	4	-25	30	30	5	35												

Source: MNP, 2010

3.4 Status of climate and hazard information at the national and regional levels

The complete picture of current and future climate hazards and trends can be obtained from the available data and information existing in Armenia. The number of meteorological stations has slightly increased during the last decade; however, considering the mountainous terrain a denser observation network is required. The country has carried out climate modeling using MAGICC/SCENGEN at a lower resolution of 2.5°x2.5°. The regional climate model, PRECIS, of the Hadley Centre, used a horizontal resolution of 25x25 km for generating high resolution climate projections. The study, however, has certain limitations, since the PRECIS model has been implemented for Armenia using outputs from only one global model HadCM. In order to have more reliable scenarios and to reduce uncertainties it is necessary to continue the studies, validating and using the results of several regional and global climate models. This requires the availability of appropriately trained and qualified personnel as well as powerful computing resources.

Another issue that needs to be tackled is the availability of historical hazard data. The information on extreme weather and climate events, as well as on the damages caused, is estimated and collected by different organizations. Often not all the events are being reported and losses evaluated. There is an urgent need to develop a mechanism for the coordination of the hazards related to monitoring and evaluation, and to establish a national hazards database and mapping mechanism.

KEY MESSAGES (CLIMATE PROFILE)

- Armenia’s climate is influenced by continental climate conditions with atmospheric circulation from the Mediterranean, Siberia and Arabian regions influencing weather patterns.

- The observable trends indicate that the temperature is increasing and snow cover is decreasing, thus leading to possible water shortage during spring months.

- The climate is highly variable with rainfall fluctuations ranging from 20 percent above average rainfall to 40 percent below average.

- Hailstorms, early frosts and long dry spells during summer seasons are the key climate extremes that impact Armenia’s agriculture sector and by extension the livelihoods of many citizens. Besides localised landslides, mudflows and floods also often affect the country.

- The projected climate trend indicates more frequent and more severe extreme events in spring and summer.

- ASHMMS maintains a rich database of observed weather and climate data sets; some of which date back over 100 years. But the climate observation network needs to be further enhanced with modern techniques and methodologies.

- The climate change studies conducted to date have certain limitations. It is therefore advisable to commission additional studies and develop projections through the application of new models.

4. CLIMATE IMPACTS AND RISKS

4.1 Past climate impacts

Climate change impacts a number of vulnerable and interconnected sectors, including, for example, agriculture, water resources, energy, and environment. The impact of climate change brings significant risks for the future, including for the sustainable development of the country.

Climate related hazards, such as floods, droughts, strong wind, snowfall, landslide, and frost, from 2004 to 2007 have led to losses of up to 65 million US$ (see Table 4.1). The economic impact of extreme events is large and increasing. The details of the impact of each hazard are discussed in the following sections (however it must be taken into consideration that presented impact does not reflect the full scale of loss and damage, as not all cases were fully reported and assessed).

Table 4.1: Natural disasters and their impact in Armenia

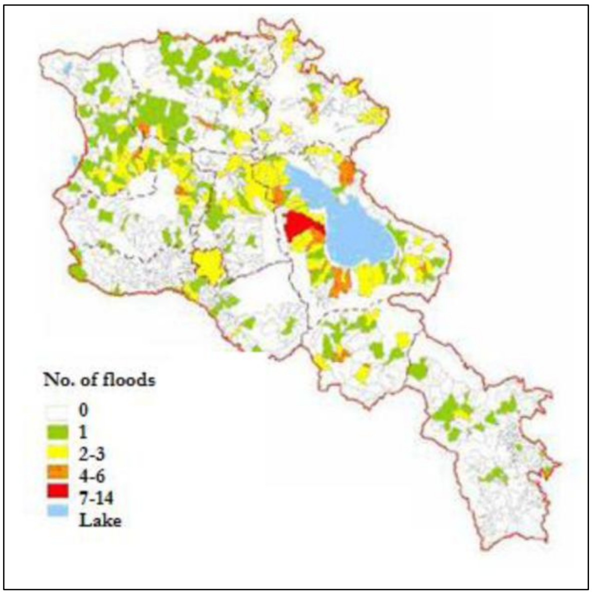
Types of natural hazards	2004		2005		2006		2007	
	No. of affected commu–nities	Damage US$ (000s)	No. of affected commu–nities	Damage US$ (000s)	No. of affected commu–nities	Damage US$ (000s)	No. of affected commu–nities	Damage US$ (000s)
Spring floods	222	4262	41	477	52	107	116	6542
Hail	103	4969	30	3884	71	7030	144	15308
Strong wind	77	337	20	149			69	15080
Snowstorm / snowfall	10				35	172	10	
Frost	13	121			97	2526		
Stone-fall			9	885	13		20	
Water coverage			1	9				
Heavy rain				9	5	213	19	
Forest fire					1	1		
Lightning							2	
Drought					338	3415		
Total	**425**	**9689**	**101**	**5413**	**612**	**13464**	**380**	**36 930**

Source: SEI and UNDP, 2009

Weather and climate hazards

Floods

Floods in Armenia are most prevalent during periods of intensive snow melt coupled with a large amount of precipitation during spring months. River volumes sometimes increase by up to ten times their normal level. The river basins of the Araks, Hrazdan, and Aghstev rivers are more prone to floods. Flash floods occur once every two years in the river basins of Meghri, Vedi and Goris. Rainfall and melting snow increase the risk of mudflows in many parts of the country. (World Bank, 2009). Major floods between 1994 and 2007 occurred in Gegharkunik (159 cases), Lori (85), Shirak (72) and Aragatsotn (71) (see Figure 4.1) (UNDP, 2008).



Source: SEI & UNDP, 2009

Figure 4.1: Number of floods reported in Armenia between 1994 and 2007

Floods and their associated damages are gradually increasing in Armenia. The economic damage caused by floods between 1994 and 2007 is estimated at US$ 41 million. In this timeframe, flooding in Lori marz incurred US$ 18 million of damage, in Syunik marz there was US$ 13 million of damage, in Tavush marz there was US$ 5 million of damage and Gegharkunik marz there was US$ 2.5 million of damage (MNP, 2010). It is estimated that severe flooding, such as the floods in 2002, could cause damage of more than US$ 10 million (UNDP, 2008).

Droughts

Reduced precipitation and humidity increase the risk of drought in Armenia. High temperatures and hot winds occur between 120 and 160 days per year in the Ararat valley and other lowlands, making these regions more vulnerable (World Bank, 2009). Drought-prone marzes have above average levels of poverty, such as Shirak (77.3 percent), Lori (61.7 percent), and Aragats (57 percent).

Droughts in Armenia significantly affect the economy. The frequency and intensity of droughts varies; in the most arid areas, severe drought occurs once or twice per decade. Armenia's environment is vulnerable to drought, which intensifies desertification processes and aggravates secondary salinization. Approximately 80 percent of the country is threatened by desertification in various degrees (and over half by severe desertification).

Due to the deterioration of infrastructure, increased electricity costs, lack of inputs, and other factors, sown irrigated areas have shrunk to 154,000 hectares from 314,000 hectares in 1991. Prolonged meteorological droughts lead to a reduction of water resources by around 20 to 45 percent. Advice and advance warning for droughts is vital for reducing the risks, but prediction of meteorological or agricultural drought is often possible with only a very short lead time, and early warning products are only sporadically available.

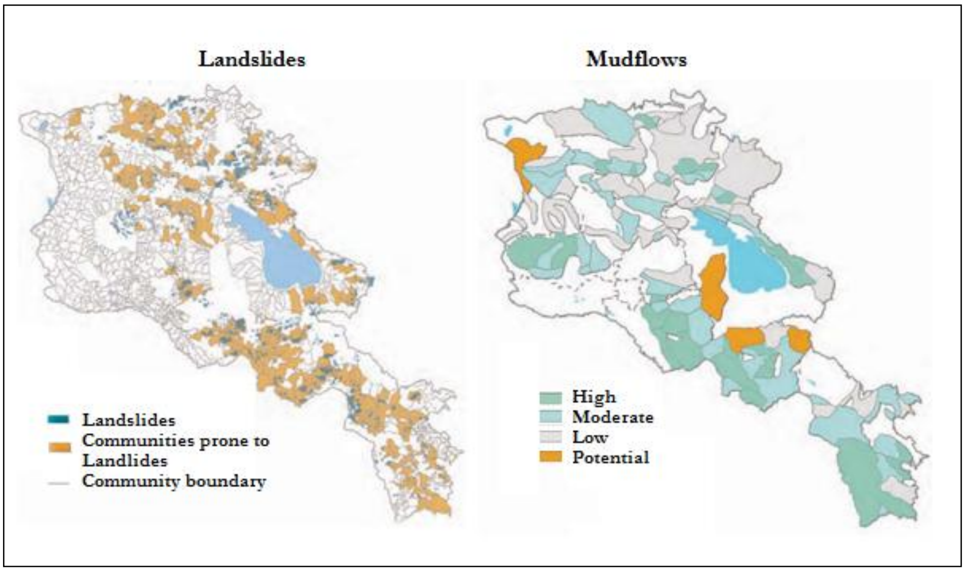
The most severe drought in Armenia was recorded in 2000 and 2001. It affected the whole country, causing damage of 38 billion AMD (US$110 million) (MNP, 2010). The socio-economic impact of the 2000/01 drought was still noticeable in 2003. The localized drought in 2006 resulted in a reduction of cereal crop production by more than 35.5 percent compared to the previous year, which in turn lead to the import of 597,000 tons of cereals (World Bank, 2009).

Hail

Hailstorms are among the most severe natural hazards for the agriculture sector. Average annual losses are US$ 30 to 40 million. About 370 villages are located in hailstorm risk areas, or 15 to 17 percent of the country's agricultural area. There is a high occurrence of hailstorms in the Shirak Valley, mountain passes, the Sevan basin and Syunik marz (ASHMMS, 2007). The analysis of trends showed that the frequency and intensity of hailstorms has significantly increased. The hailstorms in June 2011 and May 2013 were among the most severe on record in the country.

Landslides and mudflows

Around 122,000 hectares of land in Armenia is vulnerable to landslides, which are mostly triggered by heavy precipitation. Leakages from domestic water supply and irrigation systems are also perceived as contributing to landslides, as well as the deforestation of steep slopes. The existing irrigation, water supply, and sewage systems are poorly constructed; hence they contribute to landslide occurrence in Yerevan and surrounding towns. Mudflows are also a serious threat in medium-altitude mountainous areas, especially areas around the cities of Yerevan, and Kapan (World Bank, 2009). Boynagryan's (2009) study indicates that more than 3,500 landslides of various sizes have occurred in Armenia. Of them 90 percent are situated at altitudes from 2,000 to 1,500 m and below. Others are recorded at altitudes of 2,200 to 2,400 m and rarely beyond 2,500 to 2,600m. Areas at risk from landslides and mudflows are shown in Figure 4.2.



Source: MNP, 2010

Figure 4.2: Landslide and mudflow prone areas in Armenia

Landslides have affected hundreds of residential buildings, communication infrastructure, and vital facilities, including 1,744 hectares of residential areas; 240 kilometers of roads/highways; and 4.8 kilometers of railways. The estimated damage caused by landslides in 2004 is US$ 43 million. Mudflows have affected 200 settlements and 600 sites on main transportation routes between 2004 and 2007. The World Bank study indicates that landslide damage in Armenia accounts for about US$ 11.5 to 13.0 million, and mudflow damage accounts for US$ 5.7 to 7.1 million (World Bank, 2009).

Frost

Late spring and early autumn frosts occur often in Armenia causing damage to the rural economy and in particular to the agriculture sector. In recent years a rise in frequency and intensity of frosts has been observed. The analysis of situations resulting in frosts showed that 70 percent of cold invasions are from the west and north-west, which leads to advection and radiation frosts.

It is worth noting the north-western cold invasion between the 4th and 6th April 2004, when the temperature abruptly dropped by 15ºC, causing severe frost damage to crops in a vast agricultural area. Nine consecutive days of frost in late December 2002 severely damaged vines and trees on about 10,000 hectares of vineyards and more than 13,000 hectares of orchards in the Ararat Valley. Tree, vine and first-year production losses were valued at almost 15 billion drams (US$ 26 million) affecting some 75,000 farmers. The frost in 2004 caused damage of US$ 16 million (World Bank, 2009 a).

4.2 Future climate impacts

Climate extremes will have a significant impact on sectors such as, agriculture, food production, forestry, and others that require access to water resources.

Agriculture

The modeled climate change scenario indicates that the frequency of weather anomalies is likely to increase in spring and summer, along with thunderstorms and hail. This implies that the croplands in the mid altitude zones of northern and southern marzes are more vulnerable. The reduction of ten to 30 percent in soil moisture might impact crop production by seven to 13 percent. The water deficit is likely to be 25 to 30 percent in various regions. The projected decrease in water resources may create serious problems for the irrigated farming sector. A decline of eight to 14 percent in the yields of the main agriculture crops by 2030 is forecast, including a nine to 13 percent decline for cereals, a seven to 14 percent decline for vegetables, an eight to ten percent decline for potatoes and a five to eight percent decline for fruits. The change in climate might aggravate outbreaks of crop diseases and pests. By 2030, the available area for pasture is likely to decrease by four to ten percent, valuable pastures of sub-alpine and alpine zones may experience a 19 to 22 percent decline, and a lower yield of grasslands may precipitate a seven to ten percent reduction in fodder production. This will be a threat to livestock production, if proper measures are not taken (MNP, 2010).

Water resources

There is likely to be less water in rivers and streams because of reduced winter snow pack and spring runoff. The reduced river flow and lake levels might impact the groundwater reserves. Armenia’s total river flow is projected to decline by seven percent by 2030 and 24 percent by 2100. Lake Sevan’s main source is spring snowmelt, of which the flow is expected to decrease by 41 percent by 2100. This will lead to a reduced water level in Lake Sevan over time. Scarce water resources will have an impact on the agriculture sector, as most agricultural land is dependent on irrigation. A 25 percent reduction in river flow is projected to result in a 15 to 34 percent reduction in the productivity of irrigated cropland, with an average estimated reduction of 24 percent. The projected changes in water resource availability will also impact the energy sector, since power generation from hydro-electric plants and cooling water for nuclear and thermal generation plants depends on river water. The decline in flow rates will increase the threat of failing to meet domestic electricity demand (MNP, 2009).

The initial assessments related to Lake Sevan were based on studies conducted in 1990s on the evaporation from the Lake and its vulnerability to evaporation assuming an increase of temperature between one and two degrees Celsius (E1 and E2 scenarios). These studies indicated increased evaporation by 71mm (8.4 percent) and 113mm (13.4 percent) respectively. This methodology, however, contained a large degree of uncertainty as it did not include the wind as a variable within the model. Recently, these values were re-estimated applying the improved methodology under different scenarios of changes in wind velocity. The new results largely differ from the earlier estimates, for example under similar projections of climate change; the free flow from the Lake will reduce from 220 to 225 million m^3 instead of the previous estimate of 252 million m^3. In the case of a temperature increase by 0.5^{0}C, the total volume of water in the Lake will reduce by 70 million m^3, and the increase (decrease) of total precipitation by five percent will lead to an increase (decrease) of the Lake's volume by 37million m^3.

Forestry

In north-eastern marzes the lower boundary of forests (1450 to 1550m) is likely to be more vulnerable because of the expected reduction in forest growth as a result of decreased precipitation. Also the loss of 1,700 hectares of forest in this region is a risk due to the infiltration of active steppe and semi desert forest species. In south-eastern forested marzes, 5,600 hectares of lower boundary forest (from 600m) is also vulnerable due to reduced forest growth and the infiltration of semi desert forest species. The projected increase in temperature and decrease in precipitation might have a negative impact on seed regeneration. More than 17,000 hectares of forest (5 to 5.5 percent) might disappear because of poor growing conditions in Armenia. The forest ecosystems could be affected by worsening sanitary conditions, and an increase of pests, diseases and fire hazards which will possibly result in the decline of forest areas by 17,000 ha during next 20 years (MNP, 2010).

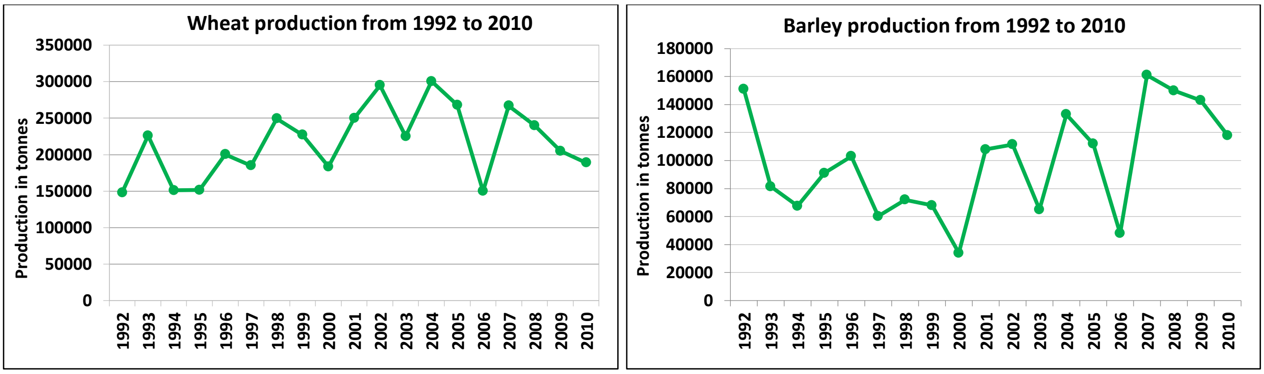
Climate extremes have played an important part in the increased wildfire occurrence. An increase in the number of wildfires has been observed in Armenia over the past decade following prevailing drought conditions and continued hot temperatures. In 2010 and 2011 the number of forest fires grew rapidly from an average of under ten fires in previous years to over 50 forest fires in both 2010 and 2011, which together burned over 1,300 hectares of forested lands. The damage caused by forest fires is significantly worsened by insufficient recovery in the affected forests under the unfavourable climate conditions. Furthermore, in both 2010 and 2011 the number of grassland fires grew five-fold compared to the average of the previous six years, reaching over 2,700 grassland fire cases in both 2010 and 2011.

4.3 Climate change sensitivity

Armenia's agriculture sector accounts for one-third of GDP, with approximately 20 percent of GDP based on agriculture production and ten percent on food manufacturing. These two components are directly sensitive to climate variability and change. Around 50 percent of the arable land is under irrigation. In precipitation deficient years a 25 percent reduction in river flow could translate into average crop production reductions of 25 percent in irrigated areas. The expected yield loss with respect to grapes is estimated at 21 percent and winter wheat at around 25 percent. The total loss to the agriculture sector could be in a range of US$ 75 to 300 million depending on the severity of droughts. The fall in agriculture production could have a cascading impact on agro-processing industries in the range of 13 to 34 percent. This could translate from US$ 75 million up to US$ 150 million worth of losses. GDP climate sensitivity could be up to five percent. In terms of direct and indirect linkages to the economy, the impact could have a cascading effect on the overall economy of around 8 to 10 percent, which is approximately US$ 1 billion based on GDP in 2012.

Wheat and barley

Wheat is grown on 150,000 hectares of agricultural lands. Early frost and hail often damage the shoots of the crop. Severe drought could impact productivity by up to 50 percent. Barley is sensitive to early frost and hailstorms in April and May, occasional flooding in flood prone regions and droughts. The fall in production could be 20 to 40 percent due to severe weather. The dynamics of wheat and barley production between 1992 and 2010 is shown in figure 4.3.



a b

Figure 4.3: Dynamics of wheat (a) and barley (b) production from 1992 to 2010

Vegetables

Vegetables are grown on 20,000 hectares of agricultural land. During the growing period, particularly between May and September, hailstorms, long dry spells and early frosts could affect the yield by around ten percent (see Figure 4.4).

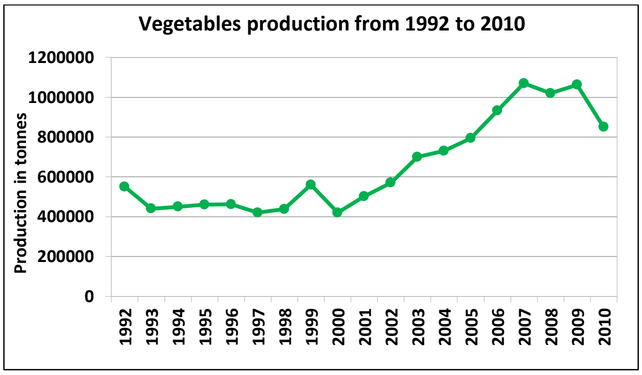
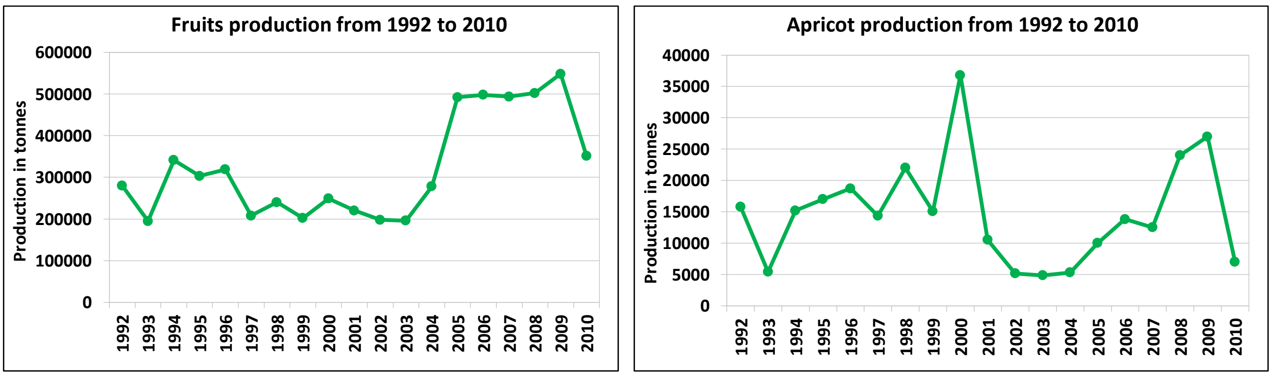


Figure 4.4: Vegetable production from 1992 to 2010

Armenia is famous for grape and other fruit production, which are increasingly becoming high value crops. Climate sensitivity to different horticulture crops such as apricot, pomegranate, persimmon, fig, grapes, walnut, peaches, cherries, cornel, apples and pears are shown in Figure 4.5. Table 4.2 presents the climate sensitive cropping activities and hazard occurrence periods.



a b

Figure 4.5: Fruits (a) and Apricot (b) production from 1992 to 2010

Table 4.2: Cropping activities and hazard occurrence periods

Type of crop, horticultural activities	Calendar of Activities											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Preparatory activities for spring			F	F								
Cleaning of ditches				F	HS DR							
Branch cutting				F	HS DR							
Orchard dykes			F	F	HS DR							
Tree blossom			F	F								
Crop ripening					HS FL	HS FL	HS DR	HS DR	DR			
Harvest					HS FL	HS FL	HS DR	HS DR	DR			
Autumn activities												
Fertilizer application			F	F	HS FL	HS FL						

F– Frost; HS – Hailstorm, FL-Flood, DR-Drought:
Note: Green shading indicates the occurrence of that activity during the particular month(s)

Livestock

The livestock population in Armenia is 500,000 head of cattle of which 200,000 are dairy cows, 550,000 sheep and goats, 71,000 pigs and 3,000,000 poultry. According to a recent FAO report, during the drought in 2000, against a normal production of 86,000 tonnes of meats and 460,000 litres of milk, the reduction was almost 50 percent. This is due to the scarcity of feed, lack of pasture and depletion of fodder reserves.

Food security and nutrition

In normal times, Armenia has to import wheat to cover the shortfall by up to 500,000 tonnes. Due to high rates of inflation, at times more than ten percent, the affordability of food grains has become a critical issue. This led to number of people falling below the poverty line; it also affected the export of food processing products.

Climate hazards' impact on agricultural economics

Year to year variation in agriculture production can be attributed to climate hazards in part as technological factors' influence on year to year basis is limited. Table 4.3 presents deviations between actual and potential agriculture output in response to severe climate events such as drought, hailstorm, early frost, landslides and floods. The analysis of the deviations shows that due to weather and climate hazards the actual agriculture output is significantly lower than expected output. The magnitude of the deviation varies from 0.0 (in 1998, 2004, and 2006) to US$ -416 million in 2010.

Table 4.3: Agriculture output

Year	Agriculture output in billion AMD	Potential agriculture output in billion AMD	Difference between actual and potential agriculture output	
			Billion AMD	Million US$
1995	333.0	402.1	-69.1	-170.6
1996	339.0	402.1	-63.1	-155.8
1997	319.0	402.1	-83.1	-205.2

Year	Agriculture output in billion AMD	Potential agriculture output in billion AMD	Difference between actual and potential agriculture output	
			Billion AMD	Million US$
1998	402.1	402.1	0.0	0.0
1999	311.7	402.1	-90.4	-223.2
2000	281.2	402.1	-120.9	-298.5
2001	351.0	504.1	-153.1	-378.0
2002	377.6	504.1	-126.5	-312.4
2003	410.1	504.1	-94.0	-232.1
2004	504.1	504.1	0.0	0.0
2005	493.0	504.1	-11.1	-27.4
2006	555.9	633.9	-78.0	-192.6
2007	633.9	633.9	0.0	0.0
2008	628.1	633.9	-5.8	-14.3
2009	552.1	633.9	-81.8	-202.0
2010	465.4[3]	633.9	-168.5	-416.0
		Total	**-1145.4**	**-2828.1**

Adapted from NSS RA, 2012

Table 4.4 represents key indicators, which characterize the development of the agriculture sector including employment and exports/imports.

Table 4.4: Key indicators of agricultural development

Indicators	2006	2010 target	2010 actual	Actual/ Target (percent)
Total				
Value added (billion AMD in current prices)	495	697	465.4[4]	66.77
GDP ratio (percent)	18.7	14.8	17.4	117.6
Index (in real terms) (2006 = 100)	100	125	94	75.2
Average annual rate of real growth (percent)		5.74	-1.47	-25.6
Average annual inflation in agriculture (percent)	11.9	3.4	7.0	206
Employment, labor productivity and income				
Number employed in the sector	504.3	504.3	454.8	90.1
Labour productivity (thousand AMD in current prices)	948.4	1383.1	1167.8	84.4
Monthly employment income from agricultural activities (thousand AMD in current prices)	46.39	80.7	74.3	92.0
Comparison with the monthly average wages in the non-agricultural sector (percent)	61.1	57.1	56.6	99.1
Export and import				
Export of agricultural goods (million US$)	26.8	56.8	39.4	69.4
Specific weight in total export (percent)	2.67	3.5	3.9	111.4
Specific weight in agricultural value added (percent)	2.32	2.6	2.4	92.3
Import of agricultural goods (million US$)	179.3	386.1	366.4	94.9
Specific weight in total import (percent)	8.17	7.5	9.7	129.3
Specific weight in agricultural value added (percent)	15.5	16.8	22.5	133.9

Source: NSS and authors' estimates cited in IMF, 2011

[3] 1995 to 2009 values are taken from Statistical year book. 2010 Agriculture output is from Republic of Armenia's Medium-Term Public Expenditure Framework of The Republic of Armenia For 2012-2014

[4] 2009 value has been used in the report. This is replaced with 2010 actual value from Republic of Armenia's Medium-Term Public Expenditure Framework of The Republic of Armenia For 2012-2014

Armenia has a high degree of sensitivity to climate variations. The compensation provided in recent years could be a useful proxy indicator in assessing the Country's sensitivity to climate risks (see Table 4.5), even though the compensation represents less than one percent of the total damage and losses incurred. The Government of Armenia recognises this in its medium term public expenditure framework for 2012-2014:"In mitigating the negative socio-economic consequences of unfavourable climatic conditions, the Government has to redirect financial means from other programmes to the solution of above-mentioned problems, and in conditions of limited resources, this will result in the displacement of funds allocated for reforms" (RA, 2010). Seen over a 15-year period from 1995 to 2010, the potential loss in agricultural output alone due to climate risks is estimated at US$ 2.8 billion.

Table 4.5: Compensation paid to farms affected by extreme weather phenomena

Year	Form of compensation	Value, (1000 US$)
2003	423 tons of winter wheat seeds	86.5
2004	550 tons of potato seeds, 65 tons of winter barley seeds	136.3
2005	1360 tons of winter wheat seeds, 300 tons of winter barley seeds	556.7
2005	Compensation for irrigation water supply	85.6
2006	20,000 tons of ammonium nitrate	192.3
2007	20,000 tons of ammonium nitrate	233.9
2007*	100 tons of corn seeds, 50 tons of alfalfa seeds, 1300 tons of winter barley seeds	1487.7
2008	20,000 tons of ammonium nitrate	261.4
2008	645 tons of winter wheat seeds	261.4

Source: MNP, 2010

4.4 Adaptive capacity

National

Armenia has a narrow and open economy. Economic flows are mostly connected with Russia and neighbouring countries. The 2008 economic crisis revealed Armenia's economic weaknesses, as the GDP fell from double-digit growth to -15 percent. As the economy is narrow, its ability to provide support to people faced climate risks is also limited. Agriculture accounts for 47 percent of employment opportunities, yet the chronic shortage of resources for maintaining irrigation infrastructure, ensuring functional markets and modernizing farm production limits development. The Government of Armenia allocated only 637 million drams during 2011 for agriculture including activities that are not directly connected with climate risk management.

Household adaptive capacity

The households in a study area adopted a different agriculture adjustment mechanism (Intercooperation and Shen, 2010). As these adjustments could not cope with the various hazards, the households resorted to the following activities in order to manage the risks.

The families, after losing their main income source due to weather phenomena, start to spend their savings. As they sell their cattle, the living standard of the family drops and the family looks for savings on food. Seeking alternative sources of income the male members of the family are migrating to urban areas or Russia. In addition, many families can't afford to pay tuition fees leading to children being deprived of higher education, which in turn often leads to youth outmigration (Intercooperation and Shen, 2010).

4.5 Threats to development

Contrary to common perceptions Armenia has a high sensitivity to climate variation. This is due to the fact that the agriculture and agro-processing industries account for one-third of GDP and support more than 47 percent of the population. Farming is under-developed, with most of the 340,000 farms owning less than 1.5 hectares of land. Thirty-four percent of the population is below poverty line. This is compounded by the limited capacity of the Government of Armenia to assist rural households. Periodic extreme climate shocks as well as annual severe weather patterns impact rural households. These climate risks of annual and periodic extremes endanger development, as efforts made to eradicate poverty cannot be sustained.

KEY MESSAGES (CLIMATE IMPACTS AND ITS RISKS)

- Almost every year severe weather events, such as hailstorms, early frosts, landslides, and spring floods, impact Armenia.
- Almost every alternate year, droughts of varying magnitudes impact Armenia, particularly the agriculture sector.
- The droughts of 2000, 2006 and 2010 reduced cereal crop production by 35 percent, potatoes by 35 percent, and vegetable crops by 16 percent.
- The agriculture sector and the national economy more broadly are highly sensitive to climate risks. Assessments indicate between 1998 and 2010, agriculture gross outputs losses totalled US$ 2.8 billion, with annual loss of US$ 450 million.
- Climate risks impact on the agriculture sector due to the fact that agriculture and agro-processing industries account for one-third of GDP and support more than 47 percent of the population.
- Since Armenia's economy is narrowly based, its adaptive capacity to manage climate risks is low. Climate risks could impact rural livelihoods by reducing incomes and increasing poverty. The cascading effects of climate risks could reduce agriculture related exports, increase imports and increase inflation, thus contaminating to other areas of the economy.

5. CURRENT CLIMATE RISK MANAGEMENT SYSTEM

This chapter examines the current capacities for CRM, particularly in the form of institutional and policy arrangements for CRM, such as frameworks of development planning, disaster risk management and climate change. A capacity assessment is also undertaken for key CRM functions, including assessment, prioritization, coordination, information management and climate risk reduction.

5.1 Institutional and policy arrangements for CRM

In Armenia, three distinct frameworks address climate risks, namely, development planning, disaster management, and climate change adaptation. The sections below discuss the lack of integration of the climate risk management approach within these frameworks.

Development planning framework

The Sustainable Development Programme (SDP), Armenia's long-term development planning framework, details the priorities and directions for development from 2008 to 2021. It plans for increased production, through programmes that develop agricultural infrastructure such as irrigation facilities, land improvements and technological support, as well as the mitigation of disaster risks. The potential impact of disasters such as landslides are noted within the urban planning context under the SDP, and it supports the on-going systematic mapping of landslide risks as well as their incorporation into land use planning and site selection processes. The SDP seems largely concerned with the impact of climate risks in the form of extreme occurrences that are obvious and which garner public attention. It does not, however, consider the impacts of climate risks that are subtle and on a continuous basis. For example, the variation of temperature by a few degrees or dry spells at critical stages in crop growth could lead to significant losses in production and thereby impact directly on GDP. Furthermore, the SDP projections and targets do not consider the overall cascading impacts on the economy from the agriculture sector, through agro-processing and other manufacturing, as well as reduced demand for products and services due to depressed incomes. Consonant with this omission, it does not consider the allocation of resources for proactive adaptation measures.

In agriculture, the most recent planning strategy, namely the National Strategy for Sustainable Development of Agriculture: 2010 to 2020, notes the need for the mitigation of risks in agriculture, such as from hail, landslides and droughts. It identifies the need for dynamic insurance schemes to reduce risks, for further development of the anti-hail system, for a crop forecasting system and for improved irrigation facilities to reduce drought risks. Much like the SDP, the agriculture strategy does not take adequate account of the risks to agriculture beyond the extreme weather phenomena identified, that impact crop growth and production on a smaller scale, but a routine and continuous basis.

Thus, while climate risks are considered in development planning from the perspective of disaster preparedness and emergency response, the above analysis of the policies and strategies reveals that efforts to integrate routine and longer-term climate risks into development process are sub-optimal. Armenia's National Self Capacity Assessment for Global Environmental Management also notes that the incorporation of climate risks into key areas like the forestry development strategy (through the promotion of drought-resistant forest belts) or the water resource strategy (through efficient water management mechanisms) has not been deliberate or fully informed by the current knowledge and understanding of climate change or its risks.

Disaster risk management framework

Institutions and Mechanisms

Established in 2008, the Ministry of Emergency Situations (MES) is responsible for disaster risk management in Armenia, including risk assessment, emergency preparedness, emergency response and risk mitigation. At the policy level, the National Security Council provides support through facilitation and coordination. Within the MES, the agency most directly responsible is the Armenian Rescue Service which is the leading agency for emergency preparedness, response and management. The Armenian State Hydrometeorological and Monitoring Service (ASHMMS) is also under the MES. While the need for a paradigm shift from response to risk reduction is recognised, the programmes and activities implemented on ground are largely oriented towards preparedness, response and hazard assessment.

In addition, there are several other Ministries and State agencies that contribute to DRR in Armenia, such as the Ministry of Agriculture, the Ministry of Health, the Ministry of Nature Protection, the Ministry of Urban Development, the Ministry of Territorial Administration, the Ministry of Energy and Natural Resources, and the Ministry of Education and Science, among others.

Policies, strategies, programmes

The overarching legislation concerning disasters is the law on ‘Civil Defence during Emergencies’, which largely focuses on emergency situations and their mitigation, as well as preparedness and response. This law does not, however, entail measures on DRR for relevant ministries and agencies. Disaster risk management/reduction is also absent from legislation or responsibilities in other sectors and ministries (UNDP, 2010).

The budgetary mechanisms governed by the State Budget law do not include provisions for DRR. Existing reserve fund is for use after disasters or emergencies for recovery (ibid). Annual budgetary provisions, reflected in the Medium Term Public Expenditure Framework for 2011 to 2013, demonstrate that the allocation for the Armenian Rescue Services is largely for conducting preparedness measures, such as drills, and responding to emergencies.

A joint mission was undertaken in May 2006 by UNDP/BCPR and OCHA with the aim of identifying key national and regional risks for both natural and man-made disasters and the level of national capacities to address these risks. Based upon the findings of the mission, a five year programme framework was developed to support the capacity building of the national disaster management capacities of Armenia. Between 2007 and 2012 the “Strengthening of National Capacities for Disaster Preparedness and Risk Reduction” project was implemented by UNDP Armenia, with financial and technical support from UNDP/BCPR, in close partnership with the MES. The National Platform was formed by the Government decision of 7th March 2012, N 281, and priority directions for DRR were identified. The National Platform currently acts as the main national structure for coordinating disaster management, including the efforts of the MES, other state and non-state agencies, as well as international and intergovernmental organisations, NGOs, private organisations and individual experts. Both the establishment of DRR National Platform and the adoption of the DRR strategy including its plan of action have provided a solid base for the cooperation and integration of different actors’ efforts in the area of disaster management.

Climate change framework

Institutions

*T*he Ministry of Nature Protection is the mandated ministry for climate change in Armenia, and is responsible for the coordination of the UNFCCC commitments. Within the MNP, the Atmosphere

Air Protection Policy Division is the focal division. In addition, a Climate Change Information Center has also been set up under the MNP, with assistance of UNDP, to assist in preparing the National Communications under the UNFCCC and for the implementation of climate change mitigation and adaptation projects. Public information is also one of its key activities (www.nature-ic.am).

In Armenia, climate change research is undertaken by ASHMMS, in particular by its Scientific-Applied Center which is comprised of divisions of climate research, applied climatology, digital modelling of hydrometeorological processes and atmosphere pollution studies. The Climate Research division conducts regional and national studies based on global and regional models simulations. It applies statistical downscaling, under which climate change scenarios for the territory of Armenia are developed, taking into account global changes.

Policies, strategies, programmes

Approximately 70 programmes relating to environmental issues have been financed by the Government of Armenia. Most are focused on biodiversity and desertification, which are also relevant to climate change (MNP, 2010).

The Climate Change programmes are mainly focused on climate change vulnerability assessments and the identification of adaptation measures (ibid). Some of them, as listed in the State National Communication on Climate Change (SNC), include:

- The assessment of water-temperature and radiation on crops yields via modern approaches;
- The assessment of the changes to water resource availability in large river basins in Armenia;
- The development of methodologies for assessing and forecasting drought conditions and the associate losses to agricultural crops, as well as piloting the methodologies in Armenia's regions;
- The development of a methodology for forecasting crop yields across Armenia.

In spite of these activities, the domains of disaster risk reduction, development planning and climate change remain as distinct frameworks and are sub-optimally integrated within programmes and implementation plans of relevant ministries and agencies in Armenia.

5.2 Major activities ongoing or upcoming in the field of CRM

From a climate risk management or adaptation perspective, most programmes are implemented with donor assistance. Some of the relevant programmes and their areas of focus as listed in the SNC include:

- *Assessment of climate change impact on the economy of Shirak region*, which identified several adaptation measures based on a vulnerability assessment;
- *Social-economic impact of climate change in Armenia*, which assessed the impact of climate change on water, agriculture, energy, forestry and natural hazards, and identified adaptation measures;
- *Assessment of climate change impact on Lusadzor community of Tavush region*, which observed trends as well as projected changes to climate at the community level in order to identify climate proofing options for development activities as well as priority adaptation measures;
- *Assessment of climate change impact on water resources in the Marmarik River basin*, which studied the vulnerability of Marmarik river basin at three time horizons (2030, 2070 and 2100) and the possible economic impact. Adaptation measures were identified, along with economic benefits.
- *Climate change related risk assessment in Ararat region*, in which public perceptions of climate risks were assessed in several communities;

- *Adaptation to climate change impact in mountain forest ecosystems of Armenia*, which identified climate related risks and appropriate response measures for implementation.

5.3 Capacity assessment for CRM

A capacity assessment for climate risk management has been undertaken utilising the World Resources Institute's National Adaptive Capacity framework (WRI, 2009). The assessment results are summarised below.

Assessment function

In Armenia, there is experience and expertise in the preparation of hazard maps for landslides and to some extent for mudflows and floods. Several landslide hazard maps have been undertaken in recent decades and the information is available from respective agencies and ministries that conducted the work, such as the Ministry of Urban Development or the Ministry of Emergency Situations. There is no organized effort, however, to map other climate-related hazards.

Despite these achievements, vulnerability mapping for the same hazards is not undertaken to the same extent. As a result risk assessments are largely unavailable. Furthermore, there is no coordinated effort to involve all the sectorial ministries and departments in a comprehensive risk assessment.

All the current efforts are focused on extreme events. Climate risk assessment, however, is not confined to extreme events alone, as climate parameters that impact bio-physical systems develop different symptoms at different frequencies. The impact of many parameters is not analyzed. Qualitative impacts could include the drop in quality of high-value horticultural produce due to temperature-variation. Climate risk assessments are not institutionalized in a systematic manner, thus opportunities exist for further improvement in Armenia.

Climate risk assessment should not be perceived as purely focused on the extremes, but also upon lower thresholds that could affect bio-physical systems of socio-economic relevance. For example, April, May and June are months in which risks consolidate with respect to climate parameters. These are months when horticulture, plants and trees are at critical stages of development. Weather events, such as early frost, hailstorms or insufficient rainfall, could severely impact production. The first requirement is the development of a flowering calendar of different horticulture crops, based on which thresholds of each of the hazards, or combinations of hazards, can be measured. This system is yet to be established in Armenia. There is also an indirect impact from climate risk on the crop and cropping system, as well as animal husbandry, in form of diseases. Weather factors influence either the rise of these diseases or magnify their impacts. There is a need to understand the relationships between weather parameters, disease patterns and the impact on crop yields.

In addition, existing risk assessments do not consider the cascading impact of occurrences into other sectors of the economy. For instance, the agricultural impact is felt in the agro-processing and manufacturing sectors which, in turn, are felt in the services sector and by extension the larger economy. Current efforts are not sensitive to these linkages.

There are several on-going development programmes and activities related to infrastructure, energy and water management. Considering the observed trends, as well as the projected trends, a risk assessment to identify emerging risks in these sensitive sectors has not been undertaken.

Risk assessment functions are not linked from the sectorial department at the national level with the marz and community levels, in order to undertake and update risk assessments through periodic ground proofing processes.

Prioritization function

The sensitivity of key economic sectors in Armenia such as agriculture and agro-processing is well established above. There is no systematic diagnosis of climate risks encompassing both extremes and non-extremes which have a significant impact on crop production systems, as happened in 2006. As such, there are no informed and prioritised activities to address climate risks in Armenia.

The lack of assessment and prioritisation has in turn led to low allocations for these sectors from public finances. For instance, the agriculture and agro-processing sectors are the most affected by climate risks, but there is no organised effort to provide budgetary resources for climate risk management in these two sectors. Overall, these sectors get less than two percent of the budgetary provisions for routine functions (see Table 5.1). The allocation for these sectors in 2012 has in fact decreased by more than 70 percent compared to previous year (2011), despite the increasing impact of climate on these vulnerable sectors.

Table 5.1: Budgetary allocation for sectors relevant to CRM in Armenia

	Budgetary Expenditure	Budget in Million US$		
		2011	2012	2013
1	Agriculture, Forestry, Fishery And Hunting	111.03	33.90	34.70
	• *Agriculture*	*20.83*	*19.22*	*19.86*
	• *Forestry*	*1.98*	*1.91*	*2.09*
	• *Irrigation*	*88.22*	*12.77*	*12.75*
2	Rescue Service	10.43	10.43	11.23
3	Environment Protection	22.28	10.97	11.11
4	Social Protection	667.81	668.05	717.78

Source: NSS RA, 2010

Furthermore, most of the budgetary allocation goes towards salaries of government staff. In addition, the programmes undertaken are mostly for routine agriculture activities and subsidies (see Table 5.2). Hence there are significant gaps in assessing climate risks and prioritising of interventions.

Table 5.2: Budgetary allocation for agriculture programmes in Armenia

Programmes	Budget allocation (million Drams)		
	2012	2013	2014
Seed Quality Testing and State Measures for Plant-Variety Expertise	51.1	54.3	55
Agro-Chemical Examination and Soil Fertility Improvement Works	48.1	51.7	52
State Support to Agricultural Land Users	550	550	550
Forests Preservation Services	708.7	779.6	779.6
State Monitoring of Forests	54	58.2	58.2
Plant Protection Measures	150	150	150
Artificial Insemination Activities	5.7	5.1	4.5
Vaccination of Livestock	1000	1051	1051
Implementation of Quarantine Restrictions by the Veterinary Police Platoon of the Police under the RA Government	40.2	44.2	44.2
Implementation of Preventive and Diagnostic Services on the Basis of Monitoring Laboratory Expert Examination of Plants Quarantine and Vegetative-Sanitary Status of Agricultural Plants	72.1	78	78.2
State Order for Laboratory Diagnosis of Agricultural Livestock Diseases and Implementation of Expert Examination of Foodstuff and Raw Materials of Livestock Origin	190.9	209	221.1
Support for the Improvement of Phytosanitary System and Professional Skills	5.8	5.8	5.8
Services Aimed at Food Safety	10	10	10

Source: NSS RA, 2010

Coordination function

With regard to disaster risk management, coordination needs to be further strengthened. For instance, several ministries, regional administrations and local bodies are involved in landslides management. According to the Government's decision, N1, of 11th January, 2007, the landslide disaster management national concept was adopted. The concept assigns the Ministry of Urban Development as the responsible state agency for landside risk management in Armenia. As a result, a comprehensive analysis of the situation was conducted by the ministry. It assessed 131 landslides throughout Armenia, provided detail information on physical parameters, as well as trends and possible losses for each registered landslide per community. It also developed a 2007 to 2015 landslide risk mitigation activity plan which included an estimation of the annual financial resources required for each case. The total allocation was 7,139 million AMD (equivalent to US$ 18 million). Only small amounts were allocated to address the damage from previous disasters. Efforts undertaken for landslides studies, mudflow assessments, and flood risk assessments need to be continued in a coordinated manner.

Other short-comings relate to the absence of an integrated system for sharing research and learning outcomes among ministries and agencies. Several of the risk assessment studies undertaken remain confined to the agencies which implemented them and results are not shared freely for incorporation into the plans and programmes of other ministries and agencies. A further constraint is the lack of capacity and absence of coordination mechanisms at the community and marz levels where such information needs to be utilised (UNDP, 2010). Furthermore, studies undertaken at the local level are not integrated to create nation-wide information systems.

Although the Ministry of Emergency Situations is designated at the responsible institution, the DRR function is distributed among several government agencies, and is not coordinated. CRM is a technical function that involves several ministries and departments with varying roles (see Table 5.3).

Table 5.3: Roles and responsibilities of institutions in Armenia mandated with CRM

Institution	Role and Responsibilities Relevant to Climate Risk Management
Ministry of Emergency Situations	Responsible for emergency mitigation, preparedness, and response/recovery, and to (i) develop a program for risk assessment and emergency preparedness; (ii) respond to and aid recovery from emergencies; (iii) coordinate a government-wide policy on risk mitigation. Responsible for the development of joint, multi-agency emergency management policies to support these priorities. Comprised of specialized agencies, such as: the National Survey for Seismic Protection; the State Reserves Agency; the National Center for Technical Security (NCTS); the Armenian State Hydrometeorological and Monitoring Service; the State Fire Inspectorate; "Crisis Management State Academy" and the Rescue Service.
Armenian State HydroMeteorological and Monitoring Service (ASHMMS)	
	Monitors weather, climate, ozone layer, water resources, and other hydro-meteorological elements; collects, processes, and stores the information; produces projections on dangerous, unfavorable hydro-meteorological, climatic phenomena such as floods, storms, extreme rises/drops of atmospheric temperature, hurricanes, thunderstorms, vortexes, dust storms, heavy precipitation, hail, avalanches, freezing, ice-slicks, hard frosts, heat, hot dry wind, and droughts; and develops weather and hydrological and agro-meteorological projections. Hydrological activities comprise monitoring of water flows in and out of Lake Sevan, monitoring of water inflows to large reservoirs, 94 observation posts (including four lakes and four reservoirs) of river basin networks, daily two-fold monitoring of water elevation, outlets, temperatures, and freezing. ASHMMS shares, with ministries and agencies as well as through mass-media, forecasts of dangerous weather, heavy frosts and freezing.
Anti-Hail	
	Although hail prevention is now under the Ministry of Agriculture (MoA), it will be transferred to the MES. In marzes bordering Turkey, the MoA has 30 anti-hail stations that transform hail into rain. Each station protects about 200 hectares from hail damage.
Armenian Rescue Service	
	Responsible for emergency management, public awareness, training responders, plans for natural disaster

Institution	Role and Responsibilities Relevant to Climate Risk Management
	response and coordinates emergency response and recovery. The ARS has 3,700 employees including firefighters, rescuers, and trainers; it has eight departments, five sections, as well as detached and regional subdivisions, including the *State Academy of Crisis Management, Public Information Center, Rescue Forces Department, and the Crisis Management Centre.*
Ministry of Nature Protection	Responsible for policies in the areas of environmental protection and sustainable use of natural resources. The overall coordination of the UNFCCC, as with all other environmental conventions, is located within the Ministry of Nature Protection. The Ministry is also Designated National Authority for Clean Development Mechanism projects in Armenia. The MNP is responsible for some elements of disaster management and has a role in flood, desertification, and landslide mitigation. MNP assists in the development of landslide mitigation policy.
Atmosphere Air Protection Policy Division	Responsible for developing and implementing policies to protect the environment, prevent and reduce pollution, undertake and update emissions inventories, implement studies on elements impacting the environment.
State Environmental Inspectorate (SEI)	Performs supervisory functions and applies responsibility measures for environmental protection, use and reproduction of natural resources.
Environmental Impact Monitoring Centre (EMIC)	Responsible for environmental impact monitoring; the development and implementation of policies, strategies and state programmes; the observation, assessment and prediction of environmental issues.
Water Resources Management Agency (WRMA)	Responsible for issuing and enforcing water use permits and establishing water quotas, especially during droughts. The WRMA receives data and information from the EMIC and ASHMMS on the allocations of water use permits, groundwater and discharged water quality, and on the detection of from metals or other elements. It coordinates development activities and reviews annual revisions of the national water management plan.
Ministry of Agriculture	Responsible for developing and implementing policies in the field of agriculture, forestry and food provision management. It has initiated a study on the introduction of an insurance system for agricultural production. It also pays out compensation to farmers whose production has been adversely impacted by various hazards, such as droughts, hail, mudflows, spring frosts (over US$ 3 million was paid as compensation between 2003 and 2008). The Ministry also takes measures for controlling pests (locusts, rodents etc).
Soil Utilization and Improvement Department	This unit has three major functions: policy on agricultural land use and reclamation; coordinating activities to improve fallow land use, agricultural lands and pasture management; coordinating programmes to prevent submergence, saturation, and flooding of agricultural land. The Government has also authorized the MoA to mitigate and prevent flooding in order to protect communities and valuable economic zones, specifically by strengthening river banks.
Landslide Mitigation	Landslides that affect water systems such as rivers or canals are the responsibility of MoA. The MoA is studying landslide mitigation options, including the possibility of resettling communities in landslide-prone areas, and engineering improvements.
State Committee of Water Management under the Ministry of Territorial Administration	Regulates drinking water, irrigation, and land reclamation/drainage. For irrigation, the SCWM regulates the discharge of water from reservoirs and receives funding from the central government for cleaning the canals. The SCWM is installing early warning systems in villages around the dams and reservoirs, and developing evacuation plans for communities. During an overflow, the SCWM would coordinate with the Armenian Rescue Service (ARS) on preventive measures such as evacuation. In a dam or reservoir emergency, SCWM staff contact the ARS directly. The Water Supply Agencies under the SCWM are responsible for dam operation and maintenance; the SCWM does not intervene operationally in serious emergencies, except to inform the ARS so that it can intervene.
Ministry of Urban	Responsible for the Law on Urban Development, as well as a number of legislative acts, through which the urban/territorial planning is regulated and different architecture-engineering projects

Institution	Role and Responsibilities Relevant to Climate Risk Management
Development	are developed and implemented. The Ministry is responsible for spatial planning, which is a critical function for an area with disaster risks. It is responsible for improving urban development legislation, including building codes for earthquake-resistant construction, which are crucial to reduce seismic risks. It is also responsible for the management of landslide disasters by recommending resettlement of landslide-prone communities and engineering improvements.
Ministry of Health	Implements awareness raising activities on health care, provides advice on the sanitary-hygienic consequences of natural disasters, organizes anti-epidemic and quarantine activities as well as the timely arrival of medical teams to communities affected by natural disasters. It provides medical assistance during evacuation and care for the injured. During any disasters and/or any emergency situation the medical aid disease prevention is carried out by Ministry of Health. The Ministry is responsible for the quality control of drinking water, as well as water in reservoirs/ponds located in and around settlements. The Ministry's subordinate agencies are healthcare units, hospitals, maternity hospitals, policlinics, the State Hygiene and Anti-epidemiological Inspectorate, psychiatric clinics and dispensaries.

Source: Adapted from Global Facility for Disaster Reduction and Recovery, Disaster Risk Reduction and Emergency Management in Armenia, "Armenia: Institutional Arrangements for Disaster Risk Management and Reduction", 2009.

The efforts being undertaken by these different institutions are not yet coordinated in a systematic enough manner to treat climate risk management as an organised effort. However CRM needs a cross-sectorial effort, which involves the integration of all relevant ministries for the management of the risks connected with climate change and natural disasters, as well as their long-term implications for development. It is worth noting, however, that this may be about to change due to the establishment of an Interagency Council on the Implementation of the UNFCCC Recommendations on 2ndOctober 2012 according to the decree N 955-A of the Prime Minister of the Republic of Armenia. The Interagency Council is chaired by the Minister of Nature Protection and involves representatives from all the Ministries and key agencies working in this area. In addition, an Interagency Working Group is being established which will develop policies and development strategies for the implementation of UNFCCC requirements and recommendations.

Hydrometeorological information management function

The ASHMMS undertakes systematic observations at 47 meteorological stations, 34 agro-meteorological stations, seven hydrological river basin stations and 94 hydrological gauges (including four lake and four reservoir sites). Five stations are in operation for the last 100 years, 36 stations are more than 50 years old and at least 45 are more than 30 years old. Thus the ASHMMS has a rich database including observations covering all climate parameters. Different divisions of ASHMMS prepare and provide a wide range of knowledge products and forecasts, including observation data, specialized climate information, climate forecasts and relevant specialized consultations on the application of information. ASHMMS continuously monitors climate conditions in Armenia based on observation data received from the all meteorological stations, producing basic monitoring products, such as anomalies of air temperature and the total precipitation at monthly, seasonal and annual timeframes. Short range forecasts (covering one to five days) are produced on daily basis for the maximum, minimum air temperatures, precipitation, and occurrence of meteorological phenomena. ASHMMS also provides monthly and seasonal predictions for temperature and precipitation, using products from the Global Producing Centres. Hydrological products include observed river flows from the main rivers basins, Lake Sevan inflow and outflow and hydrological forecasts.

The current use of weather and climate information and the additional requirements of users are listed in Table 5.4.

Table 5.4: Current use of weather and climate information and additional requirements

Current use of weather and climate information	Additional Requirements
Armenian Rescue Services	
Frost: ASHMMS forecast 10 days ahead and updated daily is used. *Sharp increase (or decrease) of temperature:* information on temperature increases in spring that lead to floods is closely watched and utilised. *Wind Velocity and direction for all provinces*- useful for managing fire responses. *Hydrological information:* river discharge, water levels. *Surface wind and Upper Air:* Surface wind information to assess conditions in the case of chemical or industrial accidents; upper air for pollutants/ radioactive accidents, which inform measures to reduce impact in the case of strong winds (>25 mps). *Floods:* April/May/June comprises the high-risk season for floods. At 2 pm everyday ARS gathers the water level and discharge information for all rivers. ARS compares recorded levels with danger levels and when it is close to the threshold issues alerts about potential flooding.	*River Basin Information:* coverage needs to improve both temporally (higher frequency) and spatially (all networks and basins). *Wind:* More data on wind- surface/ upper/ profiling is required. Can focus on priority areas- such as heavy industries/ nuclear plant. *Forest Fire:* Need more accurate information; perception that frequency has increased. *Forecasts containing probabilities:* Need more accurate, information on the probability of an event occurring. *Spatial Coverage:* coverage and resolution is not adequate. *Establishment of GIS:* essential to include all parameters such as water level, flow speed and discharge. *Snowmelt:* need depth and density of snow cover to estimate the quantity of water during the melt in order to assess flood risks.
Agriculture	
Uses five day weather forecasts	Needs longer-term forecasts (monthly and seasonal) for comparison. Routine planning should be based on information from ASHMMS. Longer lead-time forecasts could enable better planning of operations.
Health	
Based on forecasts of extreme temperatures, the Health ministry activates its awareness programmes. For instance, information is provided through news media on precautions and safety during a heat wave. It also uses forecasts to plan awareness activities during the rainy season in order to prevent intestinal diseases. Decisions to initiate anti-malarial activities (spraying for pest eradication) consider, among other factors, the information on daily temperatures provided by ASHMMS. Summer time monitoring of open water sources by ASHMMS enables action to prevent waterborne infectious diseases due to warmer water promoting the growth of microbes. ASHMMS raises awareness of UV exposure and encourages precautions.	Indices (for example a wind chill index) from ASHMMS could be helpful for raising awareness and encouraging precaution.
Energy & Natural Resources	
ASHMMS information is critical for hydro-power generation. Use of its data on rainfall, water levels, wind maps, solar radiation, extreme winds, frost and extreme cold weather ensures the safety and security of gas and power supply	ASHMMS information at a high resolution is important because the Ministry plans to meet at least 30 percent of energy demand using renewable energy sources (hydro, geo, wind, solar, etc). Information on variations in these parameters due to climate change is critical for long-term planning.

Current use of weather and climate information	Additional Requirements
State Committee of Water System	
One of the main users of ASHMMS information, as it has to provide water to the public and for other uses. It receives warnings on extreme events and monitoring information. Use the weather conditions and forecasts and discharge information from ASHMMS. A decision such as whether to use Lake Sevan water, and how much to release, requires accurate forecast information. Use of river water, over reservoir water, for irrigation is governed by the information from ASHMMS.	
Transport and Communication	
Daily information on weather conditions and forecasts is particularly useful during winter for anticipating and clearing snow and other measures to keep roads (national and regional) safe for travel.	Increased resolution and density of observations

The ASHMMS has established capacities for monitoring and observation. Despite this, it lacks the capacities to identify the thresholds of each hydro meteorological parameter and their impact on sensitive sectors and activities. It also lacks the computational and technical capacities to generate user-specific, needs-based information.

Connected to the above, stakeholders within government lack the capacities to assess the impact of forecast scenarios, to develop appropriate responses and to communicate effectively with risk-prone communities. Of concern, risk-prone communities are not involved in the risk information system.

Thus an information system, linking ASHMMS with sectorial stakeholders, through continuous feedback arrangements, and based on community and local institutional involvement is lacking in Armenia.

Climate risk reduction function

The influence of slow-impact climatic factors on horticulture and high-value crops is not currently diagnosed. In the absence of such a system, possible options to reduce risks are neither identified nor practiced.

The available knowledge on climatic factors is not used to design programmes to minimise the exposure and sensitivity of critical operations in the agriculture, horticulture and agro-processing sectors. Agricultural zoning that proposes specific crops, horticulture and animal husbandry in specific marz assumes normal climate. Forecast information is also not effectively utilised to undertake risk reduction measures.

The sections above indicate that due to the sensitivity of sectors at least US$ 500 million of productive activity is at risk from climate related factors. There are several options available to reduce this risk. The vulnerability of sensitive sectors to different patterns of climate is not studied nor are decision support tools available so that informed decisions can be taken for managing agriculture, water resources, infrastructure, energy and health.

For example, an opportunity exists to better utilise forecasts in the agriculture sector as a tool of managing climate risks, as the forecasts have a high level of accuracy up to 15 days in advance (for other options see Table 6.3).

KEY MESSAGES (CURRENT CLIMATE RISK MANAGEMENT SYSTEM)

- Though the Armenian economy is climate sensitive, there are potential climate risk reduction options available, which are not put into practice due to lack of relevant policies, institutional mechanisms and capacities.

- Climate risk management is carried out in a diffused manner in three distinct domains, namely disaster risk management, climate change adaptation and development planning.

- There is no mechanism to assess climate risk related losses and damage in a holistic manner. The conventional risk assessment approaches capture only the direct physical damage and do not capture its derived impact on industry, services, human health and the national economy, hence climate risks are underestimated.

- Climate risk assessment procedures do not adequately capture climate thresholds that affect societal systems through bio-physical pathways. In addition, climate risk assessments do not capture emerging risks considering climate change observations and socio-economic developments.

- As the assessment system is under-developed, the prioritisation of interventions to address climate risks is weak.

- CRM is undertaken in different ministries and departments with little coordination. Though climate information systems exist, capacity gaps among stakeholders within government result in an underutilisation of the available climate information.

- Preliminary CRAs encompassing the impact on agriculture and the cascading effect son other sectors indicate a potential loss in the agriculture sector of US$ 450 million annually, totalling US$ 2.8 billion between 1998 and 2010 (the estimates are based on the registered cases, however the real losses could be even higher) thus there is a compelling argument for investment in climate risk reduction.

6. RECOMMENDATIONS FOR CLIMATE RISK MANAGEMENT

Strengthening national capacities for CRM

Institutional arrangements

For sustainable planning and implementation, it is necessary to widen the knowledge base, provide scientifically sound information for decision-making, raise public awareness of existing climate risks and mechanisms for reducing these risks, develop strategies, and guide stakeholders on how to deal with uncertainties.

Climate risk management for different sectors is the responsibility of numerous Ministries and Agencies listed in section 5.3 above. Coordination mechanisms among authorities have to be well developed, which implies both coordination among various sectors as well as linkages between the central and local levels. In this respect, the recently established Interagency Council on the Implementation of UNFCCC commitments of Armenia will obviously play an important role. It will require the development of appropriate programmes and the establishment of relevant working groups.

Climate knowledge and information can be a very efficient tool for managing climate risks. Therefore, ASHMMS, as the only state authority providing climate services in Armenia, such as hydrometeorological and climate information, should be enhanced. In addition, technological advancements in this area should be regularly integrated into its work. It is necessary to implement a long-term modernization plan to reach the technical and scientific capacities of advanced hydrometeorological services.

Certain measures need to be taken in order to strengthen the institutional mechanisms for reducing climate risks. It is necessary to conduct an overall assessment of climate risks and future changes in the context of climate change, to raise awareness among policy makers, to communicate the climate risks assessment results to policy makers and a wide range of vulnerable stakeholders, to develop the capacities of stakeholders through a series of consultation seminars, and to interpret the climate risks and explain the impact for vulnerable sectors.

It is recommended that the Government examine best practice worldwide concerning the use of climate information and its inclusion in development programmes. The distribution of the case studies among all stakeholders can serve as an example of the application of climate risk information sharing for decision-making. These measures will result in evidence-based planning and the inclusion of CRM in development strategies at a national and regional scale.

Capacity development

It is important to commence with a training component in order to promote awareness of the scientific possibilities and the technical capabilities which modern NHMSs have to deliver. This includes the provision of state-of-the-art services and advanced weather forecasts to communities and different economic sectors. It also concerns the requirements that advanced data production systems put on data management, scientific and technical staff and managers. The training component should include:

- Training of middle-management and experts of general management in strategic and annual activity planning, leadership skills, management of human resources, financial resource management, international cooperation and EU research programmes, regional cooperation, operation of a modern NHMS, technical possibilities and futures, cooperation with customers and end-user sectors, dissemination of information;
- Training of IT staff;
- Training of core personnel on:

    - the generation of custom forecast products for agriculture, water resource management, energy, infrastructure disaster management and rescue services (training workshops, secondments, systems improvement);
    - the downscaling and improvement of lead-time weather/forecast products for local (marz) needs;
    - the development of specialized information/products tailored to users requirements;
    - advanced hydrometeorological forecasting, particularly focusing on very short range forecasting (now casting) services;
- Training of experts on the interaction with customers, marketing of climate services and products, and the development of tailored products;

In order to motivate the core staff, to promote rapid development and to establish adequate objectives for development, it is necessary to arrange technical visits (Visiting Scientist Programme) to advanced NHMSs (for example through bilateral cooperation agreements), and to offer training-by-doing during these one to three month working trips abroad.

It is vital to build the capacities of service users and other stakeholders. With this in mind, specialized seminars for farmers are recommended, focusing on the most vulnerable communities. It is proposed to identify partners, from among agriculture-related organizations, the national authorities and from specialists within ASHMMS, who will conduct consultations and training workshops in the field.

Guidance material should be developed and distributed among the target communities, which will include methodologies for assessing impact and socio-economic analysis. It is very important to develop and provide hazard risk maps containing historical information about hazardous events and the damages caused by the particular events. These maps should be updated on a regular basis (for example once every two years).

Climate services information system

Effective management of climate risks requires the availability of sufficient and accurate climate data as well as its effective communication to end users. It further requires access to complementary information that can inform risk analysis, such as the location and characteristics of vulnerable groups that may be exposed to particular hazards, as well as topographic and soil data, and economic development projections. Therefore, it is extremely important to further strengthen and improve the climate risk information system, which will involve:

a) *Assessment of users' information requirements*. Different users within the agriculture sector have different climate information requirements, such as those growing crops or raising livestock. Within the same group of users, information requirements are guided by planning horizons.
b) *Tailoring of climate information to users' needs*. Forecast resolution and lead-time vary with user type, for example climate projections of 20 to 25 years lead-time at a spatial scale required for adaptation.
c) *Characterizing and packaging uncertainties associated with climate information at different timescales*. Uncertainties inherent in longer-lead-time climate information need to be characterized and communicated to facilitate their application in a risk management framework. This would also prevent untrained and non-technical users from immediately perceiving and attributing climate variability-related phenomena to global warming.
d) *Interpretation and translation of climate information*. Climate information should be interpreted in terms of sector-specific thresholds that are jointly determined by institutional users and communities.

e) *Application of a risk management framework.* Climate information is applied in planning and decision-making, taking into account the risks due to uncertainties in the information.

f) *Demonstration of the economic benefits of using climate information and adopting the CRM framework.* Appreciation of the economic and social benefits derived from investing in an end-to-end climate risk management system, in terms of time, human resources, and finances, shall lead to the adoption of the CRM framework and the institutionalization of CRM system.

g) *Improvement of the mechanisms for the provision of climate information and ensuring wide access.* There are certain limitations and restrictions in the provision of climate data and information, which are regulated by Armenian laws, legal acts, WMO Resolutions N 40 and 25, ASHMMS statutes, orders of the director and contracts concluded between producer(s) and users of this information. It is envisaged to consider improving access to specialized climate information and making it freely available to government authorities, especially policy makers.

The following actions have to be taken in order to strengthen and improve climate information production and dissemination, as well as to make it widely used by decision makers and major stakeholders:

- To arrange the capacity development of senior and middle management, as well as key experts and specialists in management, operations, technical development and cooperation between customers and the Hydrometeorological Service;
    - Concerning investment in modern technology, the highest priority has to be given to actions which will significantly improve the capacity to collect data efficiently from the observation network and process information from Global Production Centres, regional entities and other advanced services. This will produce timely and reliable climate information (with a longer lead-time) for national and regional climate risk management;
- To establish a database with long lead-time series from representative climate and hydrological stations, as well as socio-economic data from different sectors, in order to improve planning and risk assessment within different economic sectors (such as energy, water resources, agriculture, transportation and health);
- To conduct applied climate research with specific user groups and develop knowledge and tools for multidisciplinary studies/applications, such as climate-agriculture, climate-health, climate-tourism, climate-water;
- To improve forecasting of weather and hydrological phenomena, with a particular focus on forecasting and dissemination mechanisms to important weather-sensitive economic sectors (based upon their share of GDP, or volume of preventable losses);
- To develop a Long Range Forecasting (LRF) System (on a national and regional level), which impliesresearch on the climate variability of Armenia, development of climate predictions and application of the forecasts to different socio-economic sectors, especially in agriculture, energy and water resources, by exploring management decision options in these domains to efficiently introduce LRF services;
- To develop human capacities in the area of LRF through a series of training seminars on LRF, as well as the verification and development of a decision support system with involvement of international experts from widely recognised institutions (for example IRI, ECMWF);
- To develop an integrated drought monitoring system (with meteorological, hydrological, agricultural dimensions), based on drought assessment methodologies, drawn from indices applied in countries with similar climate conditions;

- To study global circulation patterns influencing drought conditions across Armenia in order to improve drought prediction, and based on the results produce long range (monthly, seasonal) drought forecasts for different regions of Armenia;
- To develop a drought-water management model for the effective assessment, prediction and use of water resources (such as surface water, Lake Sevan and water reservoirs);

It is also necessary to promote the image of ASHMMS as an internationally, nationally and scientifically recognized entity, addressing burning issues and providing possibilities for international cooperation. To achieve this and to promote the production of better, more cost-effective and scientific services to the communities it is necessary to modernise the institutional structure and management**.**

Recommendations for decision makers and stakeholders

For further improving the quality and content of climate information, it is necessary to consider the needs and requirements of different users. With this purpose a survey on the "Use of Climate information by stakeholders and awareness about climate change" was conducted by ASHMMS in the regions of Shirak, Gegharkunik, Vayots Dzor and Lori. The total number of the survey respondents was 100, of which included 32 percent were employees of regional services of the MES, 28 percent were farmers and individuals, 25 percent were representatives of non-governmental organizations related to nature protection, and 15 percent were representatives of educational institutions. Ninety-five percent of the respondents were familiar with climate change and more than half responded that there are visible manifestations of climate change in their region. The change of air temperature and precipitation, as well as extreme climate phenomena were marked as indicators of climate change. Fourty-three percent considered that the air temperature rose; moreover 64 percent observed an air temperature rise during the summer months, whereas 38 percent indicated warmer winter months. In terms of precipitation, 53 percent of the respondents noticed a reduction in the summer, whereas 56 percent indicated a rise of spring precipitation.

The main recommendations based on the survey are as follows:

a) Financial investment is necessary for strengthening the infrastructure for reducing the threat of unfavourable climate hazards and for taking preventive measures.
b) It is necessary to elaborate a detailed and reliable adaptation plan for vulnerable economic sectors in order to confront climate change risks.
c) It is necessary to create conditions for an effective and reliable early warning system in order to provide stakeholders with timely information on expected hazards.
d) The provision of long-range forecasts (monthly, seasonal, climate) is of utmost importance, as is it necessary for effective organization and planning of economic activities for all sectors of the economy.
e) It is necessary to conduct and disseminate research analysing climate change impact on different sectors and ecosystems.
f) The elaboration of realistic climate change scenarios of decadal scale and their provision to stakeholders is of great importance.
g) It is necessary to include climate change factors in strategic plans which would then be implemented in different economic sectors.

It is important to strengthen the scientific and socio-economic understanding of potential climate risks facing different economic sectors and improve the institutional capacity for mitigation and response. Many users consider it very difficult for the ASHMMS to provide added value to climate information, currently available freely on the internet, with its existing policy, observation network, forecasting methods and financing. They are, however, not well aware of the possibilities for the ASHMMS service's provision of better and more customer specific products. Therefore, it is critical to be proactive in enhancing the dialogue and cooperation with the target sectors.

This could be achieved through the establishment of National Climate Forums with the involvement of climate information producers, end users and other stakeholders. It implies constructive discussions on the impact of climate risks, preparedness and preventive measures, and the use of available information in activities. It is also recommended to implement a pilot project to assess the vulnerability of communities, identify the most vulnerable, and take measures to reduce climate risks and the negative impact on agriculture products. It is necessary to ensure the collection of feedback from the users, especially farmers, which will further improve the services and products.

Transform CRM into a priority sector

Agriculture risk management

In Armenia agriculture risks are managed by a large number of small farms, which are involved in diverse crop production. Since climate risks cannot be managed in isolation, it is essential that certain prerequisites that facilitate normal agricultural operation and enable appropriate responses to climate risks be in place. For example, some of the prerequisites to manage the risks associated with droughts and dry spells are functional irrigation systems that enable the use of advance information when available, and reliable agriculture extension services to generate other response options.

Risk Management for wheat and potato crops

Wheat crops face risks from drought and dry spells, hailstorms, early frost and pest outbreaks, which result in yield reduction, or loss of the entire harvest. In order to reduce these risks, in the case of droughts or dry spells, it is recommended to monitor winter snow, to provide estimates in advance concerning the total water availability in summer for irrigation, and in some cases to switch to less water intensive crops, for example barley instead of wheat. If information on early frost is available and distributed, then farmers may undertake watering and other protection measures. It is necessary to monitor also the climate conditions favourable for pest outbreaks, in order to issue an advice for preventive spraying and the application of insecticides.

Risk Management for horticulture

Horticulture crops face risks from frosts, hailstorms, droughts and floods. The impact of these hazards and the respective risk reduction options, as well as recommendations to address constraints in adopting these options, are described below (see Table 6.1)

Table 6.1: Impact of climate on horticulture and possible risk reduction options

Hazards	Impacts	Risk reduction options
Frost	Loss of the harvest	Deep pruning and further forming Fertilization Intense irrigation Fuming/Smoking Application of chemicals to address plant pests and diseases
	Withering of trees	Intense irrigation Fertilisation Application of chemicals to address plant pests and diseases
	Loss of next year's harvest	Intense irrigation Fertilisation Application of chemicals to address plant pests and diseases
Hail-storm	Loss of the year's harvest	Deep pruning and intense nutrition Application of chemicals to address plant pests and diseases Intense irrigation

Hazards	Impacts	Risk reduction options
	Partial loss of next year's harvest	Intense irrigation Application of chemicals to address plant pests and diseases
	Loss of product quality	Intense irrigation
	Destruction of newly planted trees	Planting of new trees Intense irrigation
Drought	Partial loss of harvest	Hoeing and intense irrigation Cleaning of brooks Mulching Drip irrigation
	Partial withering of trees	Intense irrigation and cleaning of brooks Drip irrigation
	Loss of product quality	Intense irrigation
Floods	Demolition of water canals and field tracks	Construction of bank protection layers Planting of field protection and bank protection trees
	Destruction of the humus layer of soil	Planting of field protection and bank protection trees Intense fertilisation
	Loss of harvest and demolition of orchard trees	Planting of new trees

Risk management for livestock

Severe drought is a major problem facing livestock. Fodder management is the one of the recommended options. Better preparation for winter by storing hay stock and zoning of areas for winter pasture could also be undertaken.

Risk management for agro-processing

Ten to 15 percent of the risks is passed on to agro-processing industries by the agriculture sector due to a reduced availability of raw materials, which results in a reduction in the volume of processed materials. Climate risk management needs to assess the variables that will inform the need for alternate arrangements for inputs to maintain production. The risk-prone industries include high-value fruit, milk and meat processing as well as animal husbandry.

In addition, agro-processing facilities are unable to make use of their full capacities due to a shortage of raw materials, as a result of reduced production, and lower demand due to diminished rural incomes.

A special focus is needed for assessing the nation-wide impact of climate risks and to provide prioritised interventions to minimise impact. In Armenia, about 15 to 20 percent of GDP depends on agriculture and agro-processing, which is influenced almost every year by climate risks. Every ten to 15 years, this could increase to between 20 and 25 percent. The total cost of climate risks could be between US$ 75 million to US$ 450 million depending on the severity of the event and the effect on different sectors. The potential damage is much more than the annual agriculture budget, current around US$ 75 million.

Additional resources are necessary for research efforts and experiments to demonstrate the value of climate risk management interventions, in reducing risks not only to agriculture but also to agro-processing industries.

State intervention could provide raw materials from alternative sources and other forms of support. All stakeholders involved in supply chain management would benefit from capacity development concerning climate risks.

Climate risk assessment for agriculture

ASHMMS provides a range of climate information products that are useful for managing agriculture risks. There is a need to incorporate climate risk assessment in designing cropping systems in order to delineate agro-climatic zones and identify cropping patterns ideal for these locations in consultation with farmers.

Agriculture risk management in Armenia needs to incorporate a four-layered climate risk assessment, comprising:

a) The climate parameters which could affect the quality and quantity of agricultural produce, especially horticulture products promoted for export. Temperature, humidity, soil moisture levels should be incorporated in the risk assessments, which is currently not the case for routine risk assessment procedures and systems. These parameters have an impact on production almost every year and constitute about 20 percent of the risk. Therefore, they need to be assessed and incorporated properly into risk assessments.
b) Extremes that affect crops at critical stages at the community level but that are not significant enough to capture the attention of actors at the provincial or national levels. These represent about 15 to 20 percent of the risks in agriculture and horticulture. There needs to be an arrangement to determine the critical thresholds of different crops at varying stages in their growth and the potential impact of these parameters on production.
c) Severe hazards that affect three to four marzes (out of a total of ten) with large-scale impact causing severe damage, constitute seven to ten percent of the losses. These need to be assessed with reference to climate risks on certain products such as fruit crops and vegetables.
d) Widespread, national-level events that take place once in ten years may result in up to 40 percent of damages in a particular year.

These four different levels of risks need to be assessed thoroughly, using sophisticated research inputs, involving applied research institutions, stakeholder institutions and communities. This assessment requires a coordinated effort and the capacity building of institutions involved in the process.

Capacity requirements for addressing cross-sectorial priorities

Climate change downscaling and application

Many of the priorities identified by sectors could be met by building capacities to filter climate change information according to the sectorial needs, along with the identification of potential impact as well as possible response options. Absence of this vital capacity and information is a major constraint for sectorial actions.

Strengthening observation, monitoring, information generation and application

More robust automated systems for the observation and monitoring of weather and climate parameters are an essential prerequisite for providing better information to meet the specific requirements of key sectors such as agriculture, water resources and health. This will enable them to manage both current climate variability and longer term climate change issues. This will also enable Armenia to build a robust database to monitor and measure in greater detail atmospheric and environmental changes, which can better guide the implementation of appropriate adaptation actions.

In addition, the capacity to package climate information has to be created jointly by ASHMMS and stakeholders. Existing efforts in this direction, including interactions between ASHMMS and users, such as the Ministry of Health and the ARS, need to be strengthened.

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