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The Socio-Economic Impact of Climate Change in Armenia

Yerevan 2009

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FOREWORD

"The Socio-Economic Impact of Climate Change in Armenia" report breaks new ground in considering concerns to one of the biggest global challenges posed to humanity – climate change and its impacts on our society and economy.

There is a scientific consensus that even if global emissions of greenhouse gases are brought to zero, climate change will continue over the course of the next 20-30 years. The impacts of climate change are already felt across the globe and Armenia is not immune. Since climate change is inevitable, there is a strong and urgent need for the country to mainstream adaptation to development processes and policies.

Hence, Armenia has developed an analysis of the consequences of climate change in the country. This is a pilot process undertaken by UNDP in only a few countries around the globe. It aims at supporting the national dialogue on the socio-economic implications of climate change and provides a policy option for adaptation at the country level. The report provides evidence and analysis on the economics of climate change specific to Armenia and contributes to a more detailed understanding of potential costs of climate change impacts in the absence of adaptation policies and measures at the national level. It particularly focuses on priority sectors for adaptation, namely water, agriculture, energy and forests, which are subject to the anticipated impacts.

The impacts of climate change entail significant risks, therefore the Government, businesses and the civil society will need to be engaged in the discussion, and consider climate change as a real challenge for country's sustainable development.

This study is not meant to be a comprehensive overview of all aspects of climate change; however it provides economic analysis and recommendations for decision-makers that need to manage the impacts of climate change by minimizing negative impacts and maximizing adaptation opportunities.

Dirk Boberg

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ABBREVIATIONS

A2 scenario	High emission scenario
AMD	Armenian Dram
ANPP	Armenian Nuclear Power Plant
B2 scenario	Rapid stabilization scenario
BCH	Biosafety Clearing House
BPC	Basin Public Councils
CBD	UN Convention on Biological Diversity
CJSC	Closed Joint-Stock Company
CoP	Conference of Parties to the UNFCCC
EBRD	European Bank for Reconstruction and Development
GDP	Gross Domestic Product
GEF	Global Environment Facility
GET	GEF Trust Fund
GHG	Greenhouse Gas
GoA	Government of the Republic of Armenia
IPCC	Intergovernmental Panel on Climate Change
KfW	German Bank for Reconstruction and Development
LDCF	Least Developed Countries Fund
LULUCF	Land use, land use change and forestry
MCC	Millennium Challenge Corporation
MNP	Ministry of Nature Protection
NSS	Armenian National Statistical Service
NWP	National Water Program
OECD	Organization for Economic Co-operation and Development
PCB	Polychlorinated Biphenyl
POP	Persistent Organic Pollutants
PPCR	Pilot Program for Climate Resilience
PPP	Purchasing Power Parity
RWMU	Regional Watershed Management Units
SAICM	Strategic Approach to International Application of Chemicals Management
SCCF	Special Climate Change Fund
SNCO	State Non-commercial Organization
SPA	Strategic Priority on Adaptation
TACIS	Technical Assistance to the Commonwealth of Independent States
UNDP	United Nations Developmet Programme
UNFCCC	UN Framework Convention on Climate Change
US DOE	United States Department of Energy
USAID	United States Agency for International Development
USD	United States Dollar
WB	World Bank
WHO	World Health Organization

EXECUTIVE SUMMARY

There will be an enormous change in Armenia's climate over the next century. Temperatures will rise; precipitation, river flow and lake levels will fall; and heat waves, droughts, landslides, mudflows, and floods will become more common. Unless quick action is taken on large-scale adaptation measures, it is unlikely that Armenian families, their livelihoods, or their economy will be unscathed by climate change. Armenia's poor and especially its rural poor populations will be particularly vulnerable to the effects of climate change. If climate adaptation is not addressed by the state and is instead left to private actions and private purchases, the result will be an unequal distribution of adaptation and climate protection. Richer households will be able to afford to insulate themselves from the worst effects of climate change, while poorer households will suffer from preventable injuries to their livelihoods and standard of living.

The social impacts will include: an increased incidence of illness from heat waves as temperatures rise; a shortage of water and an increase to electricity tariffs as competing needs collide; food shortages or increased food prices as agricultural productivity falters; and an increased incidence of dangerous and damaging landslides, mudflows and floods as dry soil and deforestation coincide with extreme storms. There will also be very serious economic impacts: business revenues, jobs, household income, and consumption will all fall as agricultural production declines and electricity tariffs grow; smaller-scale economic losses are expected in electricity generation and forestry damages.

Losses from diminishing agricultural productivity could, on their own, exceed 8 percent of Armenian GDP by 2100. The scale of damages, however, must be analyzed not in terms of today's economic activity but instead in the context of future economic development. Armenia still has immense reserves of idle industrial and agricultural capacity in comparison with production levels under the Soviet Union. The potential for economic growth is large, but in the absence of significant adaptation measures climate change could easily impede that growth. Armenia's future economic development will depend on the decisions that the current generation makes about investments in adaptation.

Climate projections for Armenia

Climate change caused by greenhouse gas emissions is scientific fact. It is occurring and it will continue to occur as long as the concentration of greenhouse gases in the atmosphere is too high for the Earth to process in its natural cycles. The remaining controversy regarding climate change is not whether average temperatures will increase and weather patterns will change, but rather, how much and how quickly average temperatures will increase in each region of the world, and exactly how weather patterns will change over time.

To predict the scale and timing of future climate change, climate scientists use all of the best information available to them regarding past trends in temperature, precipitation and other weather phenomena, and the known properties of greenhouse gases. Climatologists also base their predictions of the future on scenarios regarding economic and population growth, and the expected increase to current emissions that will result from this growth.

The climate projections presented in this report consist of two main scenarios that span the range of likely outcomes: business-as-usual and rapid stabilization. In the business-as-usual scenario, global emissions of greenhouse gases grow larger over time, as has been the case for the past two centuries. In the rapid stabilization scenario, a global agreement is struck in the next decade to rapidly decrease emissions over time. It is important to understand that even in the best case scenario – if global emissions of greenhouse gases could be stopped altogether in the next decade – climate change would still continue because of the gases that have already been released into the

atmosphere. Global action on greenhouse gas emissions can dramatically reduce the impacts of climate change, but it cannot stop these impacts from historic emissions.

If business-as-usual greenhouse gas emissions continue worldwide over the next century (which the IPCC calls its "A2 scenario"), the national scenarios forecast the likely increase to Armenia's average annual temperature to be as high as 4.5ºC in the lowlands and 7.0ºC in the highlands. It should be emphasized that these are enormous climatic changes: for example, just 5ºC separate the climate of Stockholm from that of Paris.

The increase in Armenia's average annual temperature under the high emissions scenario is expected to take place throughout the year. In this scenario, Yerevan's average annual temperature will climb from 11.6°C today to 16.6°C by the end of this century. In Vayk, where the greatest temperature increases in Armenia are expected, the average annual temperature under the business-as-usual scenario are projected to rise to 19.2°C, very close to that of today's climate in Tel Aviv or Beirut.

With a continuation of global business-as-usual emissions, Armenia's average annual precipitation is expected to decrease by as much as 9 percent over the next century. Expected changes to precipitation vary enormously across the nation, but even in areas that are expected to have an increase in precipitation, higher temperatures can mean more evaporation and less run-off. The consequences of increased evaporation are less soil moisture and large reductions in river flows.

The biggest reductions in precipitation are predicted for Yerevan and the Ararat Valley – 30 percent less precipitation in 2100. In those mountainous areas that will see a reduction in precipitation, like the eastern slopes of Lake Sevan, decreases in snow cover can be expected, which will greatly reduce spring run-off and river flow.

Changes in river flow in the Kura-Aras river basin with a 10 percent decrease in precipitation and just a 2ºC increase in the average annual temperature – a much smaller temperature increase than the current business-as-usual forecast – have been predicted to reach as high as a 50 percent loss of flow. More conservative, Armenia-specific calculations forecast a still alarming 24 percent decrease in river flow over the next 100 years.

Finally, changes in average annual temperature and precipitation often disguise some of the most devastating effects of climate change: temperature extremes and changes in weather patterns. With increased average temperatures, heat waves – clusters of days with extremely high temperatures and detrimental health impacts – will become more common. Higher air temperatures, increased evaporation, and greater concentrations of water vapor increase the likelihood of severe storms that, in the Armenian context, may result in natural disasters like floods, landslides and mudflows.

Summary of socio-economic impacts from climate change

Changes to temperature and precipitation on this scale over the course of less than one century are extremely likely to have far-reaching effects on many aspects of social and economic life in Armenia. Ultimately, the scale of climate change damages will depend upon what individual citizens do to adapt, what businesses do, and – perhaps most importantly – on what allocative and adaptive policies the Armenian state puts in place. Inherent in discussing state action are the questions as to whether sufficient funding can be found to support adaptive policy measures and how quickly these policies can be implemented. In this report, social and economic impacts from climate change – high temperatures and heat waves, water shortages, reduced agricultural production, reduced electricity production and price increases, damage to forests, and natural disasters – are each described in detail and subjected to socio-economic analysis; in addition, potential adaptation measures to address each type of damage are discussed. Executive Summary Table 1 (below) provides a brief summary of each category of climate damages.

Executive Summary Table 1:
Summary of Socio-economic Impacts of Climate Change in Armenia

Climate Impact Category	Social Impacts	Economic Impacts	Research Needs
High temperatures and heat waves			
Increased incidence of heat stroke and other heat-related maladies	Worse health outcomes, some mortality	Unknown	Project the future frequency of heat waves in Armenia, estimate the health impacts of heat waves in Armenia
Greater demand for electricity for air conditioning	Access to air conditioning only available to richer households; poorer households go without	Unknown	
Water shortages: loss of 10-27% of precipitation and 24% of river flow by 2100			
Less water available for irrigation and more areas may need to have irrigation systems.	Reduced agricultural productivity; loss of food security for the rural poor	2-5% of GDP lost annually in agriculture production by 2100; an additional 2-3% of GDP lost in the food production industry annually by 2100	
Decreasing water level in Lake Sevan	Ecosystem damages and a loss of cultural heritage	Unknown	
Decreasing groundwater reserves	Insufficient drinking water would have serious health impacts	Unknown	Investigate the state of Armenia's current groundwater reserves; project the impacts of climate change on reserves
Declining water quality	Increased incidence of water-borne diseases like malaria and cholera	Unknown	Project the impact of climate change on Armenia's water quality
Reduced agricultural production			
Climatic zones move upward by 200 to 400m in elevation changing the appropriate mix of crops in each area	Reduced agricultural productivity; decline in food security among the rural poor	Unknown	
Less water available for irrigation and more areas may need to have irrigation systems		2-5% of GDP lost annually in agriculture production by 2100; an additional 2-3% of GDP lost in the food production industry annually by 2100	
Changing weather patterns and extreme storms cause crop damage		Unknown	
Loss of 19-22% of sub-alpine and alpine pastures and 3% of total pasture-land by 2100		Unknown	Estimate the current productivity Armenia's pastures; project changes in pasture productivity due to climate change
Reduced electricity production			
Partial loss of hydro-electricity generation		0.25% of GDP in lost electricity revenues each year by 2100	

Greater share of thermal electricity generation, which may drive up electricity tariffs	Higher prices will make electricity less affordable, especially for poorer households; less electricity used for heat could have serious health impacts	Unknown	
Damage to forests: loss of 1/3 of Armenia's forest-land by 2100			
Climatic zones move upward by 200 to 400m in elevation; precipitation decreases and evaporation increases making forest environments more arid	Ecosystem damages; losses to biodiversity; less firewood available to heat homes	0.04% of GDP lost each year in forestry revenues, on average each year from now until 2100	
Natural disasters			
Increased incidence of landslides, mudslides, and floods	Severe property and infrastructure damage will disrupt livelihoods; some injuries and loss of life	Unknown	Projected likely impacts of natural disasters in Armenia with climate change

Higher temperatures and heat waves

Armenians are at risk of impaired health due to heat waves. Vulnerable populations like the elderly, the very young, and the infirm face special risks during heat waves including mortality. As temperatures and incomes increase, demand for air conditioners may grow, along with demand for residential electricity, but purchases of air conditioners are unlikely to increase quickly: an air conditioner costs 250,000 AMD (or more), almost half of the average Armenian income in 2006. Given the boom in new construction (especially in the capital), there is an opportunity for structures to be built with heating/cooling efficiency in mind. This will lower the amount of recurring costs for heating and cooling as well as make the properties more valuable in the longer term.

Water shortage

With decreased precipitation and increased evaporation from higher temperatures, average river flow in Armenia will decrease 24 percent by 2100. Low river flows reduce the availability of water, especially for agriculture and power generation. No recent information or modeling exists on the impact of reduced precipitation and river flow on underground aquifers. This is a high priority area for new research; without accurate information on supplies of subterranean waters and their rates of recharge it is impossible to project the available of Armenia’s primary source of drinking water over the short-term or long-term.

Reductions in water supply will coincide with an increase in demand as households require more drinking water because of high temperatures and farms require more irrigation water because of hotter, drier conditions. In addition, the health consequences of reduced water supplies for drinking and sanitation purposes have the potential to be very serious.

Armenia’s agriculture sector, which accounts for 20 percent of GDP in direct agricultural production and an additional 10 percent of GDP in food manufacturing, is highly dependent on irrigation water from rivers, many of which will suffer large-scale reductions in flow as climate change progresses. More than half of Armenia’s arable land requires irrigation; with climate change more land will fall under this category but less river water will be available. The actual impact on agricultural production will depend on policy decisions regarding the allocation of irrigation water among farms, and the allocation of all water resources among all uses, as well as the introduction of farming practices that require less water. These policy decisions will include important choices regarding how much money will be invested in repairing the existing water delivery system to limit leakages.

Crops, which are more vulnerable to drought than pasture and far more likely to require irrigation, represent 14 percent of GDP. The following measurable impacts are expected:

- A 24 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 expected loss in yield for grapes would be 21 percent and for winter wheat, 25 percent.
- Total losses to the agricultural sector would amount to 65 to 145 billion AMD, or US$190 to 420 million (with an average impact of 105 billion AMD or US$300 million). To put this in perspective, this would be an annual loss of 2 to 5 percent of current levels of GDP (3 percent on average).
- Depending on policy choices, reductions in agriculture production could also impact on Armenia's food production industry and thereby have a wider-reaching effect on the economy. If agricultural losses result in losses to the food production industry of the same scale – 15 to 34 percent reduction – the additional loss to GDP would range from 2 to 3 percent.

Reduced agricultural production

Armenia's 340,000 very small farms – many less than 1 hectare in size – produce 98 percent of all crops and livestock. The rural population is highly dependent on a stable climate for both food and income, and the urban population relies on family farms' agricultural productivity to avoid food shortages, limit food imports, and keep food prices stable. More than 40 percent of Armenia's agricultural production is for self-consumption on farms, and is essential to food security in rural areas.

Climate change is projected to reduce agricultural productivity in Armenia. Higher temperatures will result in an upward shift in zones appropriate to each crop. High temperatures also contribute to increased evaporation and lower soil moisture; when coupled with reduced precipitation in much of the country, the incidence of drought is very likely to increase. More frequent droughts and lower levels of soil moisture coincide with a reduced supply of irrigation water. Pastures are also expected to deteriorate with climate change and many alpine and sub-alpine pastures will disappear altogether.

The combination of higher temperatures and lower precipitation, across most of Armenia, will result in productivity losses as the demand for irrigation – already unmet on more than half of the lands that currently require irrigation – outstrips supply. The expansion of irrigation will be limited both by infrastructure and by a loss in river flow over the next century. At the same time, changing weather patterns may cause damage to crops and agricultural lands in ways that cannot be predicted by average temperature increases or changes in annual precipitation levels. With climate change, weather patterns are expected to become more erratic with more severe storms. High winds and heavy rains can damage crops, reducing yields. Severe storms can also trigger natural disasters like landslides, mudflows, and floods, which can cause damage to agricultural lands and irrigation infrastructure.

Total pasture lands in Armenia are expected to decline by 3 percent, with 19 to 22 percent losses in sub-alpine and alpine areas. Little data is collected in Armenia on the productivity of pasture lands; the latest data is for 1992, and recent projections are based on the best guesses of local agronomists. Because of the importance of livestock (which rely for part of the year on grazing) in the Armenian diet and agricultural economy, and the likely vulnerability of pastures to climate change, this is a high priority area for new research.

Reduced electricity production and price increases

Armenia depends on its rivers to provide power generation to its hydro-electric plants and cooling water to its nuclear and thermal generation plants. If the country's current economic growth continues in the decades to come, demand for electricity will increase, as will the demand for

competing uses of water for agriculture and industry. As rates of river flow decline with climate change, the country's ability to meet its full domestic electricity demand will be at greater risk. If water reserves and releases are well managed, small changes in precipitation and evaporation need have little impact on hydro-electric generation. Regrettably, the projected changes to Armenia's river flows are neither small in scale nor temporary. Reduced river flow coupled with an increased demand for irrigation water is very likely to reduce electricity generation from these plants.

Currently, Armenia's total annual electricity supply is roughly equal to its total annual electricity demand. Armenia's lowest demand, lowest supply and highest exports of electricity all coincide in summer. Future increases to summer demand from more industrial production, more general domestic use, and especially more air conditioning use could combine with lower hydro-electric capacity to cause temporary shortages. Any shortage in electricity has serious consequences for households and businesses.

With existing infrastructure, the reduction in river flow expected from climate change could cause a loss of 261 million kWh annually in hydro-electric generation by 2100. At 30 AMD per kWh (the most common day-time residential tariff), those losses amount to 7.8 billion AMD, or US$23 million in lost electricity revenue each year.

Socio-economic impacts will depend on the season in which production is reduced, and the reaction of prices to electricity and energy shortages at home and abroad. A shortage of electricity could impede both industrial production and Armenia's energy-intensive irrigation delivery systems. The most likely result, given that two new thermal plants are planned to become operational in 2010-2011 and a new nuclear plant is planned to become operational in 2016, is an increase in electricity tariffs and the avoidance of any shortages.

At present, there is no surplus electricity generated in Armenia, however, planned additions to thermal and nuclear generation capacity are substantial and competition for domestic use of electricity is only likely under three circumstances:

1) if summer demand increases significantly due to greater air conditioning use with higher temperatures and higher incomes;
2) if economic development causes significant increases to industrial production and household electricity demand; or
3) if the new thermal plants are not built on schedule or a new nuclear plant is not built to replace Medzamor by 2016.

If electricity production falls below demand, some category of use will be curtailed or increased imports of electricity will become necessary and the allocation of this scarce resource would be a political choice. While it is impossible to predict market conditions for the next 30 years (much less 90 years), the current generation costs for hydro-electricity are lower than those for existing nuclear generation, which are far lower than those for thermal generation, again suggesting that a change in electricity tariffs is likely if hydro-power is a declining share of total power. Thus, energy efficiency measures to reduce electricity demand can actually be seen as both a mitigation measure and an adaptation measure.

Damage to forests

Armenia's forests will shrink in size and deteriorate in biodiversity with climate change. Higher temperatures will cause an upward shift in the zones appropriate to each species; trees species may have trouble migrating quickly enough to remain in a zone in which they can thrive. Reduced precipitation and increased evaporation will cause an encroachment of drought-tolerant species into existing forests. Where drought-tolerant species do not migrate quickly enough, dead zones or areas of extremely limited vegetation may develop. These dead zones will reduce the recharge of underground aquifers and promote run-off, which can result in landslides and mudflow. Arid conditions also make forests more vulnerable to wildfires and bloody-nosed beetles.

While total potential losses in forest area from climate change – including damages from changing climatic zones (a 5 percent loss of total forests), beetle infestation (21 percent), and forest fires (8 percent) – cannot be estimated with any precision given existing data, the potential territory at risk from climate change lies somewhere between 21 and 34 percent of the nation's forested lands, a devastating loss. Such large scale losses to its forests would very likely reduce the availability of firewood, at present the source of heating fuel for 10 percent of Armenian households. At the same time, winter temperatures are expected to increase, which may reduce demand for wood for heating. A consistent supply of heating fuel, especially at higher elevations, is essential to maintaining health and well-being in the cold Armenian winters.

The national forest authority, Hayantar SNCO, estimates the average value of Armenian forest land – in timber and firewood values – at 1,115,000 AMD per hectare. The loss of 21 to 34 percent of forests, or 70,000-114,000 hectares, can be valued at 78-127 billion AMD or US$230-370 million. The average annual cost over the period 2010 to 2100 would be 0.03 to 0.04 percent of GDP. This calculation does not include any value for the ecological losses of such large-scale deforestation, or the economic value of other forest industries, primarily hunting, gathering of plants and mushrooms, and grazing.

Natural disasters

Climate change will increase the incidence of severe storms, flooding and other natural disasters. These kind of costly impacts, however, are the most difficult to predict. It is impossible to say where or when storms will strike; it can only be said that weather will become more erratic and that, on average, Armenia will suffer more frequent severe storms leading to natural disasters.

Armenia suffers an average of 10 billion AMD or US$33 million in damages from natural disasters each year. Landslides and mudflows are among the most devastating of these disasters. Landslides are caused by erosion, changes in subterranean water levels, and earthquakes. There are more than 2,500 active landslide areas totaling 1,200 sq.km, or 3.9 percent of all land area. Over one-fifth of all communities are affected by active landslides as are 3 percent of the nation's roads.

Mudflows are saturated deposits of water, silt, stone and mud that flow like slow rivers. Mudflows are caused by deforestation and arid soils, which reduce the ability of the land to absorb water into underground aquifers. Instead, rainfall, snowmelt, and improperly applied irrigation waters run off the surface causing erosion and picking up dirt and stones as it flows. Both landslides and mudflows occur primarily on areas with steep grades – mountain slopes and hillsides. Much of Armenia's land area is prone to mudflows.

Armenia is also subject to numerous floods each year. Almost every marz suffers some flooding each year, but some marzes are by far the most susceptible. From 1994 to 2007 the marzes with the highest cumulative incidence of floods were: Gegharkunik (159 floods); Lori (85); Shirak (72); and Aragatsotn (71).

Climate change will increase the incidence of landslides, mudflows and floods. Arid conditions, increased deforestation and forest damages, and heavy rainfall in extreme storms can create the exact conditions in which landslides, mudflows, and flooding are most likely to be generated. Both the increase in the incidence of landslides, mudflows and floods and the portion of damages for which climate change will be responsible are highly unpredictable. This is an important area of further research; while these impacts can never be predicted with any precision, much more can be done towards identifying the most vulnerable areas and the types of adaptive measures that would protect property and lives all around Armenia.

Policy recommendations

Many of the best climate adaptation measures that Armenia can pursue are also important steps for economic development; these are "no-regrets" adaptation measures – no extra cost is imposed by

climate change. In other words, they are measures that will improve economic and social outcomes regardless of climate change. Even some adaptation measures that do not directly aid economic development can be characterized as no-regrets because of their low or negative costs and high probability of leading to much larger positive economic outcomes given changes in climatic conditions. "Low-regrets" measures are those for which the benefits of avoiding climate damages outweigh the costs of new infrastructure or other responses. In the context of climate change, there should be no regret about funds spent to avoid what would have been costly future damage. Key policy recommendations include:

Repair and expand poor infrastructure: Aging water and power generation infrastructure must be replaced, rebuilt and expanded. The results will be profound: an expansion of irrigated agricultural land; increased economic security for farmers during times of drought; additional water and power capacity with which to expand Armenia's industrial sector; redundancy in the event of failures of electricity supply or short-term increases in demand; and protection from future climate impacts that will decrease the supply of water and electricity while increasing the demand for these utilities.

Integrate climate change adaptation in current plans for economic development – especially for energy production: Perhaps the most important case in point is that of planned increases to (and replacements of) power generation infrastructure. The new nuclear plant and thermal plants must be planned in the context of higher temperatures and decreased river flow for cooling water. Hydro-generation plans must take into consideration predicted river flow throughout the lifetime of this infrastructure.

Plan for economic development: Public investment, infrastructure development and climate adaptations must all be planned in the context of a growing economy. If Armenia sustains its high growth rate without increasing the efficiency of resource use, it will need more water and power infrastructure to accommodate both increasing industrial use and the higher rates of consumption that come with higher incomes. Choices regarding climate adaptation, too, should be viewed through this lens: the future Armenian economy will be much larger and so too will some of the potential climate damages. This is particularly important for land-use planning and building codes. The likely increased risks from natural disasters such as floods, mudslides, and landslides can be diminished by effective infrastructure and urban planning. Furthermore, adjusting building codes to create well-insulated, and energy efficient buildings will not only decrease net greenhouse gas emissions and decrease energy costs for consumers, but also lead to better adapted buildings for a future climate.

Plan for a low-carbon economy: Investments made today in fossil-fuel-intensive power generation or other energy-intensive infrastructure appear to be short-sighted. While Armenia is unlikely to be called upon to reduce its greenhouse gas emissions in the next one or two decades, longer term global mitigation efforts may require lower per capita emissions from Armenia by the middle of this century if not sooner. A perspective that includes the lifetime of planned infrastructure is essential for making choices today that will save money in the long run.

Protect rural and low-income communities: Planning for the average climate impact on the average Armenian citizen will do little to protect those most vulnerable to climate damages. In order to protect all Armenians, adaptation measures must explicitly consider the needs and vulnerabilities of rural and low-income households. In effect, this means that the state must take an active role in all adaptation measures through policy setting, appropriate subsidization, price signals, climate risk reduction programs, and public education. It is the role of the state to ensure that poorer families are not left without defenses against negative climate change impacts.

Urgent adaptation measures

To offer the best protection for Armenian households, farms and other businesses, significant climate adaptation must take place in advance of climate damages. Climate changes have already

begun, and their effects will become more pronounced over the next few decades. Rapid implementation of climate adaptation measures is essential to prevent the worst effects of climate damages. Ten adaptation measures discussed in this report stand out as the most urgent.

1) *Support essential research needs with state funding.* There are numerous gaps in Armenian research that – if filled – would reduce uncertainties about likely climate impacts and, therefore, would reduce the costs of climate adaptation. Among the most important research gaps are: health costs of heat waves and other potential health effects of climate change; the impacts of climate change on water quality; the extent of current ground-water reserves and the likely changes to these reserves with climate change; the current health and productivity of pasture lands and the likely climate impacts to these ecosystems; the potential for low-carbon power generation consistent with falling river flows; and the current impacts of natural disasters and the likely effect of climate change on their incidence and costs.

2) *Improve existing water infrastructure in the context of current and future temperatures, precipitation levels, and river flows.* This is likely a "no regrets" measure because the advantages of investment appear to be justified in the current climate conditions and would help with adaptation to future climate change. At the same time, this is a large-scale project that may require additional water diversion between rivers, the replacement of much existing infrastructure, and the expansion of the irrigation water delivery system. In planning such a project, the viability of future agricultural products (during the lifespan of the infrastructure) given likely future climate conditions should be taken into account.

3) *Promote water and energy efficiency in households, farms and other businesses.* Reducing demand is an important step towards avoiding the water and power shortages made more likely by climate change. The state can promote efficiency using monetary incentives, free equipment, public education, regulations on new building designs, and providing technical support. This is a "no regrets" measure because it would save money and resources in the near and long term as well as increase the well-being of people living and working in energy efficient buildings with greater thermal comfort.

4) *Prepare farms for a changing climate.* As temperatures and precipitation levels change, the state can provide agricultural extension services (public education and technical support) to help farmers adjust planting seasons, choose new crops, install irrigation equipment, or adopt a more efficient use of water.

5) *Build redundancy into the existing power generation system.* Redundancy will protect the electricity supply in the event of: a generation failure; a delay in the construction of planned replacements to the power plants; the seasonal cycle of high and low periods of demand; and an increase to demand caused by higher temperatures and increased use of air conditioning. At the same time, any large infrastructure project that will last more than 20 to 30 years should account for expected variability in the climate and input (fuel) prices.

6) *Protect Armenia's forests by funding projects for stewardship, reforestation, pest management, erosion control, and fire-risk reduction.* As climatic zones shift, careful management and replanting can prevent the creation of dead zones. This will also help natural disasters such as mud slides; it may even be a way to reduce net greenhouse gas emissions.

7) *Prepare for natural disasters through prevention and emergency response readiness.* Drought damages can be reduced by improving and expanding irrigation infrastructure or farming techniques. Some floods, mudslides and landslides can be avoided through erosion control, reforestation, and river bed or irrigation canal maintenance. Effective urban and infrastructure planning is also important when controlling for the risk of floods, mudslides and landslides. When disasters do occur, a well-funded and efficient emergency response system – including early warning systems involving close contact between emergency

services and hydro-meteorological services – can greatly reduce loss of life and damages to infrastructure.

8) *Mandate and encourage (through building codes, subsidies and information campaigns) that new buildings are built and older buildings are retrofitted to be acclimated to Armenia's existing and likely new climate.* Warmer temperatures may require better ventilation and/or air conditioning for the good health of their occupants. At the same time, improved building designs and materials can help structures withstand the existing cold winters and hot summers in a cost efficient way. State-funded incentives such as interest rate subsidies for climate-proofing homes can make these changes accessible to all regardless of income.

9) *Provide public education to prepare the population for climatic changes and retraining programs for workers who may lose jobs due to climate change.* Public education regarding the health impacts of climate change and the need for water and power conservation can protect Armenian citizens while enlisted their support in adaptation measures. Job retraining may be necessary if industries like agriculture, food processing or forestry decline with climate change.

1. INTRODUCTION

Responding to climate change represents one of the largest challenges facing humankind today. In the coming decades, the decisions made by policy-makers, businesses, and individuals, will shape how climate impacts the economy and society. Climate conditions – including extreme climatic events – are already impacting the society and economy of Armenia. Droughts, heat waves, winter cold spells, and general climatic conditions shape the livelihoods and lifestyles of the Armenian people as an important factor in the development of the country.

If major efforts are not undertaken on a global scale to reduce greenhouse gas (GHG) emissions which are causing climate change, it is likely that the climate in Armenia will change dramatically, causing new conditions which must be adapted to in the near and long-term future. At the same time, adaptation measures taken today to reduce vulnerability to climate shocks will be helpful in reducing the negative impacts which are expected with climate change.

This report provides a general overview of potential vulnerabilities to climate change and analyzes specific sectors in which climate is an important factor and wherein climate change will likely have a strong impact in the coming century. In particular, the report carries out the following:

- Identifies the climate change impacts considered to be of greatest concern to Armenia;
- Conducts a qualitative analysis of each main area of concern as it relates to the social and economic impacts on Armenia;
- Wherever possible, conducts a quantitative economic analysis based on climate projections for the next century, current conditions in vulnerable sectors, and likely economic impacts discussed in the literature;
- Identifies potential adaptation measures that would reduce Armenia's vulnerability in each of the key impact areas;
- Provides an overview of Armenia's current funding for projects related to environmental protection and/or poverty reduction (or economic development) and potential international funding sources; and
- Makes recommendations for "no regrets" and "low regrets adaptation measures which would help Armenia adapt to climate change while advancing socio-economic development aims.

The Report is divided into three parts - Part 1: The Armenian Context, Part 2: Socio-Economic Impacts of Climate Change in Armenia, and Part 3: Conclusions and Policy Recommendations.

Part 1 provides the human development context and climate change context in Armenia and then discusses their interaction. Part 2 analyzes specific sectors where climate change will likely have a strong impact in the coming century. The specific impacts which this report addresses are: (i) impacts on health (ii) impacts on water resources availability; (iii) impacts on agricultural systems; (iv) impacts on electricity production and consumption; (v) impacts on forests and the economic activity associated with them; and (vi) impacts on natural disasters. Finally, Part 3 emphasizes the areas of greatest concern with regards to potential climate damage, provides key policy recommendations, and lists urgent adaptation measures that are essential to prevent the worst effects of expected climate damages in Armenia.

2. THE ARMENIAN CONTEXT

Armenia lies high up in the Lesser Caucasus Mountains, in the center of the bridge of land in between the Black Sea and Caspian Sea. It is a landlocked country bordered by Georgia to the north, Azerbaijan to the east, Iran to the south, and Turkey to the west. Since its independence from the Soviet Union in 1991, Armenia has maintained strong economic and political relations with Russia, one of its primary trading partners. Armenia's relations with its direct neighbors have been less stable. The conflict between Armenia and Azerbaijan over disputed territories in and near both countries is still unresolved. Turkey, as an ally of Azerbaijan, has also had difficult political relations with Armenia.

Figure 1: Armenia administrative map

In the years since the economic depression and energy crisis that followed independence, Armenia's economy has shown remarkably strong growth, even as its population has fallen due to emigration. Armenia's GDP fell by 40 percent in the four years following its independence from the Soviet Union (see
Table **1**).[1] In the last ten years, Armenia has made a strong recovery with GDP growing by 14 percent per year over much of this period. While the population continues to fall and exports as a share of GDP are still far below their pre-independence levels, GDP per capita is now two times its 1991 level: an impressive achievement. Still, much of the industrial and agricultural productive capacity developed under the Soviet Union today stands idle.

Table 1: Armenian economy and population, 1991-2007

	1991	**1995**	**2000**	**2005**	**2007**
Exports of goods and services (% of GDP)	40.7	23.9	23.4	27.3	19.0
GDP (in billion 2007 US$)	5.21	3.12	4.00	7.12	9.18

[1] World Bank Group 2008

	1991	1995	2000	2005	2007
GDP (in billion 2007 AMD)	1,783	1,066	1,369	2,437	3,139
Annual growth in GDP/period		-10%	6%	16%	14%
GDP/capita (2007 US$)	1,484	966	1,299	2,361	3,058
GDP/capita (2007 AMD)	507,657	330,461	444,244	807,569	1,046,146
GDP/capita annual growth/period		-9%	7%	16%	15%
Population (million people)	3,512,440	3,226,978	3,082,000	3,017,661	3,000,874
Annual change in population/period		-2.0%	-0.9%	-0.4%	-0.3%

Source: World Bank Group 2008

2.1. Economy and population

In 2007, Armenia's gross domestic product (GDP) was 3 trillion AMD (US$9 billion).[2] Of this 23 percent was generated by industrial production and 20 percent from agricultural production (see Table 2).[3] Most industrial production (45 percent) is centered in its capital, Yerevan City, while agricultural production and smaller amounts of industrial production are spread throughout the Armenian countryside (see Table 3 below).[4] Mining contributes 17 percent of total industrial production in Armenia. Most mining operations are centered in Gegharkunik and Syunik Marzes, although some mining takes place in almost every marz.[5]

Table 2: Armenian GDP and its sectors, 2007

	billion AMD (2007)	million US$[a] (2007)	Share of GDP (%)
Armenia GDP 2007	3,149	9,115	
Industry	**716**	**2,073**	**22.7%**
Production and distribution of electricity, gas and water	*125*	*361*	*4.0%*
Mining industry	*114*	*330*	*3.6%*
Manufacturing industry	*477*	*1,382*	*15.2%*
Agriculture	**634**	**1,835**	**20.1%**
Plant growing	*430*	*1,244*	*13.7%*
Cattle breeding	*204*	*591*	*6.5%*
Capital construction	**667**	**1,932**	**21.2%**
Construction of industrial projects	*225*	*651*	*7.1%*

[2] All money values are in 2007 AMD or 2007 U.S. dollars unless otherwise stated. Throughout this report, AMD has been converted to U.S. dollars (and vice versa) using the following rate: on July 01, 2007 1.00 AMD = 0.002895 USD retrieved from http://www.oanda.com/convert/classic.
[3] Central Bank of the Republic of Armenia 2007
[4] National Statistical Service of the Republic of Armenia 2007d
[5] A Marz is an Armenian province.

	billion AMD (2007)	million US$[a] (2007)	Share of GDP (%)
Construction of non-industrial projects	*443*	*1,281*	*14.1%*
Retail trade turnover	**934**	**2,705**	**29.7%**
Services	**543**	**1,571**	**17.2%**
Freight turnover, general purpose transport	**3**	**8**	**0.1%**

Source: Central Bank of the Republic of Armenia 2007

Table 3: Share of industrial production by marz

	Share of total industry	Mining industry	Manufacturing industry	Production and distribution of electricity & water
		As a share of total industry		
Armenia	100%	17%	65%	18%
		Each marz's share of category		
Yerevan city	45%	2%	60%	30%
Aragatsotn	1%	0.1%	1%	1%
Ararat	8%	0.1%	12%	5%
Armavir	5%	0.0%	3%	16%
Gegharkunik	2%	4%	1%	2%
Lori	7%	1%	10%	3%
Kotayk	10%	1%	8%	26%
Shirak	2%	0.2%	2%	3%
Syunik	19%	92%	1%	12%
Vayots dzor	1%	0.0%	1%	1%
Tavush	1%	0.1%	1%	1%

Source: National Statistical Service of The Republic Of Armenia 2007a

Sixty-four percent of Armenia's population lives in urban areas – Yerevan and a few much smaller cities. The remaining 36 percent of the population lives in villages and on farms (see Table 4).[6] It is important to highlight the general poverty of the rural communities; half of this population lives in poverty and almost one-quarter lives in extreme poverty.[7] In general, the rural population is more reliant upon livelihood activities such as agriculture – which are more likely to be vulnerable to climate shocks and future climate change.[8] The share of the rural population living in poverty is highest in the areas of highest elevation where climate changes are likely to be the most extreme, as discussed below.

[6] National Statistical Service of the Republic of Armenia 2008e

[7] In recent years, the population has been shifting slowly away from rural areas towards the cities.

[8] Republic of Armenia 2003: 72. The World Bank (in Republic of Armenia 2008a) defines poor and very poor as follows: Poor population is the population whose average per capita income is more than the food poverty threshold, but less than the general poverty threshold. Very poor population is the population whose average per capita income is less than the food poverty threshold.

The World Bank attributes Armenia's rural poverty to low farm productivity caused by a lack of irrigation, long distances to market, and few employment alternatives. Agriculture is both important to Armenia's GDP and important to the livelihoods of its most vulnerable citizens, the rural poor.[9]

Table 4: Urban and rural population by marz, 2007

Marz	Total (1000s)	Urban (1000s)	Rural (1000s)	Number of Poor	Number of Very Poor
Armenia	**3,222.9**	**2,065.9**	**1,157.0**	**855,977**	**132,430**
Aragatsotn	140.0	33.0	107.0	38,638	3,653
Ararat	275.1	81.0	194.1	74,655	15,208
Armavir	280.2	99.6	180.6	86,733	9,574
Gegharkunik	239.6	79.6	160.0	71,550	6,243
Kotayk	276.2	155.1	121.1	88,896	22,502
Lori	282.7	166.1	116.6	76,140	15,510
Shirak	281.3	107.9	110.4	104,813	10,397
Syunik	152.9	103.7	49.2	38,658	3,209
Tavush	134.2	52.6	81.6	31,537	4,429
Vayots Dzor	55.8	19.4	36.4	6,361	725
Yerevan	1,104.9	1,104.9	0.0	232,638	38,773

Source: National Statistical Service of the Republic of Armenia 2008e

Damages from climate change have the potential to reduce Armenian GDP; this is a central theme of this report and specific sectoral damages are discussed at length in Section 3 below. Just as importantly, these damages have the potential to impede further utilization of Armenia's idle productive capacity and retard further growth in its GDP, another important theme of this report. If Armenia could continue to increase its GDP per capita 15 percent each year, in 15 years it would be on par with current income levels in many countries in Western Europe (an unlikely, but possible scenario). If GDP per capita growth continued but at a slower and more conservative rate of 5 percent per year, it would take 40 years to achieve Western European income standards. Without significant investments in adaptive mechanisms, damages and economic losses from climate change have the potential to slow or even stop this process of development.

2.2. Human development in Armenia

Twenty-six percent of Armenia's population is poor, and 4 percent are very poor as defined by the World Bank.[10] In 2006, Armenia ranked 83rd by the UNDP's Human Development Index[11]. While Armenia has one of the highest adult literacy rates in the world (99.4 percent), it scores poorly in school enrollment (a measure that includes primary through university students) and Purchasing Power Parity (PPP)-adjusted GDP per capita.[12]

[9] Republic of Armenia 2008a

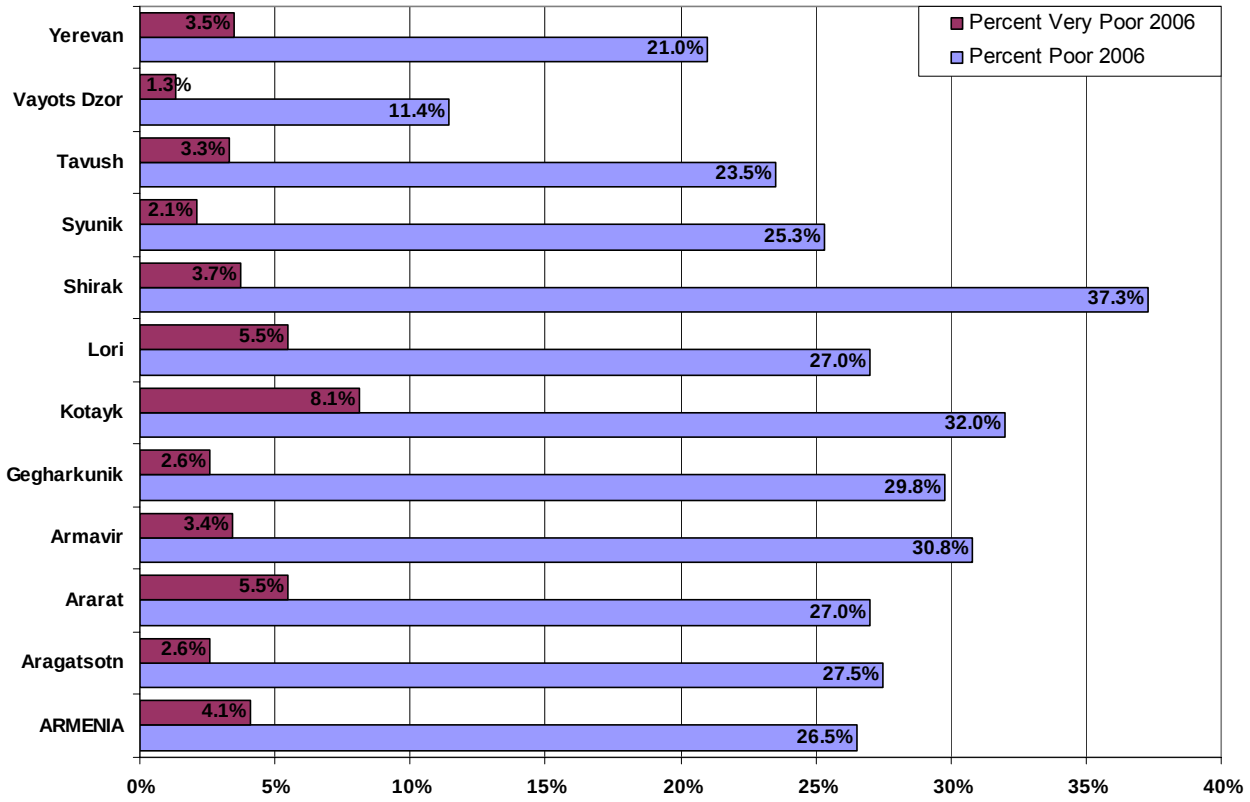
[10] Poor population is the population whose average per capita income is more than the food poverty threshold, but less than the general poverty threshold. The very poor population is the population whose average per capita income is less than the food poverty threshold. (Sources: Republic of Armenia 2003 and Republic of Armenia 2008a)

[11] An index combining per capita GDP, life expectancy, and education levels

[12] UNDP 2007. PPP adjustments to GDP per capita are an output of the International Comparison Project (ICP). According the World Bank: "The ICP uses a series of statistical surveys to collect price data for a basket of goods and services. For meaningful inter-country comparisons, the ICP considers the affordability and price level of necessities and luxuries, which exchange rates ignore. Surveys are held every three to five years, depending on the region. The data collected are combined with other economic variables from countries' national accounts to calculate Purchasing Power

Figure 2 shows the distribution of Armenia's poor and very poor by marz. Twenty-seven percent of the total number of people living in poverty live in Yerevan, as do 30 percent of the very poor. Nonetheless, the share of people living in poverty within each marz is higher than that of Yerevan in every marz but Vayotz Dzor.[13]

Figure 2: Percentage of poor and very poor people by marzes in Armenia



Source: National Statistical Service of the Republic of Armenia 2008e; Republic of Armenia 2008a
Notes: Population data is for 2008. Poverty share data is for 2006.

Yerevan has the highest GDP per capita among the marzes, US$3,700, while Shirak has the lowest GDP per capita at US$1,050 (see

It is important to note that Armenia has a significant amount of idle productive capacity. The damages from climate change could impede further utilization of this idle productive capacity and retard further growth in its GDP. Furthermore, climate shocks due to existing vulnerability to extreme events will – if not addressed – continue to have impacts on socio-economic development, undermining efforts to alleviate poverty and increase the standard of living of Armenians. Thus, climate change needs to be taken into account as a factor for development.

Figure 3).[14] There is a vast difference in the standard of living from Yerevan to the poorest marzes (for more detailed data comparing the economy and population of Armenia by Marz see Appendix D). Vulnerability to the impacts of climate change is enhanced by poverty and inequality. In Armenia, the poorest households will be the most vulnerable to climate damages and least able to afford adaptation measures to protect themselves against its worst effects.

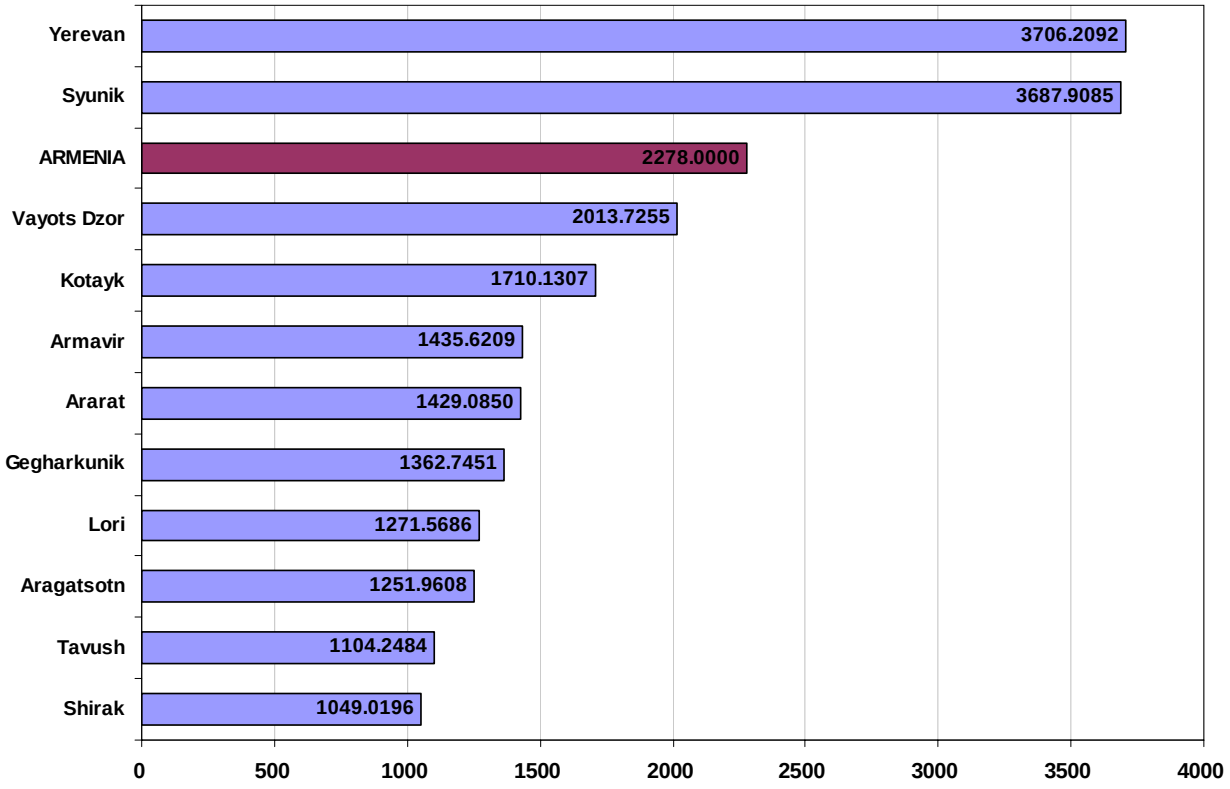
Parities or PPPs, a form of exchange rate that takes into account the cost and affordability of common items in different countries, usually expressed in the form of US dollars. By using PPPs as conversion factors, the resulting comparisons of GDP volumes enable us to measure the relative social and economic well-being of countries, monitor the incidence of poverty, track progress towards the Millennium Development Goals and target programs effectively." See http://www.worldbank.org.

[13] Republic of Armenia 2003, Republic of Armenia 2008a

[14] Republic of Armenia 2003, Republic of Armenia 2008a

It is important to note that Armenia has a significant amount of idle productive capacity. The damages from climate change could impede further utilization of this idle productive capacity and retard further growth in its GDP. Furthermore, climate shocks due to existing vulnerability to extreme events will – if not addressed – continue to have impacts on socio-economic development, undermining efforts to alleviate poverty and increase the standard of living of Armenians. Thus, climate change needs to be taken into account as a factor for development.

Figure 3: Armenian GDP per capita (US$) by marz, 2005



Source: Republic of Armenia 2008a

Damages from climate shocks and natural disasters already have an impact on Armenia and climate change will likely have a negative impact on Armenian economic development in the coming decades. This report analyzes specific sectors which are sensitive to climate and carries out a preliminary assessment of potential long-term damages which may arise if global emissions are not reduced quickly and drastically.

The results of the preliminary analysis show that without significant investments in adaptive mechanisms, damages and economic losses from climate change have the potential to slow or even stop the process of economic development in certain sectors.

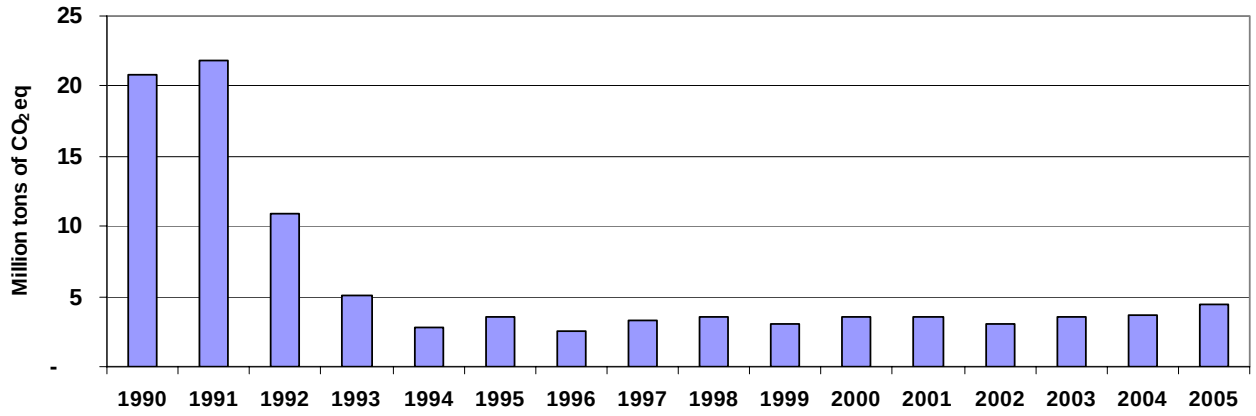
2.3. Armenia's greenhouse gas emissions

Armenia's annual GHG emissions fell from 24.4 million tons in 1990 to just 4.8 million tons in 1995 as a consequence of fuel shortages and rapid industrial decline following independence from the Soviet Union. Since 1995, Armenia's annual emissions have increased only slightly to 5.2 million tons (see Figure 4).[15]

[15] UNDP Armenia 2009

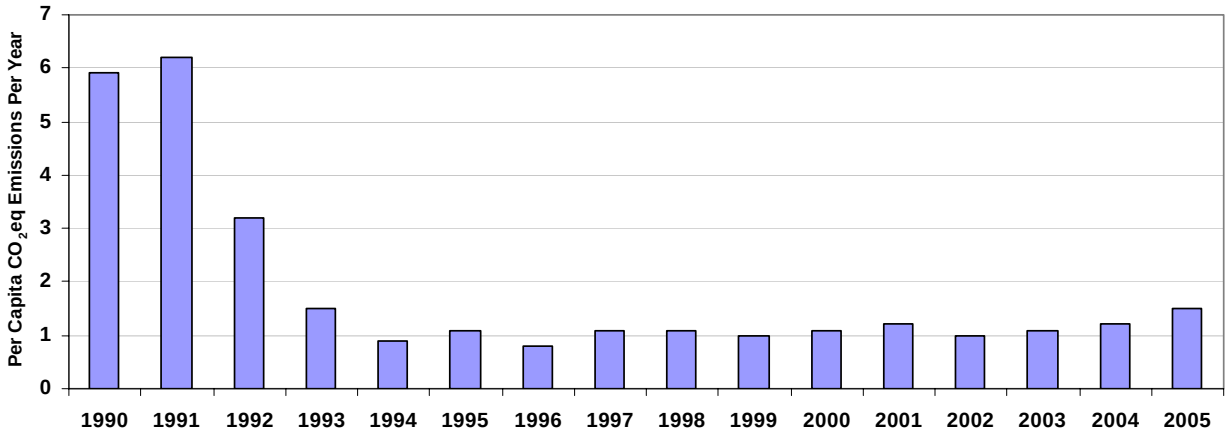
Even before independence, Armenia's per capita GHG emissions were comparable to today's levels for the least emissions-intensive high-income OECD countries (e.g. France, Iceland, Sweden, and Switzerland). This is primarily due to the fact that Armenia has a very high share of non-fossil fuel energy use from nuclear and hydro-generation. In 2005, Armenia emitted 1.6 metric tons of CO_2eq per capita each year, about one-third the global average of 4.3 tons of CO_2eq per capita (see Figure 5).[16]

Figure 4: Armenia's greenhouse gas emissions in CO_2 equivalent, 1990-2005



Source: UNDP Armenia 2008

Figure 5: Armenia's GHG emissions per capita, 1990-2005



Source: UNDP Armenia 2008

In 2004, out of 174 countries, Armenia had the 96th highest emissions intensity, or carbon emissions per unit of purchasing-power-parity (PPP)-adjusted[17] GDP per capita. Looking just at the group of

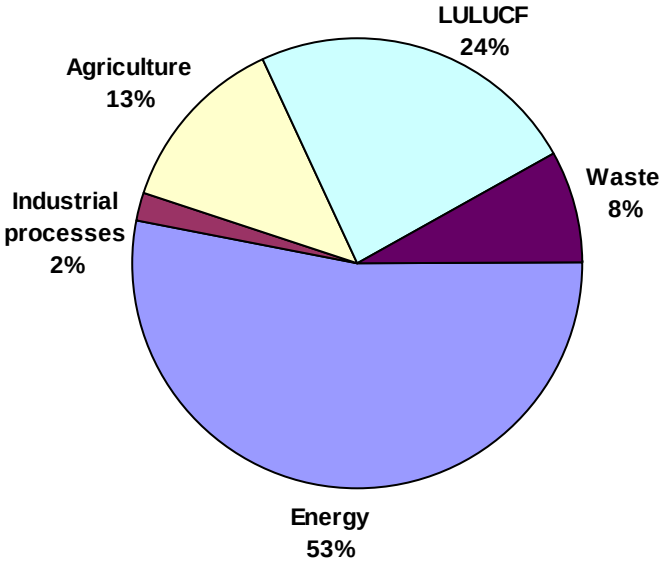
[16] World Resources Institute 2008. The term CO_2eq (CO_2 equivalent) refers to all GHGs combined – including, for example, methane. Different GHGs have different levels of impact per ton released into the atmosphere. To simplify this difference and make calculations possible, tons of GHGs are converted (as to their warming potential) to tons of CO2 equivalent.

[17] PPP adjustments to GDP per capita are an output of the International Comparison Project (ICP). According to the World Bank: "The ICP uses a series of statistical surveys to collect price data for a basket of goods and services. For meaningful inter-country comparisons, the ICP considers the affordability and price level of necessities and luxuries, which exchange rates ignore. Surveys are held every three to five years, depending on the region. The data collected are combined with other economic variables from countries' national accounts to calculate Purchasing Power Parities or PPPs, a form of exchange rate that takes into account the cost and affordability of common items in different countries, usually expressed in the form of US dollars. By using PPPs as conversion factors, the resulting comparisons of GDP volumes enable us to measure the relative social and economic well-being of countries, monitor the incidence of

50 countries closest to Armenia in PPP-adjusted GDP per capita, Armenia has the 33rd highest emissions intensity. The countries that most closely resemble Armenia in terms of PPP-adjusted GDP per capita and emissions intensity are Georgia, Grenada, Namibia, and the Republic of Congo.[18]

Carbon dioxide makes up seventy-one percent of Armenia's GHG emissions. The largest categories of GHG emissions are from following sectors: Energy (53 percent), Land use, land use change and forestry (24 percent), Agriculture (13 percent), and Waste (8 percent) (see Figure 6).[19]

Figure 6: GHG emissions (CO_2, CH_4, N_2O) by sectors, 2000 (CO_2eq)



Source: UNDP Armenia 2009

Changes to Armenia's climate will depend on the global emissions of greenhouse gases. Armenia has little control over the rate of global emissions: its own total emissions are quite small by world standards, as are its emissions per capita. In the first stages of international negotiations over greenhouse gas emissions abatement, Armenia – and the other Eastern European and Former Soviet Union transition countries that suffered severe economic downturns after 1990 – are unlikely to face any stringent requirement regarding reductions to emissions. To achieve the lower atmospheric stabilization trajectory recommended by the IPCC[20], however, global average emissions of less than 1 metric ton per capita will be necessary in the long run. On this time scale, looking out several decades towards the middle of this century, it may be necessary for Armenia to reduce its per capita greenhouse gas emissions in order to fully participate in global abatement initiatives.

2.4. Climate projections for Armenia

Although Armenia itself contributes very little to global GHG emissions, its standard of living, economic productivity and future economic development are threatened by the effects of climate change. It is a well-established scientific fact that climate change is occurring and will continue to occur as long as the concentration of GHGs in the atmosphere is too high for the Earth to process in its natural cycles. The remaining controversy regarding climate change is not whether average

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poverty, track progress towards the Millennium Development Goals and target programs effectively." See http://www.worldbank.org.

[18] Data and calculations are for 2004 from the World Bank's World Development Indicators database.

[19] World Resources Institute 2009

[20] IPCC 2007

temperatures will increase and weather patterns will change, but rather, how much and how quickly average temperatures will increase in each region of the world, and exactly how weather patterns will change over time.

Armenia's current day climate varies greatly, from its arid plains to its cold highlands where the highest levels of precipitation occur. Global GHG emissions are changing both the average global annual temperature and local weather patterns in every region around the world. Armenia's climate damages will not be less severe because of its relatively small GHG emissions: all countries are impacted by climate change regardless of their contribution to the problem.[21]

For Armenia, average annual temperatures will rise, both in the plains and in the highlands. In some regions of the country, precipitation levels will increase; in other areas they will decrease. Overall, the average amount of precipitation that Armenia receives each year will fall. Specific local weather patterns will change as well, although the exact ramifications are almost impossible to predict. In general, Armenia can expect more intense weather – more heat waves and stronger storms.

2.4.1. Armenia's climate today

The Lesser Caucasus Mountains cross through Armenia creating vast differences in altitude, terrain, temperature and precipitation from town to town and marz to marz. Even Armenia's "lowlands" are 500 to 1,500 m above sea level; these arid, rolling plains include the southwestern Ararat Valley – Yerevan, the capital, and Ararat and Armavir marzes – as well as Lori and Tavush marzes in the northeast and Syunik marz in the south. Temperatures in the lowlands range from an average of 25ºC in summer to 10ºC in winter, and annual precipitation is often as little as 200 mm each year.[22]

Armenia's highlands extend up to Mt. Aragat's 4090 m; 75 percent of the territory is above 1000 m, 50 percent is above 2000 m, and 3.4 percent is above 3000 m. These mountainous areas include Aragatsotn, Kotayk and Shirak marzes in the northeast, the Lake Sevan area in Gegharkunik marz, and Vayots Dzor marz in the south. Temperatures in the highlands range from an average of 10ºC in summer to 13ºC below zero in winter, although temperature extremes can be far colder at the highest elevations. Precipitation in the highland areas is often as great as 1,000 to 1,300 mm each year.

With this wide range of temperatures and precipitation levels by region, it is clear that there is no one "Armenian climate". Rather, each region has a unique climate and will face somewhat different challenges with climate change. More information on the current climate of various regions within Armenia according to the season can be found in Figure 7 for temperature information and Figure 8 and for precipitation information.

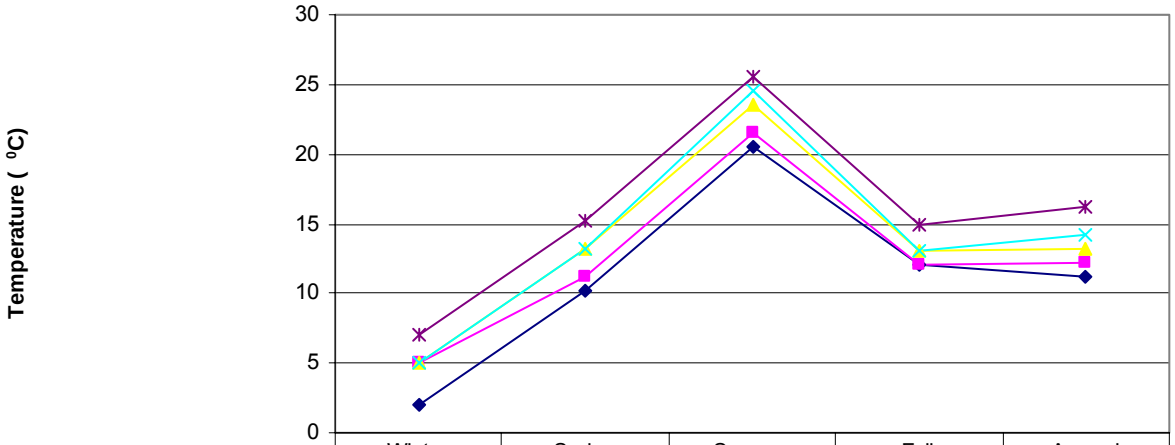
2.4.2. Projected changes to Armenia's climate[23]

To predict the scale and timing of future climate change, climate scientists use all of the best information available to them regarding past trends in temperature, precipitation and other weather phenomena, and the known properties of GHGs. Climatologists also base their predictions of the future on scenarios regarding economic and population growth, and the expected increase to current day emissions that will result from this growth.

[21] For more, see IPCC 2007
[22] Baseline climate data provided by ArmStateHydromet 2008.
[23] All climate projections for Armenia are taken from the Hydromet study using the PRECIS regional model.

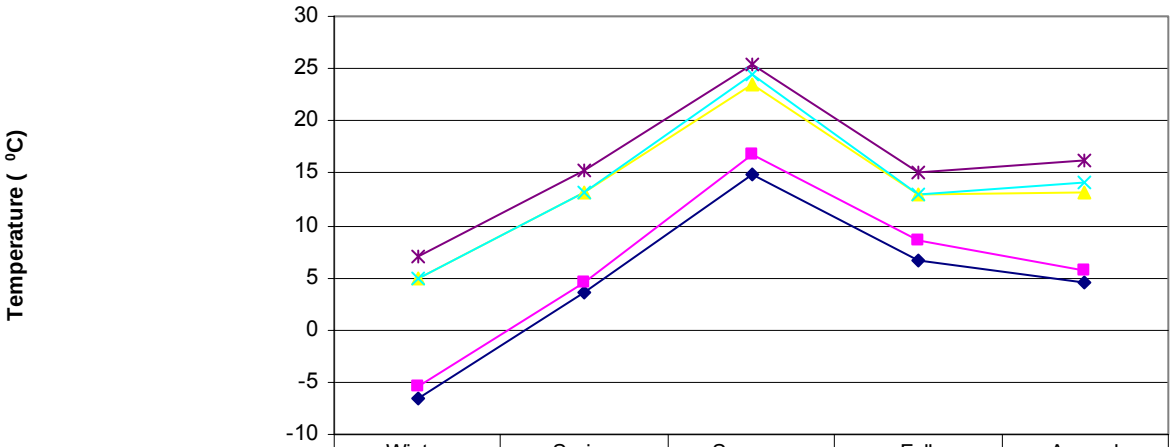
Figure 7: Projected increase in seasonal average temperatures in various regions of Armenia (in °C) under a high (A2) emissions scenario

Northeast



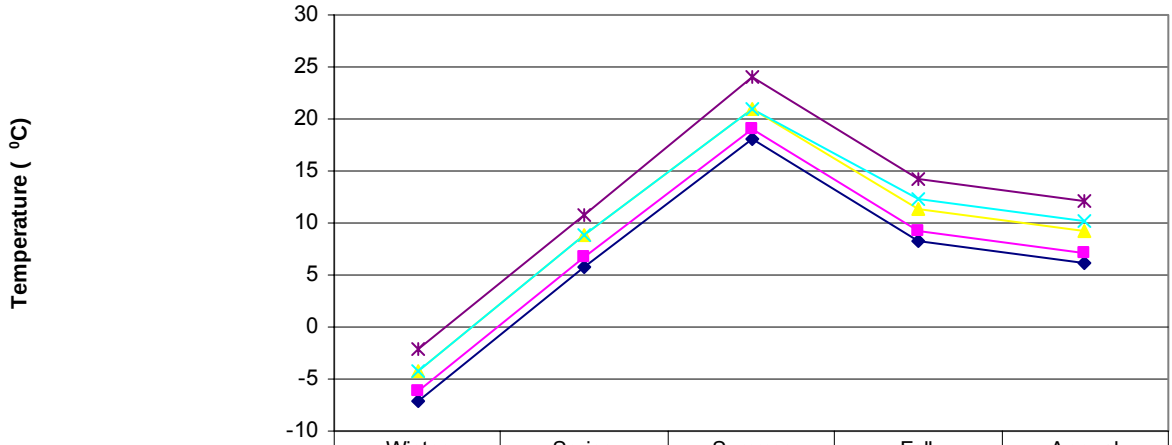
	Winter	Spring	Summer	Fall	Annual
1960-1990	2	10.2	20.5	12	11.2
2030	5	11.2	21.5	12	12.2
2070	5	13.2	23.5	13	13.2
2100 - Lower estimate	5	13.2	24.5	13	14.2
2100 - Higher estimate	7	15.2	25.5	15	16.2

Lake Sevan basin



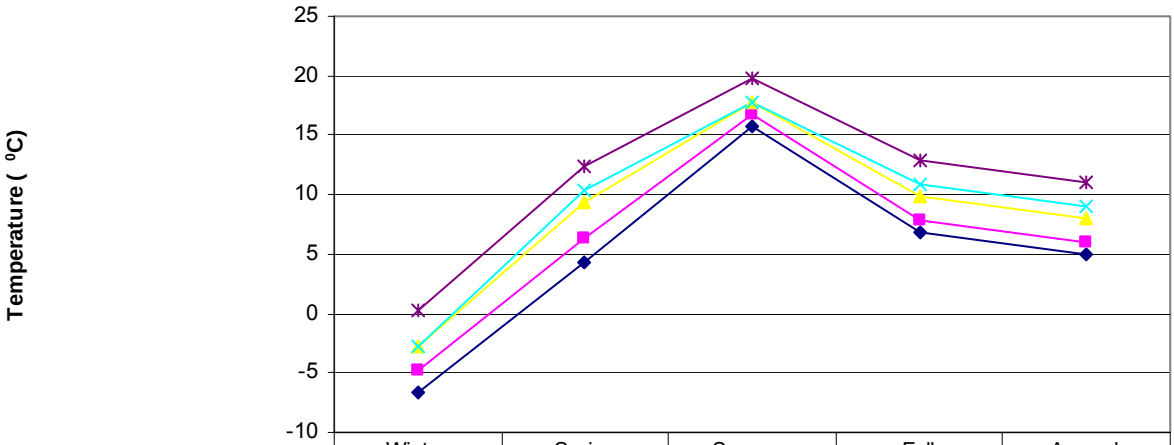
	Winter	Spring	Summer	Fall	Annual
1960-1990	-6.5	3.6	14.8	6.6	4.6
2030	-5.5	4.6	16.8	8.6	5.6
2070	5	13.2	23.5	13	13.2
2100 - Lower estimate	5	13.2	24.5	13	14.2
2100 - Higher estimate	7	15.2	25.5	15	16.2

Shirak



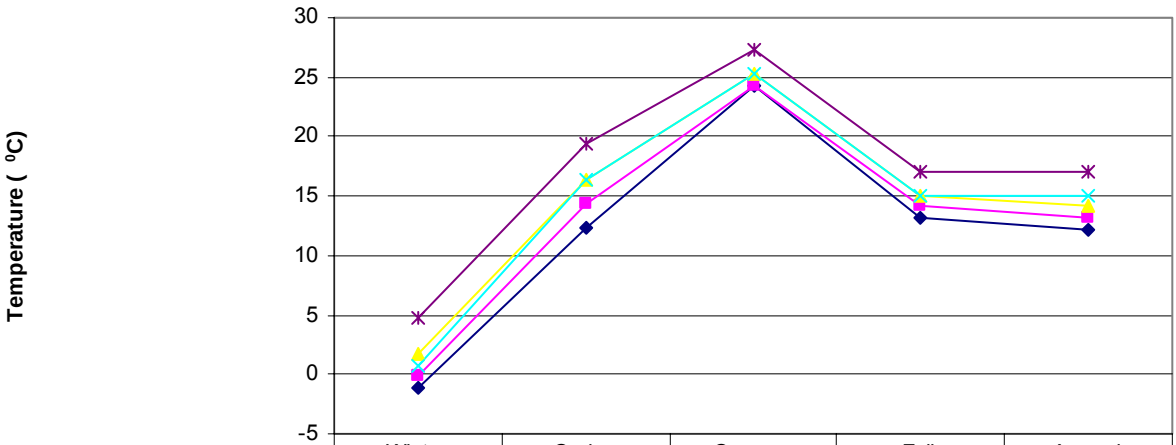
	Winter	Spring	Summer	Fall	Annual
1960-1990	-7.2	5.8	18	8.3	6.2
2030	-6.2	6.8	19	9.3	7.2
2070	-4.2	8.8	21	11.3	9.2
2100 - Low er estimate	-4.2	8.8	21	12.3	10.2
2100 - Higher estimate	-2.2	10.8	24	14.3	12.2

Aparan-Hrazdan



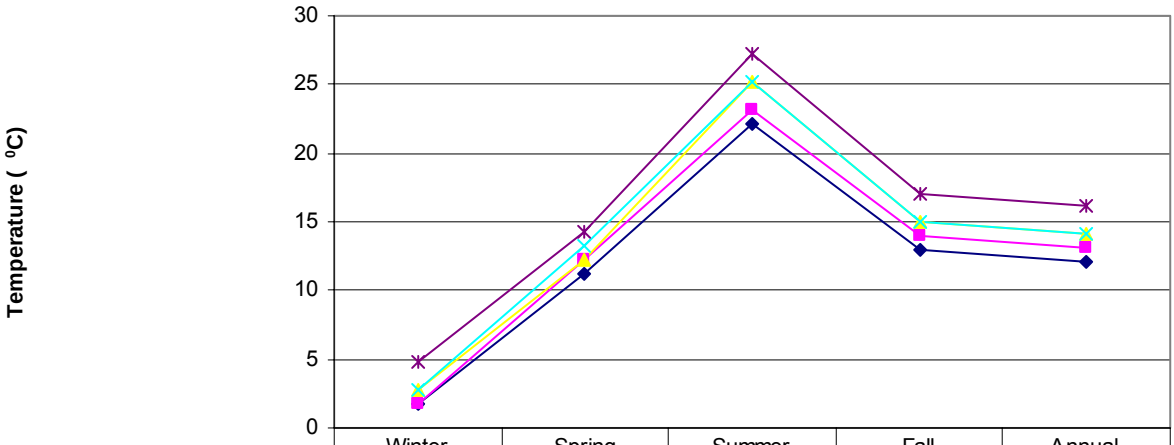
	Winter	Spring	Summer	Fall	Annual
1960-1990	-6.7	4.3	15.7	6.9	5
2030	-4.7	6.3	16.7	7.9	6
2070	-2.7	9.3	17.7	9.9	8
2100 - Low er estimate	-2.7	10.3	17.7	10.9	9
2100 - Higher estimate	0.3	12.3	19.7	12.9	11

Ararat Valley



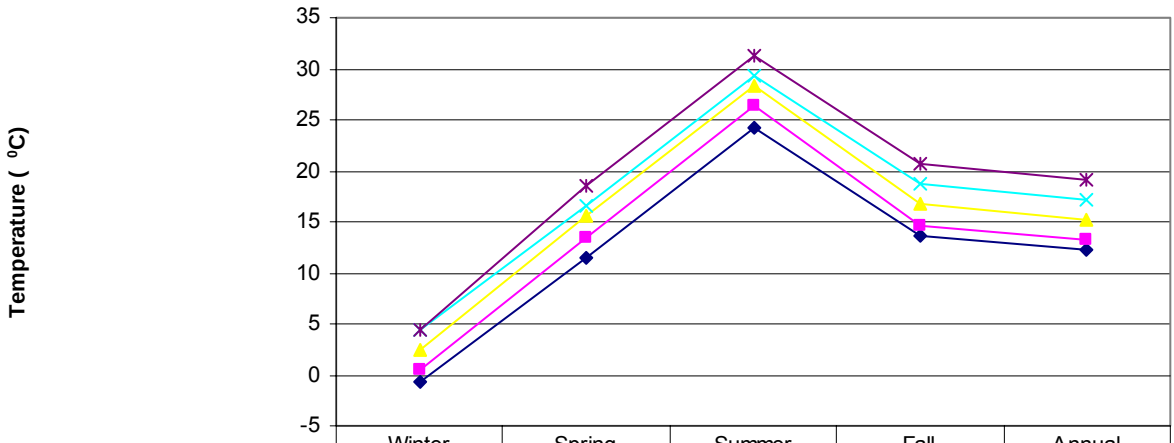
	Winter	Spring	Summer	Fall	Annual
1960-1990	-1.2	12.4	24.3	13.1	12.1
2030	-0.2	14.4	24.3	14.1	13.1
2070	1.8	16.4	25.3	15.1	14.1
2100 - Low er estimate	0.8	16.4	25.3	15.1	15.1
2100 - Higher estimate	4.8	19.4	27.3	17.1	17.1

Syuniq



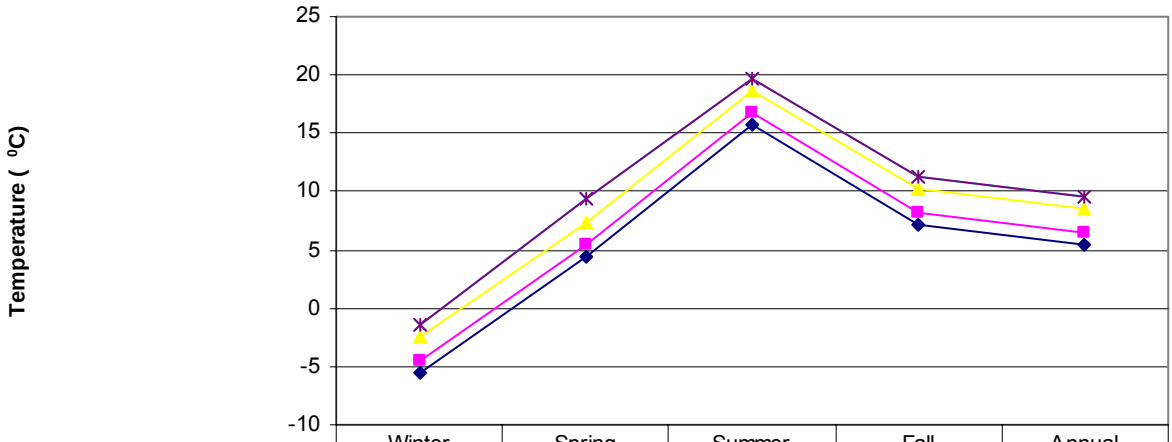
	Winter	Spring	Summer	Fall	Annual
1960-1990	1.8	11.2	22.2	13	12.1
2030	1.8	12.2	23.2	14	13.1
2070	2.8	12.2	25.2	15	14.1
2100 - Low er estimate	2.8	13.2	25.2	15	14.1
2100 - Higher estimate	4.8	14.2	27.2	17	16.1

Vayq



	Winter	Spring	Summer	Fall	Annual
1960-1990	-0.6	11.5	24.3	13.7	12.2
2030	0.4	13.5	26.3	14.7	13.2
2070	2.4	15.5	28.3	16.7	15.2
2100 - Low er estimate	4.4	16.5	29.3	18.7	17.2
2100 - Higher estimate	4.4	18.5	31.3	20.7	19.2

Armenia



	Winter	Spring	Summer	Fall	Annual
1960-1990	-5.5	4.4	15.7	7.2	5.5
2030	-4.5	5.4	16.7	8.2	6.5
2070	-2.5	7.4	18.7	10.2	8.5
2100 - Low er estimate	-1.5	9.4	19.7	11.2	9.5
2100 - Higher estimate	-1.5	9.4	19.7	11.2	9.5

Source: According to PRECIS model,,UNDP/GEF 2009

The climate projections presented in this report consist of two main scenarios that span the range of likely outcomes: business-as-usual and rapid stabilization. In the business-as-usual scenario, global emissions of GHGs grow larger over time, as has been the case for the past two centuries; these are the "high" predictions presented below. In the rapid stabilization scenario, a global agreement is

struck in the next decade to rapidly decrease emissions over time; these are the "low" predictions presented below.

If business-as-usual GHG emissions continue worldwide over the next century (the "high" in the tables below, which the IPCC calls its "A2 scenario"), the increase to Armenia's average annual temperature is expected to be dramatic and occur across the country throughout the year (see below).[24] It should be emphasized that the changes depicted in the figures below are enormous climatic changes: for example, just 5ºC separate the climate of Stockholm from that of Paris.

In this scenario, Yerevan's average annual temperature will climb from 11.6°C today to 16.6°C in 2100 (see the Ararat Valley's increases in below for the seasonal changes). In Vayk, where the greatest temperature increases in Armenia are expected, the average annual temperature under the business-as-usual scenario will rise to 19.2°C, very close to that of today's climate in Tel Aviv or Beirut.

The increase in Armenia's average annual temperature is expected to take place throughout the country and is projected to increase steadily throughout the century. It is expected to include all seasons, as described in below. Thus, in the near to middle term (2030 to 2070), temperature changes are projected that could be dramatic.

The rapid stabilization scenario (represented as the "low" in the tables below, or the IPCC's "B2 scenario"), depends on slower global population growth and the rapid development and deployment of low-carbon technology. It is important to note that – even with rapid stabilization -- significant average temperature increases and precipitation reductions are expected.

Table 5: Forecasted changes in average annual temperature and precipitation in Armenia according to a high emission scenario (A_2) and a rapid stabilization scenario (B_2)

Temperature (°C)		Precipitation % change	
A_2	B_2	A_2	B_2
2030			
1.1 to 1.2	1.0 to 1.1	-2 to -6	-2 to -6
2070			
3.2 to 3.4	2.9 to 3.0	-6 to -17	-3 to -15
2100			
5.3 to 5.7	4.8 to 5.1	-10 to -27	-8 to -24

Source:According to the MAGICC/SCHENGEN model implemented in UNDP/GEF 2009

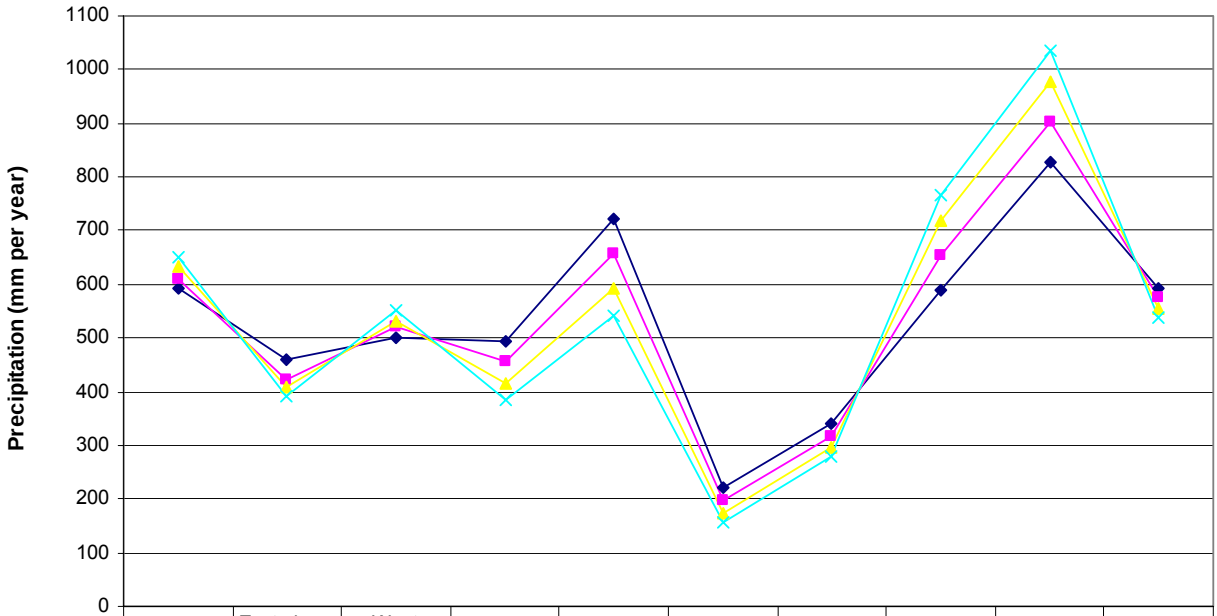
With a continuation of global business-as-usual emissions, Armenia's average annual precipitation is expected to decrease by 10-27 percent over the next century (see Table 5 for two different emissions scenarios, Figure 8 for the total amounts of precipitation projected and Figure 9 for seasonal expected changes). Expected changes to precipitation vary enormously across the nation, with some of the most arid – and most populated – marzes in the Ararat valley suffering the greatest reductions to precipitation. Some marzes are projected to see an increase in average annual precipitation over time, especially in the mountainous areas. But even in areas that are expected to increase in precipitation, higher temperatures can mean more evaporation and less run-off. The consequences of increased evaporation are less soil moisture and surprisingly large reductions in river flows.[25] The biggest reductions in precipitation are predicted for Yerevan and the Ararat Valley – 30 percent less precipitation in 2100. In those mountainous areas that will see a reduction

[24] UNDP and Oxford University School of Geography and Environment 2009. Changes to temperature and precipitation as projected in Hovsepyan 2008a, as well as UNDP/GEF 2009

[25] Hovsepyan 2008a, Hovsepyan 2008b, WHO 2007

in precipitation, like the eastern slopes of Lake Sevan, decreases in snow cover can be expected, which will greatly reduce spring run-off and river flow.[26]

Figure 8: Armenia's projected change in average total annual precipitation with climate change under a high (A2) emissions scenario



	North-east	East shore of Lake Sevan	West shore of Lake	Shirak	Aparan-Hrazdan	Ararat Valley	Vayq	Syuniq	Aragats	ARMENIA
1960-1990	592	459	502	495	722	222	341	590	827	592
2030	610	422	522	455	657	198	317	655	901	574
2070	633	409	532	416	592	173	297	720	976	556
2100	651	390	552	386	542	155	280	767	1034	539

Region

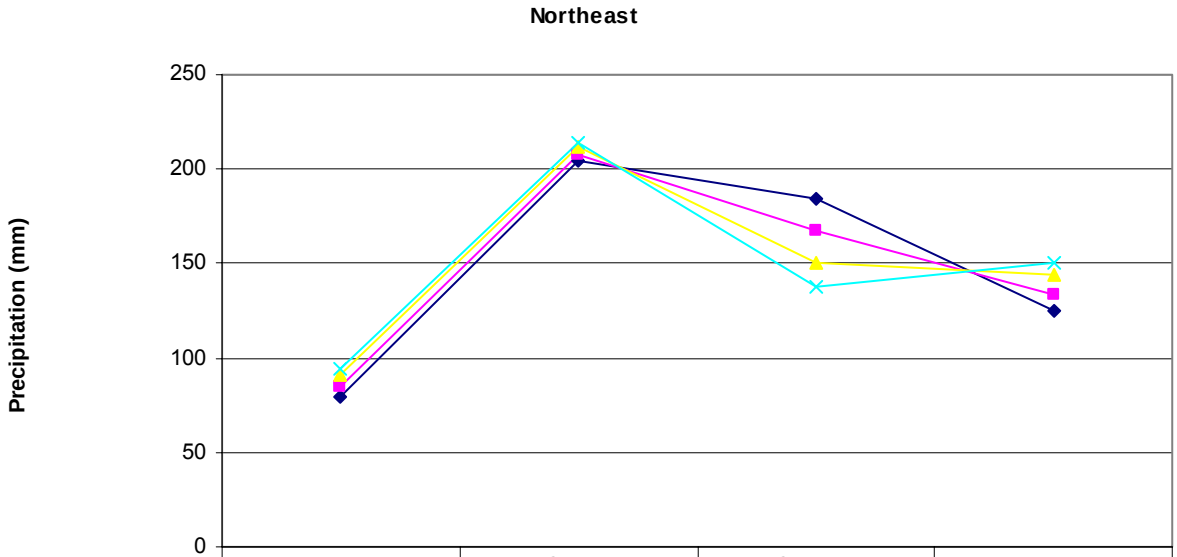
Source: According to PRECIS model implemented in UNDP/GEF 2009

Changes in river flow in the Kura-Aras river basin with a 10 percent decrease in precipitation and just a 2ºC increase in the average annual temperature – a much smaller temperature increase than the current business-as-usual forecast – have been predicted to reach as high as a 50 percent loss of flow.[27] More conservative, Armenia-specific calculations project a still alarming 24 percent decrease in river flow over the next 100 years.[28]

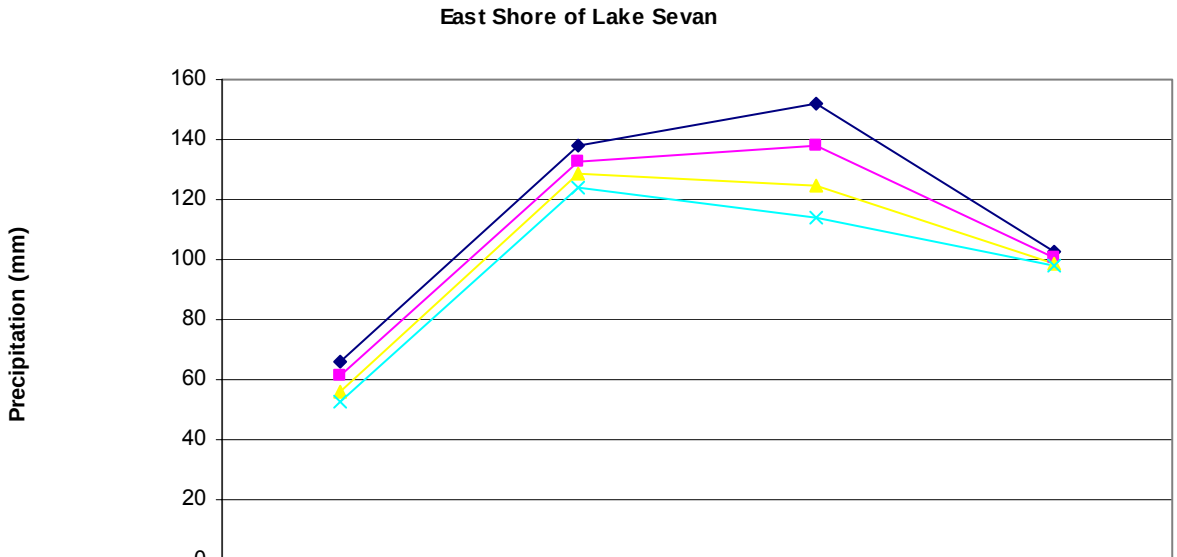
Finally, changes in average annual temperature and precipitation often disguise some of the most devastating effects of climate change: temperature extremes and changes in weather patterns. With increased average temperatures, heat waves – clusters of days with extremely high temperatures and detrimental health impacts – will become more common. Higher air temperatures, increased evaporation, and greater concentrations of water vapor increase the likelihood of severe storms that, in the Armenian context, may result in natural disasters like floods, landslides and mudflows.[29] These climatic impacts are discussed in greater detail in Section 3.6 below.

[26] Zakaryan et al. 2008
[27] Beglarashvili and Elizbarashvili 2006, Kura Aras Stakeholder Advisory Group 2007
[28] Zakaryan et al. 2008
[29] Hovsepyan 2008, and UNDP Sida 2005

Figure 9: Armenia projected average seasonal precipitation changes by region by marz (in mm precipitation per season) under a high (A2) emissions scenario

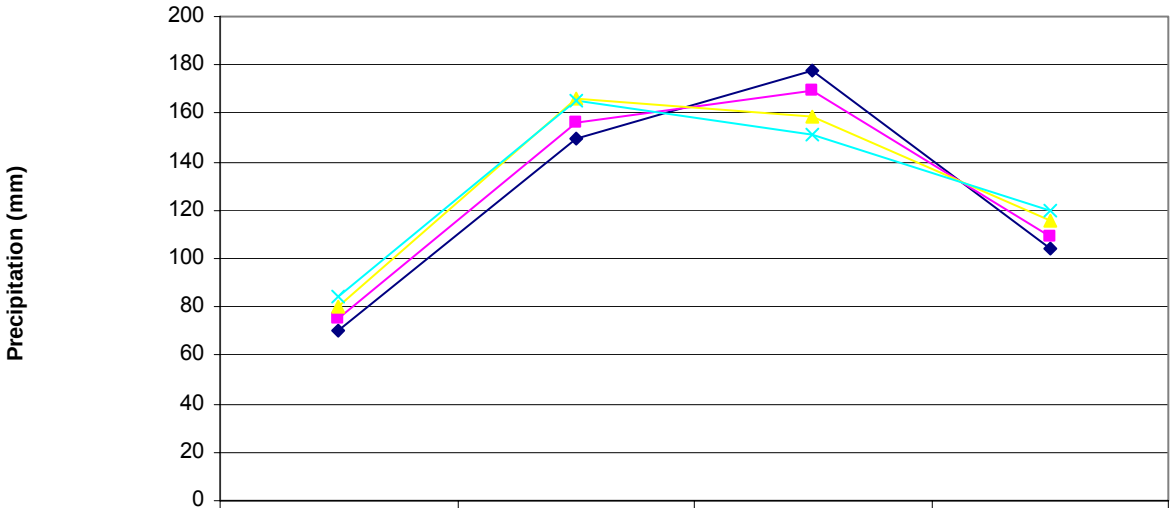


	Winter	Spring	Summer	Fall
1960-1990	79	204	184	125
2030	85	208	167	134
2070	91	212	151	144
2100	95	214	138	150



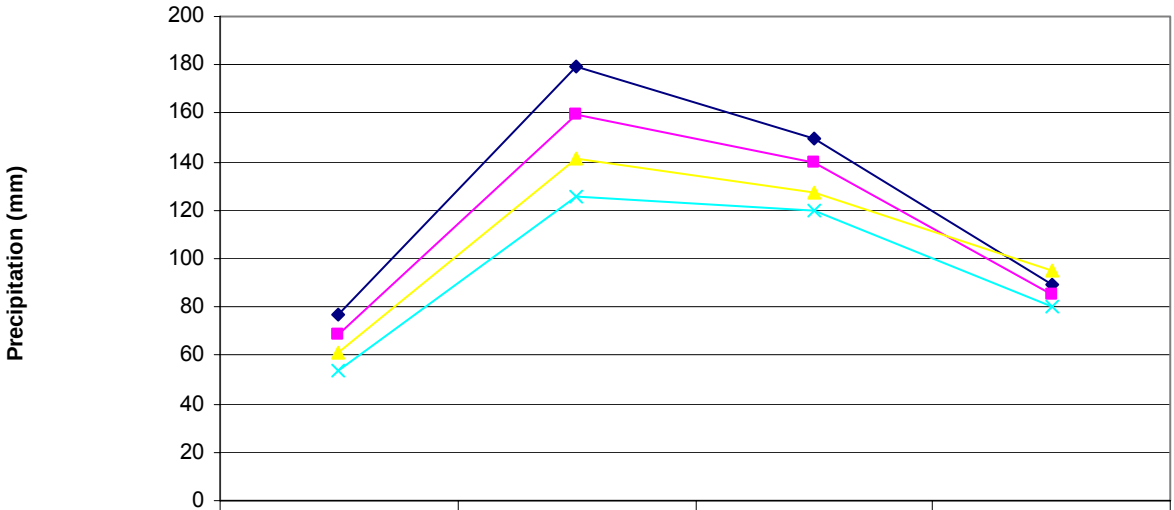
	Winter	Spring	Summer	Fall
1960-1990	66	138	152	103
2030	61	132	138	101
2070	56	128	125	99
2100	53	124	114	98

West Shore of Lake Sevan



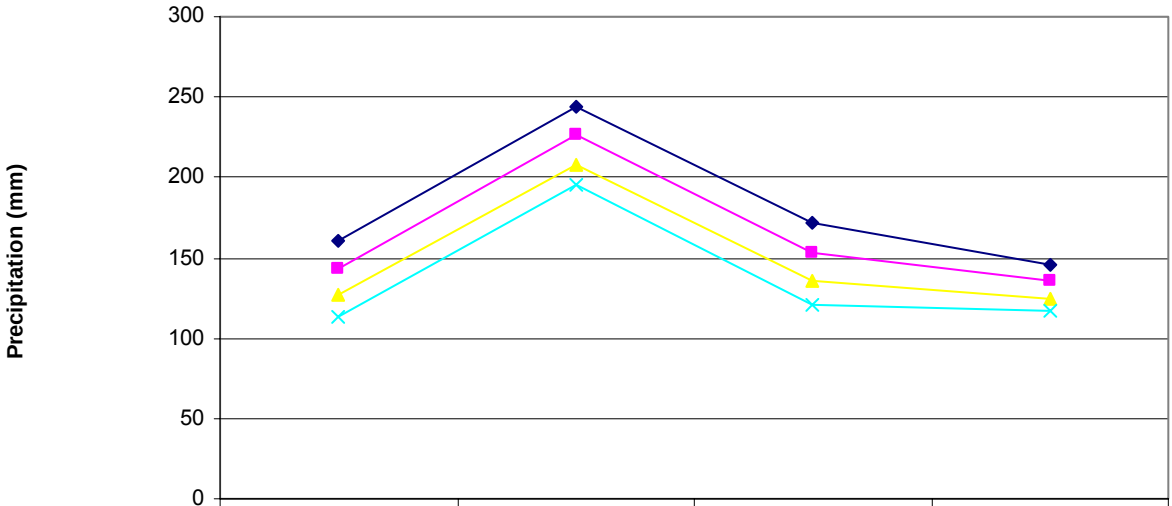
	Winter	Spring	Summer	Fall
1960-1990	70	150	178	104
2030	75	156	169	109
2070	81	167	158	115
2100	84	165	151	120

Shirak



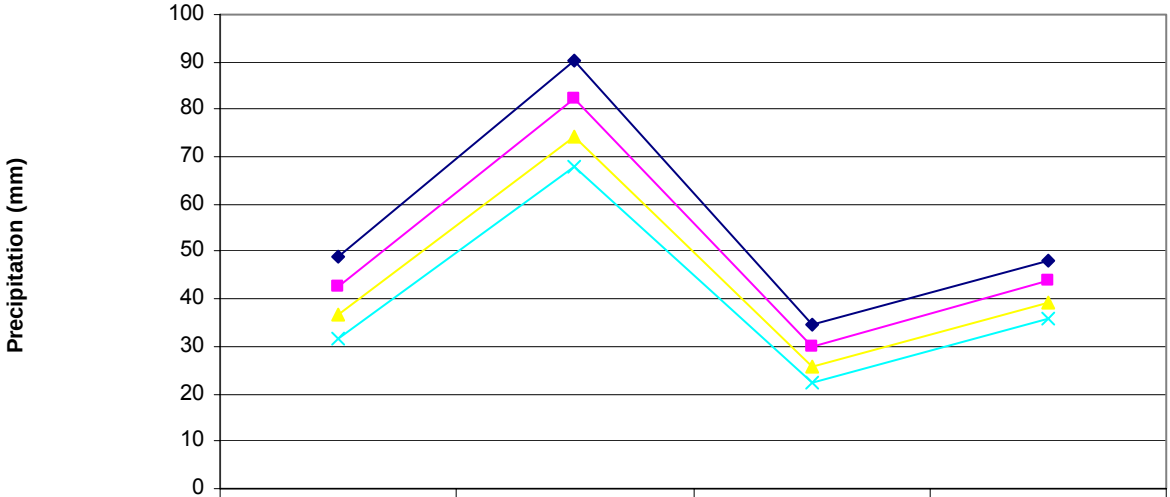
	Winter	Spring	Summer	Fall
1960-1990	77	179	150	89
2030	69	159	140	85
2070	61	141	128	95
2100	54	125	120	80

Aparan-Hazdan



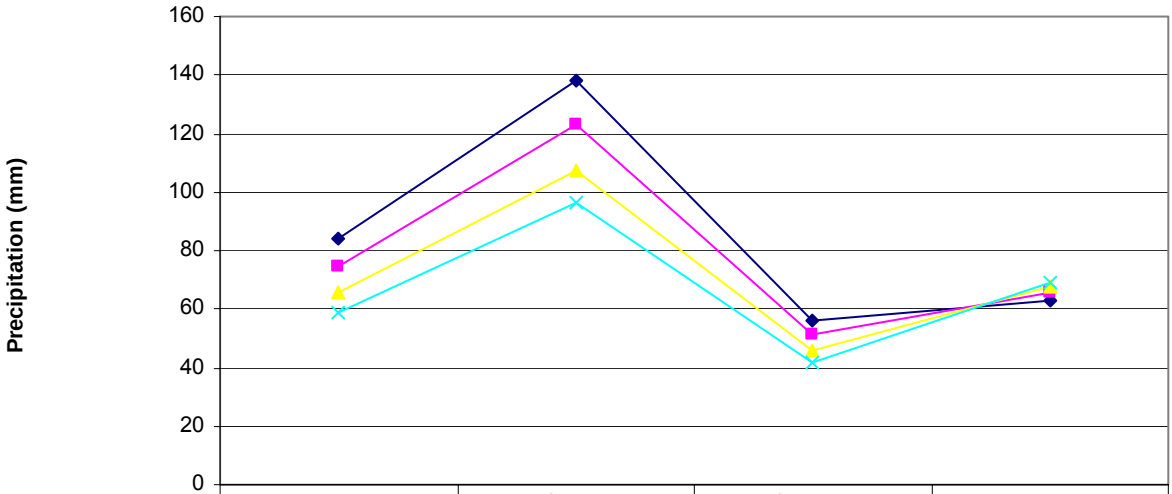
	Winter	Spring	Summer	Fall
1960-1990	161	244	172	146
2030	143	227	153	136
2070	127	207	136	124
2100	113	195	120	117

Ararat Valley



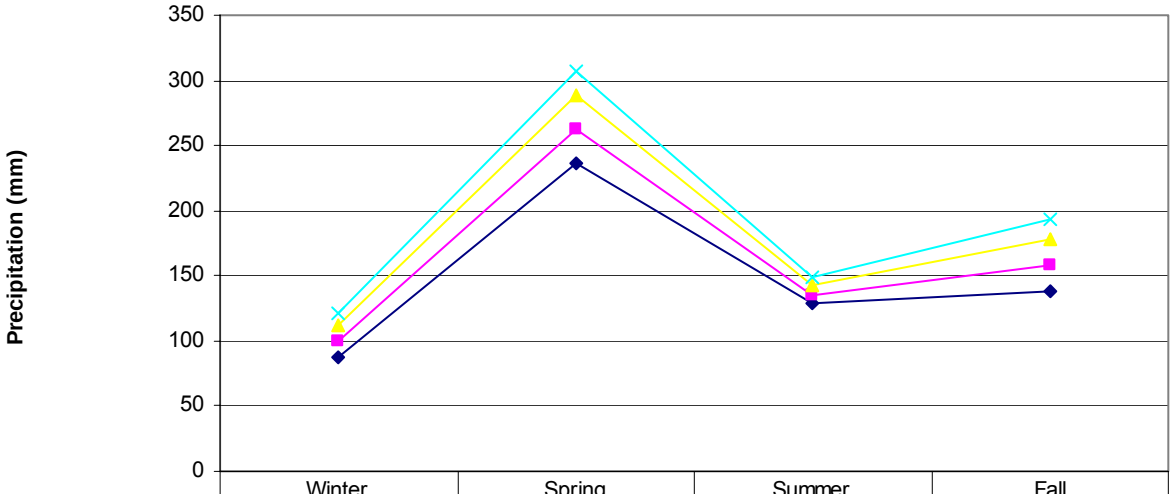
	Winter	Spring	Summer	Fall
1960-1990	49	91	35	48
2030	43	82	30	44
2070	37	74	26	39
2100	32	68	22	36

Vayq

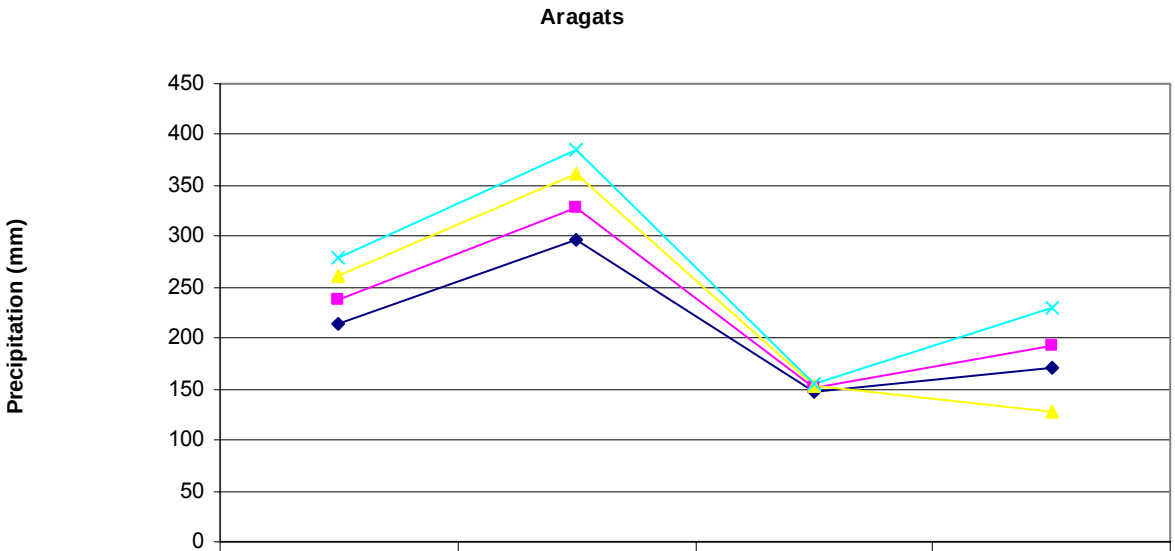


	Winter	Spring	Summer	Fall
1960-1990	84	138	56	63
2030	75	123	51	66
2070	66	108	46	67
2100	59	97	42	69

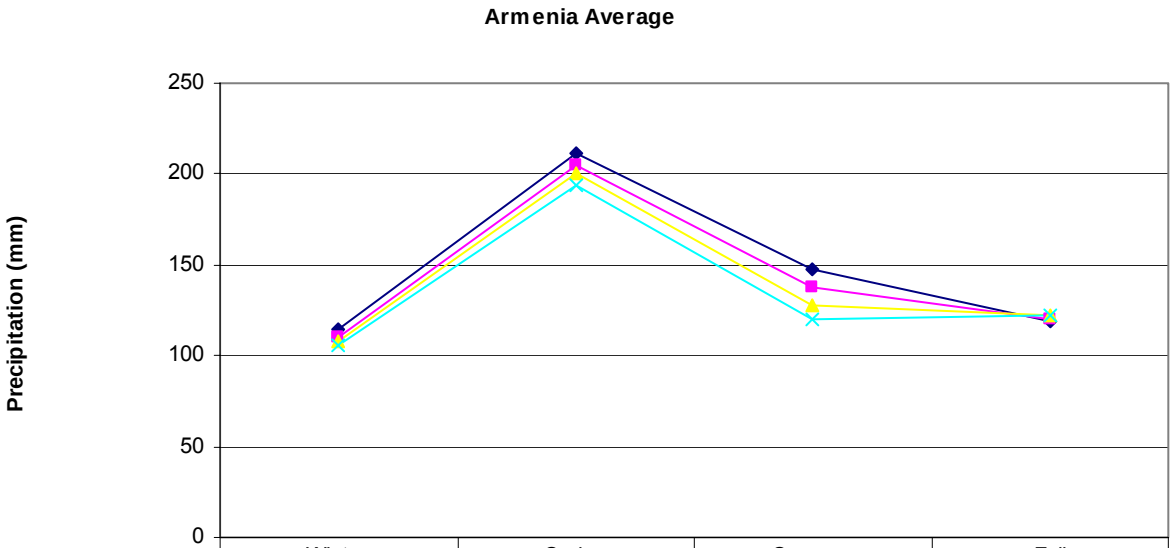
Syuniq



	Winter	Spring	Summer	Fall
1960-1990	87	236	129	138
2030	100	262	135	159
2070	112	288	143	178
2100	122	307	148	193



	Winter	Spring	Summer	Fall
1960-1990	214	296	148	170
2030	238	329	151	192
2070	261	361	154	128
2100	278	385	155	230



	Winter	Spring	Summer	Fall
1960-1990	114	211	148	119
2030	111	205	138	120
2070	108	200	127	123
2100	106	194	120	123

Source: According to PRECIS model, UNDP/GEF 2009

2.5. Climate change and human development

Human development goals, such as adequate income, nutrition, and health, and decreased child mortality, are directly and indirectly tied to climate change damages and adaptation. The UNDP's *2007/2008 Human Development Report* focuses on this two-way interaction, reporting on ways in which climate change can contribute to underdevelopment, and ways in which poverty and inequality increase vulnerability to the impacts of climate change.[30] While there is no one solution to the combined problem of climate and development, a stronger social safety net and asset accumulation can lead to dramatic gains in human development and a reduction in vulnerability to the effects of climate change.

2.5.1. Impacts of climate change on human development in a global context

Not all people are affected equally by climate change. Vulnerabilities to climate impacts – both due to existing climate and future climate change – depend greatly on geographic, sectoral and social contexts.[31] Armenia's low-income households are generally more vulnerable to climate risks (both present and future) than richer households. For this reason, it is important to analyze who will be affected by climate change risks and what are the consequences for human development implied by those risks. The number of people worldwide affected by floods, droughts and storms has increased in recent decades and evidence demonstrates that climate change can enhance exposure to those risks. Other social factors that may contribute to higher exposure to climate change risks include ecological stress and the expansion of human settlements in especially vulnerable areas.[32]

In Armenia, rural low-income communities are the most vulnerable to climate impacts because they have limited resources with which to insulate themselves from damages and a greater dependence on both agriculture and natural ecosystems. Inequalities in income and opportunities, and lack of political enfranchisement of poor communities can contribute to a community's vulnerability (see Table 6 below).

Table 6: Factors that enhance vulnerability to climate change impacts

Factors	Examples of potential vulnerability
Poverty and low human development	Armenia, while listed as having medium human development, has over 50 percent of its population living under the national poverty line and 31.1 percent living with an income of less than two dollars a day (PPP).[33]
Disparities in human development	While there are significant problems with – especially – rural poverty, the income disparities in Armenia appear to be relatively limited, with a Gini coefficient (a way of measuring inequality) ranking 33rd in the world in 2003 at 33.8.[34]
Lack of climate-defense infrastructure	While some climate defense infrastructure (such as irrigation) does exist in Armenia, there is much that can be done to improve the situation in numerous sectors – as is explored later.
Limited access to insurance	While this is not explored thoroughly in this report, access to insurance – for floods, agricultural damage, health problems, etc. – can have a large impact on resiliency to climate shocks. For example, social insurance to prevent climate-related losses amounts to over 12% of GDP in OECD countries, but less than 2% of GDP in Sub-Saharan Africa.

Source: Based on UNDP 2007: 79-80

[30] UNDP 2007
[31] IPCC 2007
[32] See UNDP 2007: 78 for more.
[33] See UNDP 2008
[34] See UNDP 2008

Among the climate change impacts with which poverty and inequality are most closely associated are: heightened water insecurity; increased health risks; reduced agricultural productivity; and increased incidence of extreme weather events and flooding.[35]

Heightened water insecurity: Human settlements and agriculture will be affected by a decrease of water availability with climate change. By 2080, 1.8 billion people worldwide will live in places where the supply of water is already critically threatened. Human development will suffer as access to safe water declines.[36] Reduced water availability will be an important issue in Armenia with climate change (see Section 3.2 of this report).

Table 7 (below) gives examples of the projected impact of climate change on water supplies from regions around the world.

Table 7: Some examples of projections of climate change impacts to water supply and human development from around the world

Northern Africa (Morocco)	Increase of 1ºC Reduced water runoff	Water supply reduction of 10%
Western Asia (Lebanon)	Increase of 1.2ºC Runoff patterns and evaporation changes	Water supply reduction of 15%
Eastern Asia (China)	Increase of 1-2.5ºC	Dramatic retreat and disappearance of glaciers
Central Asia	Glacial melt losses into Amu Darya and Syr Darya rivers	Water flow restriction for irrigation into Uzbekistan and Kazakhstan
Indus River	Reduction of glacial water banks Reduction of water flows	River flow decrease of 70%

Source: UNDP 2007: 96-97

*Increased health risk***:** In countries throughout the world, health will be compromised by the impacts climate change will have on temperature, humidity, air and water quality, agricultural productivity and exposure to extreme events. Climate change will cause more frequent heat waves, another important threat to human health. In 2003, Europe lost from 22,000 to 35,000 lives, mostly among the elderly and infirm. In the United States, the incidence of heat-waves is expected to double by 2050.[37]

While increased incidence of heat waves, decreased air and water quality, and exposure to extreme weather events are expected in Armenia with climate change (see Sections 3.1, 3.2 and 3.6 of this report), health risks are not included as a specific area of economic analysis in this report because of a lack of data.

Reduced agricultural productivity: In Armenia, an estimated 24 percent of the population is undernourished.[38] Rural communities are already – and will be more – exposed to agricultural losses and consequently more exposed to malnourishment.[39] A reduction in agricultural productivity is likely to be one of the most important impacts of climate change in Armenia (see Section 3.3 of this report). UNDP predicts that reduced agricultural production from climate change will have serious impacts on human development around the world – potentially affecting global commodity prices and driving import prices up significantly.

[35] UNDP 2007
[36] UNDP 2007: 94-96
[37] UNDP 2007: 106
[38] UNDP 2008
[39] UNDP 2007: 90-93

Increased incidence of extreme weather events and flooding: Extreme weather events have long-term effects on education, labor productivity and health.[40] Because of Armenia's steep geography and wide variety of climates, it already suffers significant damages each year from land and mudslides, floods and droughts; these impacts will become more serious with climate change (see Sections 3.6 of this report).

Armenia's poor and especially its rural poor populations – who are both more isolated from assistance and more dependent on agricultural productivity for food and income – will be more vulnerable to the effects of climate change. In the sections below, the specific climate damages projected for Armenia will be discussed along with recommendations for adaptation measures to protect Armenia's population from these damages. If climate adaptation is not addressed by the state and is instead left to private actions and private purchases, the result will be an unequal distribution of adaptation and climate protection. Richer households will be able to afford to insulate themselves from the worst effects of climate change, while poorer households will suffer from preventable injuries to their livelihoods and standard of living.

2.5.2. Assessing Vulnerability in Armenia

The greatest climatic damages to Armenia will be qualitative or social in nature. Any reduction to the standard of living for any group is a social damage. Many forms of social damage are experienced most acutely by poorer, more vulnerable segments of the population; households with greater resources can often protect themselves from harm by replacing temporarily lost income with savings, or using their greater purchasing power to assure access to scarce resources. Armenia's poorer households have less defense against scarcity. Reductions in these households' standard of living can result in serious human suffering due to limited access to clean water, food, heating fuel, or lack of economic opportunity.

Climate change will have direct and indirect effects on Armenia's economy. Electricity production, for example, is itself an industry that generates revenue and provides jobs. Revenue and jobs in the agricultural sector and in industry depend on reliable supplies of both electricity and water. Any decline in household income – from lost wages or business revenues – has a ripple (or multiplier) effect throughout the economy: lower incomes mean fewer purchases, and less revenue and wages generated by consumption.

In addition, a lower standard of living can have an indirect effect on the economic well-being of Armenia as a whole. Shortages of water and electricity, shortages of food and lower incomes for the rural population, and detrimental health effects from extreme temperatures during heat waves are all harmful to the labor force and, therefore, have the effect of reducing overall productivity. Impaired health can lead to losses in labor productivity – how well or how quickly each person works – and a loss of household income if wage-earners become too ill or weak to work. In addition, worsening social conditions can lead to increased rates of emigration, especially among working age adults, and a smaller and older total Armenian labor force.

The qualitative analysis provided in this report considers each major climate impact in the light of its effect on the Armenian standard of living over the course of the next century. In addition, quantitative economic analysis has been performed wherever sufficient data existed. The following section describes in greater detail the methods of economic analysis used in the report.

Where possible, some quantitative economic analysis has been performed to demonstrate the potential scale of the impact of climate change. There are limits to the scope of the economic analysis in this report (See Box 1 for more). However, the report aims to be a first step in understanding the likely impacts of climate change and in highlighting the importance of climate as a factor in the socio-economic development of Armenia.

[40] UNDP 2007

Box 1: Notes on the economic valuation of climate impacts

The purpose of the economic analysis in this report is to identify, describe and – wherever possible – project the monetary damages associated with climate change in Armenia. The dram and dollar values of damages presented here are not intended to be comprehensive, but rather to illustrate the scale of certain categories of climate damages. To understand the full climate change impact to Armenia it is essential to include qualitative social damages that are not easily translated into monetary terms as well as more easily measured economic damages.

Due to data limitations on the likely longer term future economic scenarios for Armenia, and because of concerns with accuracy, this report uses a form of quantitative analysis that is static in nature – frequently comparing projected future climate impacts to today's economy. There has been no attempt to measure the interactive effects among climate change impacts, nor to adjust for potential future differences in the economic situation which will undoubtedly occur. For more on modeling of economic impacts of climate change, see Appendix C.

Many of the economic damages projected in this report are more likely to be caused by increasing prices, rather than by absolute shortages. Forecasts of market prices are rarely accurate, especially over the long time-frames necessary in any analysis of climate change. In the case of Armenia, moreover, prices for certain key commodities – electricity and water – are set by the government, not the market. This means that economic tools for forecasting prices cannot be employed; the state's choice to change prices will depend on political forces.

Even in extreme cases, where shortages are possible, measuring a week without electricity as the loss of 7/365 of annual electricity revenues, for example, misses the most serious consequences for Armenian households: a week spent without lights or appliances, or, for many, a week without heat. Very serious impacts on the standard of living can be difficult to express in terms of losses to GDP.

2.5.3. Understanding adaptation measures

Adaptation measures have the potential to protect Armenia from the worst social and economic impacts of climate change. These measures can be sorted into categories according to whether they involve natural or human systems; are public or private; and are anticipatory or reactive (see Table 8 for a taxonomy created by the IPCC). It should be noted that there is a great deal of overlap between climate change adaptation and economic development.[41]

Table 8: Taxonomy of climate adaptation measures

		Anticipatory	Reactive
Natural systems			Changes in length of growing season
			Changes in ecosystem composition
			Wetland migration
Human systems	**Private**	Purchase of insurance	Changes in farm practices
			Changes in insurance premiums
			Purchase of air conditioning
	Public	Early-warning systems	Compensatory payments, subsidies
		New building codes, design standards	Enforcement of building codes
		Incentives for relocation	Rebuilding damaged waterway boundaries

Source: Adapted from Klein and Nicholls 1998 and Smith et al. 2001 for the Armenian context

[41] Stanton and Ackerman 2009, Stanton, Ackerman and Kartha 2009

In Armenia, for example, better management of water resources and essential improvements to poorly functioning water infrastructure are simultaneously climate change adaptation measures and necessary changes for overall economic development. Specific adaptation measures related to each type of climate damages are discussed in detail in Sections 3.1 through 3.6 of this report.

Natural Systems and Human Systems: Impacts from climate change will affect both natural and human systems. All natural environments adapt to climatic changes, often by a gradual change in the composition of plant and animal species: those species that are poorly suited to new conditions are replaced by species that are better suited. For example, as an environment becomes more arid, water intensive species will be replaced by drought-resistant species.

These kinds of shifts in ecosystem composition have the potential to create adverse effects for humans in two ways first. If climatic changes occur too rapidly, poorly adapted species may die off or migrate away more quickly than well-adapted species can replace them, thereby reducing local biodiversity. Areas left with little or no plant cover, even for short periods of time are extremely susceptible to erosion, and the loss of resource-rich top soil can have very long reaching effects on ecosystem health. In extreme cases, there is the potential for the creation of dead zones with little plant cover or soil-based nutrients. Dead zones cannot absorb water or assist in the recharge of underground aquifers; instead, water run-off will cause further erosion to areas at lower elevations and result in landslides and mudflows.

Rapid changes to ecosystem composition have a second negative effect on human systems. The older generation of poorly adapted species may be more highly valued by humans than the newer generation of well-adapted species. For example, the current mix of tree species in Armenia's forests may be far more valuable to humans than the mix of more drought-resistant semi-desert or steppe plants that are likely to replace forests as the environment becomes more arid.

Public and Private Investments: Human systems will suffer climate impacts not directly related to ecosystem changes. Adaptive measures to avoid negative climate impacts to human systems may be public, private, or a combination, for example, public funding that supports private measures.

Public investments in adaptation will protect segments of the population by, for example, assuring consistent supplies of water or electricity, funding improvements to public infrastructure, or creating new regulations that enforce conservation measures, introducing changes to building codes, etc. Private adaptation investments protect individual households or businesses. Families may protect themselves from higher temperatures by improving home ventilation and building design or from water shortages by installing water catchment tanks on roofs. Adaptive measures taken by businesses and farms are also private; these may include conservation measures or improved irrigation, planting, or plowing techniques. It is important to note that individual ability to undertake many adaptive measures will be determined by household income and wealth.[42] In order to mitigate this problem, the state can provide funding for private measures to insure that poorer households do not suffer preventable damages.

Anticipatory and Reactive Measures: Adaptation to climate change may occur either before or after the fact. Some forms of adaptation can be launched in advance of climatic effects and may prevent damages from ever occurring. Older infrastructure can be retrofitted to be more appropriate to new climatic conditions and building codes for new construction can be revised to meet higher standards. Where a decreased supply of natural resources like water is anticipated, new systems for better storage and distribution can be built and other conservations measures taken in advance of actual shortages. Improving political and trade relations with resource-rich neighbors can also be an anticipatory adaptation strategy.

Many of the impacts of climate change will have diverse effects on each specific locality; these types of changes in micro-climates are difficult if not impossible to predict. For this reason, many

[42] IPCC 2007

adaptive measures will need to be reactive instead of anticipatory – that is, much climate change adaptation will take place after damages have begun to occur, instead of taking place sooner and preventing all damages. As conditions for agriculture change, farmers must react by changing crops as well as irrigation and cultivation techniques. Forest maintenance and the strategic implementation of sustainable logging practices may also require an evolving adaptation in response to local climatic changes.

While some adaptation measures can be taken by individual households or businesses, the actions that have the biggest potential for protecting Armenia's standard of living and future economic development are public policies and programs to be undertaken by the state. Many of these public adaptation measures are large-scale infrastructure projects that will take years or even decades to complete, and may require external funding to accomplish.

Because much of Armenia's economy is operating below its true productive capacity, some adaptive polices will also be productive investments; these are win/win – or "no regrets" – situations where the policy response to impending climate change results in a valuable return to the investment. For example, extensive expansion to Armenia's irrigation will be necessary to prevent a significant loss of agricultural production in the long run, however, in the short run these same investments will make it possible employ the idle capacity of farmlands that currently require irrigation but are not receiving it.

Other defensive costs are not productive in this sense. Instead, these adaptation costs are a deadweight loss to the economy, but in many cases the costs of allowing damages to occur (in the absence of defensive measures) would be an even greater loss. Taking this viewpoint, many adaptation measures can pay for themselves in the long-run. In making decisions regarding what adaptation measures to take and when, it will be important for policy makers to weigh the costs of all forms of damages including those that cannot easily be assigned a monetary value, like the quality of human lives or irreversible environmental damage.

The specific adaptation measures recommended in Section 4.1 for each area of climate damages are not limited to what is possible with existing funding or known funding sources. Instead, they are recommended measures for which government, individuals, and firms should seek funding in order to limit costly climate damages (the availability of adaptation funding from international sources is discussed in Appendix B).

3. SOCIO-ECONOMIC IMPACTS OF CLIMATE CHANGE IN ARMENIA

The changes projected for the Armenian climate are very serious. By 2100, with a continuation of the current trend in global GHG emissions, a 5.3 to 5.7°C increase in average annual temperature and a loss of 10 to 27 percent of precipitation are projected. If international climate negotiations progress and large-scale mitigations efforts are employed rapidly around the world, Armenia's climate will experience somewhat smaller changes: a 4.8 to 5.1°C increase in average annual temperature and a loss of 8 to 24 percent of precipitation. Changes to temperature and precipitation on this scale over the course of less than one century are extremely likely to have far reaching effects on many aspects of social and economic life in Armenia.

Ultimately, the scale of climate change damages to Armenia will depend almost entirely on what allocative and adaptive policies are put in place, whether sufficient funding can be found to support adaptive policy measures, and how quickly these policies can be implemented. In this section, social and economic impacts from climate change in Armenia – high temperatures and heat waves, water shortages, reduced agricultural production, reduced electricity production and price increases, damage to forests, and natural disasters – are each described in detail and subjected to socio-economic analysis.

The sub-sections below also include discussions of adaptation measures that would lessen each type of climate impact. Table 9 (below) provides a brief summary of each category of climate damages.

Table 9: Summary of Socio-economic Impacts of Climate Change in Armenia

Climate Impact Category	Social Impacts	Economic Impacts	Research Needs
High temperatures and heat waves			
Increased incidence of heat stroke and other heat-related maladies	Worse health outcomes, some mortality	Unknown	Project the future frequency of heat waves in Armenia, estimate the health impacts of heat waves in Armenia
Greater demand for electricity for air conditioning	Access to air conditioning only available to richer households; poorer households go without	Unknown	
Water shortages: loss of 10-27% of precipitation and 24% of river flow by 2100			
Less water available for irrigation and more areas may need to have irrigation systems.	Reduced agricultural productivity; loss of food security amount the rural poor	2-5% of GDP lost annually in agriculture production by 2100; an additional 2-3% of GDP lost in the food production industry annually by 2100	
Decreasing water level in Lake Sevan	Ecosystem damages and a loss of cultural heritage	Unknown	
Decreasing groundwater reserves	Insufficient drinking water would have serious health impacts	Unknown	Investigate the state of Armenia's current groundwater reserves; project the impacts of climate change on reserves
Declining water quality	Increased incidence of water-borne diseases like malaria and cholera	Unknown	Project the impact of climate change on Armenia's water quality
Reduced agricultural production			
Climatic zones move upward by 200 to 400m in elevation changing the appropriate mix of crops in	Reduced agricultural productivity; decline in food security among the rural poor	Unknown	

each area			
Less water available for irrigation; more areas may need to have irrigation systems		2-5% of GDP lost annually in agriculture production by 2100; an additional 2-3% of GDP lost in the food production industry annually by 2100	
Changing weather patterns and extreme storms cause crop damage		Unknown	
Loss of 19-22% of sub-alpine and alpine pastures and 3% of total pasture-land by 2100		Unknown	Estimate the current productivity Armenia's pastures; project changes in pasture productivity due to climate change
Reduced electricity production			
Partial loss of hydro-electricity generation		0.25% of GDP in lost electricity revenues each year by 2100	
Greater share of thermal electricity generation, which may drive up electricity tariffs	Higher prices will make electricity less affordable, especially for poorer households; less electricity used for heat could have serious health impacts	Unknown	
Damage to forests: loss of 1/3 of Armenia's forest-land by 2100			
Climatic zones move upward by 200 to 400m in elevation; precipitation decreases and evaporation increases making forest environments more arid	Ecosystem damages; losses to biodiversity; less firewood available to heat homes	0.04% of GDP lost each year in forestry revenues, on average each year from now until 2100	
Natural disasters			
Increased incidence of landslides, mudslides, and floods	Severe property and infrastructure damage will disrupt livelihoods; some injuries and loss of life	Unknown	Projected likely impacts of natural disasters in Armenia with climate change

3.1. Higher temperatures and heat waves

As average temperatures rise, human health may be at risk, especially among the elderly, very young, or infirm. Of particular concern are the effects of heat waves, or clusters of days with very high temperatures relative to local conditions. In Armenia, summer average temperatures are projected to reach 19.7ºC by 2100 (up from 15.7ºC currently, see above), with regional variations.[43] With higher average temperatures, heat waves become far more likely and health risks escalate.[44] The areas of Armenia at the greatest risk of heat waves are Vayotz Dzor marz and the Ararat Valley (including Yerevan), closely followed by Syunik, Lori and Tavush marzes.[45]

[43] Hovsepyan 2008a
[44] IPCC 2007
[45] Hovsepyan 2008a

Health impacts of heat effects range from mild discomfort to short-term infirmities like skin rashes, heat fatigue, heat cramps, heat exhaustion and heat stroke. Among vulnerable groups – the elderly, the infirm – heat waves can cause multiple deaths.[46]

3.1.1. Social impacts of heat waves

Human health is very sensitive to rapid changes in temperature; heat waves in Europe and the United States have resulted in hundreds and sometimes thousands of deaths and far more hospitalizations. While Armenians should be able to adapt to the gradual increase in average summer temperature over the next century,[47] heat waves – or clusters of very hot days – can have extremely detrimental health impacts. With a GDP per capita of 1 million AMD (US$3,000), very few Armenian have air conditioning in their homes; indeed, only 57,000 air conditioning units have been imported into the country in the last five years (the expected lifespan for a small, window air conditioner; it is unlikely that many air conditioners imported before 2004 are still operational).[48] At most, 2 percent of Armenian households own air conditioners and therefore have a means of cooling their homes during times of extreme heat.

3.1.2. Economic impacts of heat waves

Increased incidence of heat-related maladies, like heat stroke, may raise health costs and decrease labor productivity in Armenia. No national information currently exists on the likely future frequency of heat waves/ with climate change. Nor does any information exist on changes in health costs due to high or low temperatures in the Armenian context. This is an important area for further research.

As temperatures and incomes increase, demand for air conditioners may grow, along with demand for residential electricity, but purchases of air conditioners are unlikely to increase quickly: an air conditioner costs 250,000 AMD (US $750) (or more), almost half of the average Armenian income in 2006.[49] Of course, prices for electronic goods tend to decrease over time, which would make air conditioning purchases more affordable to a greater share of Armenian households.

3.1.3. Anticipatory adaptations to heat waves

Private measures:

- Houses and places of employment can be retrofitted for better ventilation, air conditioning, and better insulation from the sun's rays. Keeping homes and workplaces cooler in the summer will protect Armenians from the worst health impacts of extreme heat.
- New buildings (construction is booming throughout Armenia and especially in the capital) can be built with heating/cooling efficiency in mind. This will lower the amount of recurring costs for heating and cooling as well as make the properties worth more in the longer term.

Public measures:

- Existing building codes can be improved and new building codes can be introduced to ensure that all newly constructed structures have adequate ventilation and insulation for

[46] Ministry of Nature Protection of the Republic of Armenia 1998, WHO 2003, WHO 2007

[47] While deaths can be caused by sudden temperature extremes, there is little or no evidence of changes in the number of deaths due to gradual temperature changes which populations have time to adapt to. This is discussed in Ackerman and Stanton 2008

[48] Air conditioner imports as reported by the State Revenue Committee of the Government of the Republic of Armenia for 2004-2007 and the first 10 months of 2008 (UNDP Armenia 2009b).

[49] *Statistical Yearbook of Armenia, 2007*, "Living Standards of Population" section, Table 44 reports the Armenian average income for 2006 as 540,000 AMD.

comfortable and healthy indoor conditions in a warmer climate as well as better insulation/heating systems for existing cold weather.

- Private measures should be encouraged through state intervention. This can take the form of funding provided through grants or loans to households and businesses for the purposes of retrofitting old buildings for improved ventilation and better insulation. A failure to provide state facilitation of private adaptation measures will very likely result in one-sided distribution of these measures: richer households will be better protected from temperature extremes than will poorer households.
- The state can initiate a system of monitoring the well-being of at risk individuals (the elderly, shut-ins, the infirm) during heat waves.
- The state can initiate a system of advance warning of extreme temperatures that will alert all residents in areas of very high temperatures of their risks and of measures that can be taken to lessen risks.
- The state can increase investment in public health resources, including training for medical professionals, social workers and community leaders on identification of the symptoms of heat-related illness; identification of at-risk individuals; and provision of treatment as appropriate.
- The state can fund research on the likely future frequency of heat waves with climate change and the costs of treating patients made ill by extreme heat.

3.1.4. Reactive adaptation to heat waves in real time

Private measures:

- During heat waves all individuals – and especially at-risk populations – can increase their intake of drinking water and maintain low levels of exertion.
- Individuals can also monitor the well-being of friends and family.

Public measures:

- During heat waves the state can assure the proper functioning of systems that monitor the well-being of at-risk individuals, give advance warning of extreme temperatures, and provide health care to those in need.
- The state can open community centers or other government buildings that are better adapted to high temperatures than are individual homes. These buildings would act as safe havens for those in need of a cooler environment for the extent of the heat wave.[50]

3.2. Water shortage

3.2.1. General information about rivers and lakes in Armenia

From the Armenian highlands, water flows into the Kura River (in Georgia) and Aras River (along the border of Armenia and Turkey) and out to the Caspian Sea (see Figure 10). Armenia's 14 major river basins include nearly 10,000 rivers and streams, only 300 of which are more than 10 km in length; some of these rivers originate from runoff and subterranean springs, while others are fed primarily by melting snow and ice. Along with more than 100 small mountain lakes, Lake Sevan – one of the largest high-altitude lakes in the world – stores meltwater and run-off, spreading river flow from the wet seasons into the dry seasons.[51]

[50] See IPCC 2007, Ministry of Nature Protection of the Republic of Armenia 1998, and WHO 2004
[51] Ministry of Nature Protection of the Republic of Armenia 1998

Figure 10: Rivers and lakes of Armenia

Source: FHen 2007

For a country with so many important rivers and lakes, Armenia is surprisingly arid with an average annual rainfall of 590mm in the 1960s through 1980s that has shrunk to an annual average of just 530mm over the last ten years. One-fifth of the country's land area receives less than 400mm of rainfall each year. In the populous Ararat Valley, average rainfall is just 220mm each year; in contrast, the Aragats highlands average 830mm each year (see Figure 8 in Section 2). Most precipitation (on average, 37 percent of the annual total) falls in March, April and May while the least precipitation (17 percent) falls in December, January and February.[52] With such a high degree of variation in altitude, temperature, and precipitation level, Armenia has not one climate, but many: one area of the country may be at risk of drought while another area suffers a flood.[53]

3.2.2. Expected Changes to Precipitation

Under the A2 higher emissions scenario, with few exceptions, Armenia's driest regions are projected to lose the most rainfall with climate change, while its wettest regions will gain in average precipitation. On average, Armenian precipitation is projected to decline from 10 to 27 percent by 2100: 7 percent in the winter and 19 percent in the summer, the driest months, and 8 percent in spring, the wettest months. The Ararat Valley is projected to lose 30 percent of its precipitation with climate change, dropping from 220mm to 155mm.[54]

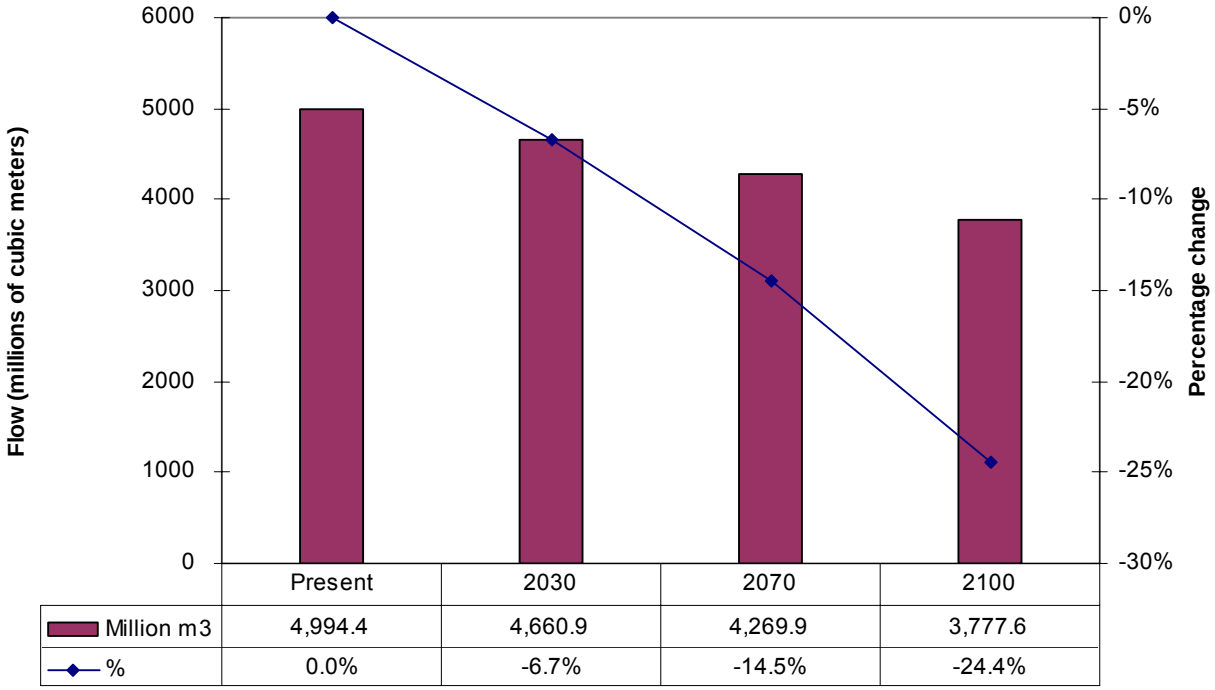
3.2.3. Resulting changes to river flow

Lower precipitation levels combine with higher average temperatures to increase evaporation rates and reduce winter snowpack and spring run-off: As a result less water reaches streams and rivers. Climate change will reduce river flow, lake levels, and, eventually, groundwater reserves.

[52] Hovsepyan 2008a, Ministry of Nature Protection of the Republic of Armenia 1998
[53] Gabrielyan 2003
[54] Hovsepyan 2008a

Armenia's total river flow is projected to drop 7 percent by 2030 and 24 percent by 2100 (see Figure 11).[55]

Figure 11: Total projected river flow change



Source: Adapted from Zakaryan 2008 Table 10.1

The change in river flows – a loss of one-quarter of total flow by 2100 – varies greatly across Armenia's river basins (see Table 10 below). The Vorotan and Voghji river basins are some of the few river basins that will increase in flow; in these areas, primarily in the Syunik Marz in southern Armenia, the increase in precipitation is projected to outweigh faster rates of evaporation caused by higher temperatures. In most river basins, however, the opposite is expected to take place: rivers flows will decrease as lower precipitation is compounded by the effects of high temperatures. Some of the rivers with the most severe expected decline in river flow are the Marmarik, Martouni, Vedi and Dzknaget, all projected to lose more than three-quarters of river flow by 2100.[56]

Table 10: Projected river flow change in 2100

River-Observation station	Scenarios	Flow	Change in the flow	
		Million m^3	Million m^3	%
Pambak-Toumanyan	Baseline	358		
	T+3.6, 1.01Q	275.5	-82.5	-23.0
Dzoraget – below Gargar	Baseline	477.4		
	T+3.6, 1.01Q	358.4	-119	-24.9
Debed-Ayrum	Baseline	1069.4		
	T+3.6, 1.01Q	842.1	-227.2	-25.1
Aghstev-Ijevan	Baseline	306		
	T+3.6, 1.01Q	218.1	-87.9	-28.7
Getik-Gosh	Baseline	110.7		
	T+3.6,1.01Q	83.8	-26.9	-24.3
Tavush-Berd	Baseline	19.78		

[55] Zakaryan et al. 2008
[56] Zakaryan et al. 2008

River-Observation station	Scenarios	Flow	Change in the flow	
		Million m^3	Million m^3	%
	T+3.6,1.01Q	16.12	-3.66	-18.5
Akhuryan-Haykadzor	Baseline	953.5		
	T+4.4,0.765Q	604	-349.6	-36.7
Hrazdan-Hrazdan	Baseline	248.9		
	T+5.0,0.75Q	159.1	-89.9	-36.1
Marmarik-Aghavnadzor	Baseline	150.4		
	T+5.0,0.75Q	32.8	-117.6	-78.2
Dzknaget – Tsovagyugh	Baseline	34.6		
	T+5.1,1.06Q	8.4	-26.2	-75.6
Masrik-Tsovak	Baseline	105.8		
	T+5.1,0.854Q	73	-32.8	-31.0
Martouni-Geghhovit	Baseline	57.4		
	T+5.1,0.854Q	12.5	-44.9	-78.2
Argichi-Verin Getashen	Baseline	172.9		
	T+5.1,0.854Q	54.6	-118.3	-68.4
All the rivers of the Sevan basin	Baseline	757.7		
	T+5.1,0.954Q	448.6	-309.1	-40.8
Vedi-Urtsadzor	Baseline	52.84		
	T+3.6,0.712Q	12.02	-40.8	-77.2
Arpa-Jermouk	Baseline	167.1		
	T+6.0,0.787Q	56.4	-110.6	-66.2
Meghriget- Meghri	Baseline	92.9		
	T+2.9,1.305Q	90.4	-2.5	-2.7
Voghji-Kapan	Baseline	332.2		
	T+2.9,1.305Q	383.3	51.1	15.4
Vorotan-Vorotan	Baseline	376.8		
	T+2.9,1.305Q	545.5	168.7	44.8
Sevjoor-Taronik	Baseline	466.9		
	T+3.6,0.712Q	369.2	-97.7	-20.9
Metsamor-Taronik	Baseline	466.9		
	T+3.6,0.712Q	369.2	-97.7	-20.9

Source: Adapted from Zakaryan 2008 Table 10.1

Q is the change in average annual precipitation in the relevant river basin or basins. A number less than one preceding Q indicates a decrease in precipitation (e.g., 0.75Q is a 25 percent decrease in precipitation) while a number greater than 1 indicates an increase in precipitation (e.g., 1.25Q is a 25 percent increase in precipitation).

For a number of Armenia's rivers the greatest cause of reduced flow will be less accumulation of snow and ice, with lower winter precipitation and higher winter temperatures. Snowmelt is responsible for 20 to 40 percent of Armenia's river flow, with most important sources of snow and ice accumulating at 1800 to 2800 meters above sea level. In terms of declining river flow due to reduced snowmelt, Armenia's most vulnerable river basins are the Akhuryan, Arpa, Azat, Hrazdan, and Kasakh.[57]

[57] Zakaryan et al. 2008: 6 and 17

3.2.4. Expected changes to lake levels

Spring snowmelt is the main source of Lake Sevan's chilly alpine waters. The 28 rivers and streams that flow into the lake are expected to decrease 41 percent in flow by 2100 (see Table 11); as a consequence, Lake Sevan's water levels will fall over time.[58]

In the twentieth century, there have already been significant changes to lake levels and rivers due to various large-scale projects:

- Lake Sevan's level fell by 19 meters (a 40 percent loss of volume) as the demand for irrigation water and hydro-electric generation grew.
- In the 1980s a 48 km tunnel was built to bring 250 million cubic meters of water each year from the Arpa River to Lake Sevan.
- In 2004, a second tunnel diverted water from the upper Vorotan River to the Arpa.[59]

The Arpa river is projected to decrease a stunning 66 percent in flow by 2100.[60] Without a large-scale investment in the further diversion of water from southern Armenia (where river flows are projected to increase) to Lake Sevan, the decrease in its water levels is likely to be severe.

Even large-scale water transfer projects, however, cannot compensate for the losses projected to the Sevan basin in 2100; the projected change in the combined volume of water flowing in the Sevan basin, the Arpa and the Vorotan is a loss of 250 million cubic meters, or 19 percent of current flow by 2100.

Table 11: Lake Sevan Basin river flow change

River-Observation station	Scenarios	Flow	Change in the flow		Period
		Million m^3	Million m^3	%	
All the rivers of the Sevan basin	Baseline	757.7	0	0	
	T+1.5, 0.983Q	664.7	-92.9	-12.3	2030
	T+3.3, 0.973Q	558.6	-199.1	-26.3	2070
	T+5.1, 0.954Q	448.6	-309.1	-40.8	2100
Arpa-Jermouk	Baseline	167.1	0	0	
	T+1.4,0.923Q	138.1	-29	-17.4	2030
	T+3.2,0.844Q	103.1	-64	-38.3	2070
	T+6.0,0.787Q	56.4	-110.6	-66.2	2100

Source: Adapted from Zakaryan 2008 Table 10.1

In Table 11, Q is the change in average annual precipitation in the relevant river basin or basins. A number less than one preceding Q indicates a decrease in precipitation (e.g., 0.75Q is a 25 percent decrease in precipitation) while a number greater than 1 indicates an increase in precipitation (e.g., 1.25Q is a 25 percent increase in precipitation).

3.2.5. Water consumption

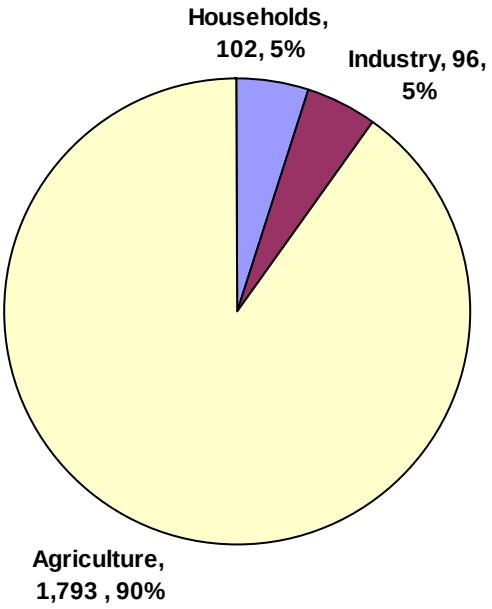
Armenia's river and lake water is critically important for irrigation, hydro-electric power generation, and industrial use. Lake Sevan and the Hrazdan River, which connects Lake Sevan to Yerevan and the Aras River, serve the densely populated Ararat Valley and Hrazdan River Basin areas and are of vital importance both economically and culturally.

Four-tenths of the water consumed each year is groundwater while six-tenths is taken from rivers and lakes[61]. Nearly ninety percent of all water consumed in Armenia is used for irrigation or other agricultural purposes (see Figure 12); almost all irrigation water is drawn from rivers and lakes, while ninety-six percent of the country's drinking water is groundwater. Residential water service, amounting to just 5 percent of all water used each year, is provided by five State water companies

[58] Babayan et al. 2005, Zakaryan et al. 2008, Torosyan 2007
[59] USAID 2007
[60] Zakaryan et al. 2008
[61] USAID 2007: 4

(see Appendix Table C.1 for detailed information on the State water companies). The overall water volume abstracted by these companies is 590 million cubic meters, of which an astounding 84 percent is lost as leakages in the water delivery system[62] (note that Figure 12 shows water delivered, not water abstracted).

Figure 12: Water consumption in Armenia, 2006 *(Millions of cubic meters, percentage of total consumption)*



Source: National Statistical Service of the Republic of Armenia 2007e

Armenia's water infrastructure was built in the Soviet era and efficiency was not a high priority in its design. Forty percent of the nation's irrigated lands depend on high-lift pumping stations that use electricity to raise water by as much as 500 meters. Nine percent of national electricity consumption is used to pump water for agricultural and residential use.[63] Less than half of all lands requiring irrigation currently receive it; Armenia's tiny, post-land-reform farms cannot afford the high cost of maintain aging irrigation systems and other related infrastructure[64]. At the same time, in looking at the gross margins and profits from farmers who could utilize irrigation systems, it seems that there are possibilities to fund such irrigation systems – especially for such crops as vegetables, grapes, other fruits, and even potatoes.[65] Thus, it could be that the limiting factor is capital rather than operating budgets.

As the effects of climate change are felt in Armenia from losses to precipitation and river flow, less total water will be available for use by households, farms, and industry. There is an enormous opportunity to avoid water shortages by repairing and maintaining the State-owned water delivery system.

3.2.6. Health and water quality

Water quality is an area of great concern as climate change progresses in Armenia. Water-borne diseases are already serious health problems in the country, and climate change is expected to create more favorable conditions for the reproduction and spread of many diseases. There is no Armenian-

[62] Public Services Regulatory Commission of the Republic of Armenia 2007
[63] USAID 2007
[64] National Statistical Service of the Republic of Armenia 2007c
[65] See Eghizaryan et al. 2009, UNDP

specific research available that forecasts the scale of the likely increase in incidence of water-borne diseases with climate change. This is a priority area for future research. Planning for these kinds of serious public health crises begins with careful epidemiological research, a key adaptation measure for Armenia.[66]

3.2.7. Social impacts of a water shortage

Over 95 percent of the nation's residential water comes from groundwater supplies for which there is no immediate evidence of impending scarcity.[67] However, no data on Armenia's subterranean waters has been collected since 1990.[68] Further research is strongly recommended to evaluate the vulnerability of national groundwater reserves to the effects of climate change.

In the long-term, however, increasingly scarce surface waters will affect groundwater availability in two ways; as river flow is projected to decrease by 24 percent over the next century due to climate change, the recharge of underground reservoirs from surface water will also decrease, while some former users of surface water will switch to groundwater withdrawals. As a result, water shortages may impact on human welfare – demand for groundwater will increase while supplies of surface water, and eventually of groundwater, will decrease. At the same time, demands for all categories of water will likely rise with higher temperatures and more rapid evaporation. The health consequences of reduced water supplies for drinking and sanitation have the potential to be very serious.

3.2.8. Economic impacts of a water shortage

Armenia's agriculture sector, which accounts for 20 percent of year 2007 GDP in direct agricultural production and an additional 10 percent of GDP in food manufacturing (together, 945 billion AMD, or US$2.7 billion), is highly dependent on irrigation water from rivers, many of which will suffer large-scale reductions in flow as climate change progresses. More than half of Armenia's arable land requires irrigation; with climate change more land will fall under this category but less river water will be available. The actual impact on agricultural production will depend on policy decisions regarding the allocation of irrigation water among farms, and the allocation of all water resources among all uses. These policy decisions will include important choices regarding how much money will be invested in repairing the existing water delivery system to limit leakages.

Crops, which are more vulnerable to drought than pasture and far more likely to require irrigation, represent 14 percent of GDP (430 billion AMD, or US$1.2 billion). A 24 percent reduction in year 2100 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.[69] The expected loss in yield for grapes would be 21 percent and for winter wheat, 25 percent. The climate projected for 2100, if it occurred in today's economy, would cause total losses to the agricultural sector of 65 to 145 billion AMD, or US$190 to 420 million (with an average impact of 105 billion AMD or US$300 million); this would be an annual loss of 2 to 5 percent of GDP (3 percent on average). These figures do not take into account any adaptation measures that may be adopted in response to climate change, such as shifting the crops farmed, changing the locations where they are farmed, or changing the inputs into the farming process. However, they do provide a sense of scale of the potential impact of climate change if there is no adaptation in the agricultural sector.

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[66] Ministry of Nature Protection of the Republic of Armenia 1998, Sahakyan and Keshishyan 2008, WHO 2007

[67] PA Consulting Group 2005

[68] Zakaryan et al. 2008: 14

[69] These calculations use the FAO's crop yield response to water deficit methodology (Doorenbos and Kassam. 1979), substituting the ratio of projected to current water availability (assumed to be proportional to losses in river flow) for the ratio of actual to maximum evapotranspiration. This substitution may render a more conservative (lower than likely) result because it considers only water availability (via irrigation) and not increased evaporation due to higher temperatures. High and low results are based on the FAO's range of yield response factors by crop.

Depending on policy choices, reductions in agricultural production could also impact on Armenia's food production industry and thereby have a wider-reaching effect on the economy. If agricultural losses result in losses to the food production industry of the same scale – 15 to 34 percent reduction – the additional decrease to GDP from the climate projected for 2100 would range from 1.5 to 3.4 percent. In total, direct agricultural and food processing losses from climate change expected by 2100 could amount to 3.5 to 8.4 percent of GDP.

Box 2: Example of the potential impacts of climate change: grape production and the brandy industry

An important example of how climate change could have far-reaching consequences for the economy of Armenia is grape production and the brandy industry. These two products account for 65 percent of Armenia's food exports or about 8 percent of total exports.[70] Since many rural areas in Armenia are expected to experience higher temperatures, more evaporation, and less rainfall, a greater share of vineyards may require irrigation. Fields that have not previously needed irrigation may lack the necessary infrastructure to transport and apply water. Even fields that are currently under irrigation may receive less water as river flows slow. If Armenia's grape production declines, so too will its brandy production, revenues, and jobs. A 21 percent loss to grape productivity would result in a 14 percent loss to Armenia's total food exports. Brandy is an important export for Armenia; losses in this industry could also impact on Armenia's trade balance.

3.2.9. Anticipatory adaptation – preparing for future water shortages

Private measures:

- Households can install small-scale rainwater collection and storage tanks in yards and on rooftops.
- Households, farms and other businesses can implement conservation measures to reduce water use and reuse water where appropriate (for example, the use of non-sewage wastewater in gardens). The development of good conservation practices now will prepare individuals and firms for future shortages.

Public measures:

The state can invest in large-scale infrastructure projects to increase Armenia's capacity for water storage and limit losses from inefficient distribution systems. These investments would include:

- Building dams and reservoirs to increase water storage capacity by 1 to 2 billion cubic meters
- Upgrading the irrigation water distribution system to reduce losses
- Extending the existing irrigation water distribution system to cover more arable land (depending on policy choices regarding how scarce water will be allocated across uses)
- Increasing the flow of water to Lake Sevan by transferring water from basins that are predicted to have increased river flow with climate change
- The state can introduce conservation laws limiting the use of water by households, industry, and farms. These laws could specify the use of particular irrigation techniques or equipment.
- The state can initiate public education programs on conservation and training programs for individuals in water intensive fields like agriculture.

[70] Ministry of Agriculture 2006

3.2.10. Reactive adaptation – managing water shortages in real time[71]

Private measures:

- In times of periodic drought or longer-term water shortage, more profound conservation measures may be necessary. Households, farms and other businesses can further limit water use in response to current conditions.

Public measures:

- In periods of water shortage, the state can adopt regulations enforcing tighter restrictions on water use by households, industry and farms. Public information campaigns on conservation measures can accompany these new regulations.
- If water demand exceeds water supply, the state can and must allocate water among different users including energy production, irrigation, and use by households and industry.

Box 3: The Millennium Challenge Corporation and water supply adaptation in Armenia

Established by the U.S. government in 2004, the mission of the Millennium Challenge Corporation (MCC) is to reduce poverty in the poorest countries in the world. Countries currently working with the MCC include: Armenia, Benin, Cape Verde, El Salvador, Georgia, Ghana, Honduras, Lesotho, Madagascar, Mali, Mongolia, Morocco, Mozambique, Nicaragua, Tanzania and Vanuatu. The MCC also works in partnership with other U.S. agencies, donors and development partners, such as the World Bank, the African Development Bank and the U.S. Trade and Development Agency.[72]

The MCC and the Republic of Armenia have signed an agreement to work together to solve irrigation problems and improve the water supply in Armenia, and have planned projects budgeted at US$112 million. These projects fall under two main goals. The first goal is to increase irrigation by 25 percent and improve irrigation efficiency by converting from pump to gravity-fed irrigation. Major projects planned to achieve this goal include: conversion of 15 irrigation systems from pump to gravity; rehabilitation of up to seven reservoirs; rehabilitation of six main canals; renovation and resizing of 68 pumping stations; rehabilitation of the Ararat Valley drainage system; and rehabilitation of tertiary canals.

The second main goal of the projects in which MCC is involved is to transfer financial liability for irrigation management from the Armenian government to water users. Major projects planned to achieve this goal include: strengthening water users associations; clarifying responsibilities for different stakeholders; developing institutional and legal guidelines for farmers' activities; developing a professional irrigation association; drafting irrigation law; and developing plans to monitor and evaluate project performance.

3.3. Reduced agricultural production

Climate change will have profound effects on agricultural production all around the world. Warmer temperatures, changing weather patterns, changes in precipitation levels and access to irrigation water will make it difficult to keep the same crops growing in any given area. New crops that are more appropriate to the climate and available water will have to be planted. In many cases, these new crops will require different infrastructure and different knowledge on the part of farmers. In some areas, growing conditions will become inappropriate for growing any crops at all. In a country like Armenia, with a strong agricultural sector that makes an important contribution to GDP, climate change's impact on agriculture could have a serious effect on the economy as a whole.

[71] Gabrielyan 2003, IPCC 2007, Ministry of Nature Protection of the Republic of Armenia 1998
[72] Millennium Challenge Corporation 2008, Millennium Challenge Corporation 2009

3.3.1. General information on agriculture in Armenia

Following Armenian independence in 1991, all collective and state farms were disbanded. The nation's farmland was privatized into more than 340,000 small farms, some smaller than one hectare (ha) in size. The early 1990s were a time of great economic hardship in Armenia. Cut off from its neighbors by war and economic blockades, its farmers and food manufacturers were no longer able to export their goods; a depressed domestic economy greatly reduced sales within the country as well. It was under these conditions that private family farms attempted to reallocate irrigation infrastructure and farm machinery from a very large scale to a very small scale. The results were mixed, and today many farms that would benefit from irrigation do not receive it.[73]

Cash-constrained farmers rapidly replaced Armenia's production for export with production for self-consumption. Much of the country's fruit trees and grape vines were replaced by annual crops like wheat, potatoes and vegetables. Armavir, Ararat, Kotayk, Syunik and Vayotz Dzor Marzes experienced the largest reductions in orchards and vineyards. Land planted in fruit trees decreased from 50,000 ha in 1990 to 23,000 ha in 2000, while vineyards dropped from 29,000 ha to 15,000 ha. At the same time, the land area planted in grains increased from 138,000 ha to 181,000 ha (see Appendix Table E.2).[74]

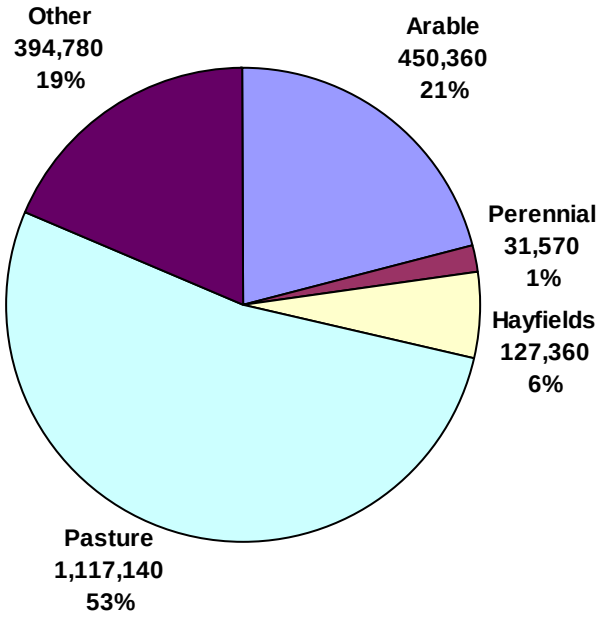
Similarly, the population of Armenian livestock also decreased rapidly during the post-independence period of farm privatization. From 1991 to 2000, the number of cattle fell by 25 percent, pigs by 77 percent, sheep and goats by 54 percent; and poultry by 55 percent (see Appendix Table E.3). Only milch cows and horses maintained their numbers or grew in the 1990s. The number of milch cows grew by 4 percent as sales of meat fell and milk overshadowed meat in dietary importance (see Appendix Table E.4). Much of the farm equipment used on collective and state farms was not easily divisible or too expensive for small farmers; horse-drawn plows replaced tractors on many farms and the Armenian horse population grew by 76 percent.[75]

Since 2000, Armenia agriculture has grown substantially in terms of area in orchards and vineyards, and number of livestock animals, although it has not yet reached the 1990 level of productivity.[76] It is in this context of expansion that any damages or losses to the agricultural sector must be understood: climate change not only may decrease current levels of agricultural production; it also has the potential to impede future growth in agricultural production. While Armenia attempts to expand active agricultural lands and the productivity of those lands, climate change will likely be a force working in the opposite direction; it will reduce the availability of agricultural lands and the productivity of those lands.

Today, 98 percent of agricultural output is produced by family farms with an average size of 1.4 ha. The remaining 2 percent of production comes from larger commercial organizations and some state entities (CJSCs and SNCOs) that work primarily on selection and crop protection, but also sell their produce.[77] More than two-thirds of Armenia's total land area is farmland: 480 million ha in crops and perennials and over 1 billion ha in pasture and hayfields (see Figure 15 and below).[78] According to 2006 report, out of 250,000 ha that require irrigation, only 123,480 ha were receiving it.[79]

[73] Khachatryan 2008
[74] Khachatryan 2008, Sargsyan 2008
[75] Sargsyan 2008
[76] Sargsyan 2008
[77] Ministry of Agriculture 2006, UNDP Armenia 2009b
[78] Nazaryan 2008
[79] Ministry of Agriculture 2006

Figure 13: Armenian agricultural lands usage in 2006 (in 1000 hectares)



Source: Republic of Armenia, 2008c

Agriculture and food processing accounted for 30 percent of Armenian GDP in 2007, making them by far its largest industry – though this will likely decline over time.[80] Even so, the importance of the commercial agricultural sector is outweighed by that of production for self-consumption, which is not counted in official GDP statistics. Large shares of all crops are consumed by farm families (see Table 12) and agricultural production is essential for meeting these families' nutritional needs. By weight, Armenia's most important agricultural product is cow's milk, followed by potatoes, wheat, tomatoes and other fresh vegetables. By value, Armenia's most important agricultural product is again cow's milk, followed by potatoes, beef, wheat, and tomatoes (see Appendix Table E.5 for a listing of Armenia's most important agricultural products by weight and value).

Table 12: Agricultural production (2007)

Type of crop	Total production (1000 metric tons)	Production for sale (%)
Wheat	250-260	40-50
Potato	580-620	80
Vegetables	900-950	60-65
Fruit and berries	250-300	65-70
Grapes	150-200	90-95

Source: Avagyan and Manucharyan 2008 and 2009

Because Armenia is so geographically and climatically diverse, some areas are better suited to particular crops.[81]

- Ararat, Amavir, Vayk, Syunik, Aragatsotn, and Tavush Marzes grow a wide variety of fruits, including grapes;
- Lori, Aragatsotn, Gegharkunik, and Shirak Marzes specialize in potatoes; and

[80] Food and Agriculture Organization 2008b, National Statistical Service of the Republic of Armenia 2007c
[81] Khachatryan 2007, Khachatryan 2009

- Shirak, Kotayk, Syunik, and Gegharkunik Marzes predominantly grow grains.[82]

Some of each crop or type of livestock is grown or raised in most marzes (see Figure 14 and Table 13).

Figure 14: Land use in Armenia

Legend	
Red line – specially protected areas of nature	
Bright yellow – arable lands	Light yellow – meadows
Red – multiyear plantings	Light green – forests
Green – hayfields	Blue – waters

Source: Nazaryan 2008 [Fig.1]

Food and agricultural products accounted for 12 percent of Armenian exports and 20 percent of imports by value in 2005. Armenia imports staple foods like wheat, corn, pasta, dairy products and infant food, and exports fruit and berries, alcoholic beverages and meats; 65 percent of food exports, by value, are brandy (see Figure 15).[83] Most of the nation's exports are purchased by Russia and other Eastern European countries.[84]

Table 13: Armenian agricultural products by marz (2005)

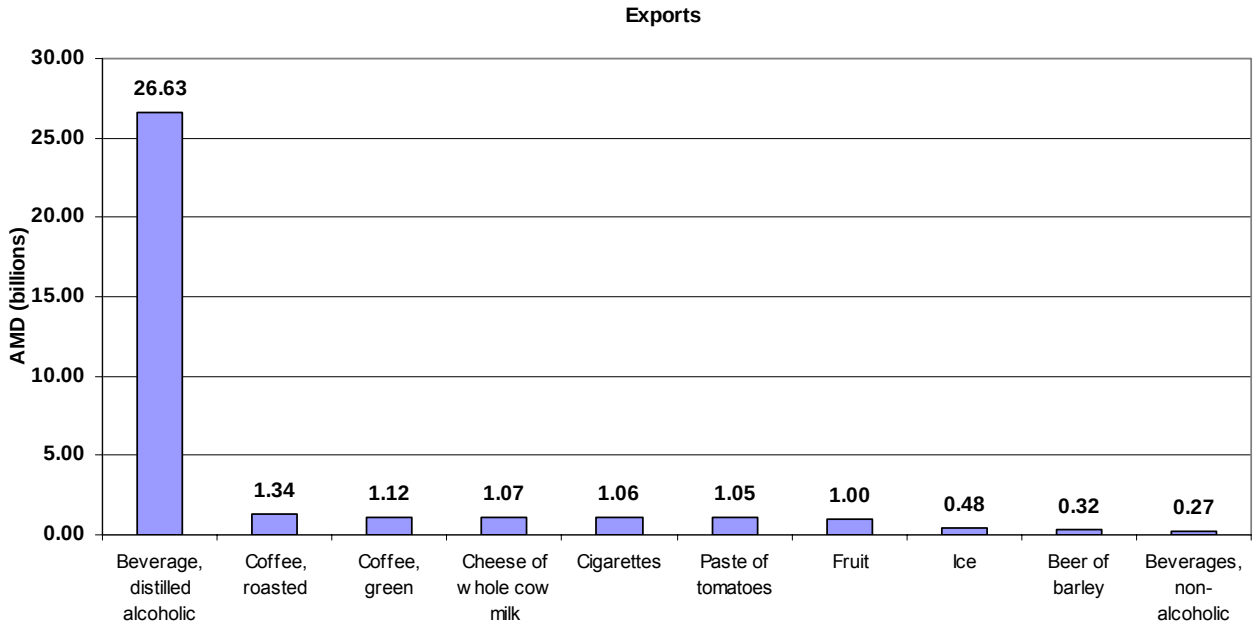
Marz	Veget-ables	Grapes	Fruit	Milk and Meat	Sheep	Pigs	Potatoes	Grains	Fodder
Aragatsotn			x	x			x	x	
Ararat	x	x	x	x			x	x	
Armavir	x	x	x				x	x	
Gegharkunik	x			x			x	x	
Kotayk	x		x	x				x	
Lori				x			x	x	x

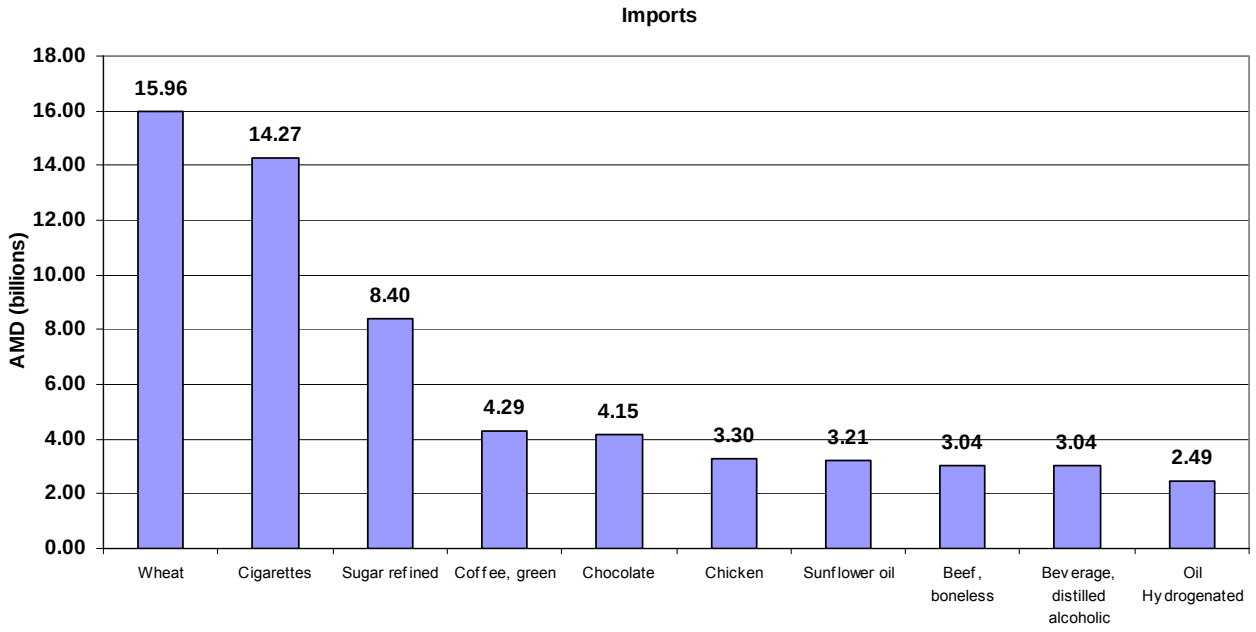
[82] Khachatryan 2009, Khachatryan 2008
[83] Food and Agriculture Organization 2008b, Khachatryan 2009,
[84] Ministry of Agriculture 2006

Shirak	x			x	x		x	x	
Syunik				x	x		x	x	
Tavoush		x		x	x	x	x	x	
Vayots Dzor			x	x					

Source: Ministry of Agriculture 2006

Figure 15: Main Armenian food and agriculture exports and imports, 2005





Source: Food and Agriculture Organization 2008b

3.3.2. Climate change and crops

Climate change is expected to have three main effects on Armenia's crops. First, the appropriate zone for growing each crop will likely move upwards in altitude 100 m by 2030 and 200-400 m by

2100.[85] For the most part this should represent an expansion of zones; there do not appear to be any important crops grown in Armenia for which a 3-5ºC increase in average temperature will make cultivation in the lower end of the current zone untenable.[86] In general, more lands at higher elevations will become appropriate for growing crops, which may create some competition for higher elevation lands now used for pasture or hayfields. In most cases, sub-alpine pasture and hayfields cannot move further upward into the rocky mountainous outcroppings in response to this competition.

Second, the combination of higher temperatures, increased evaporation and – for many areas of Armenia – lower precipitation levels, will lead to a loss of productivity for most crops unless irrigation levels can be increased and the irrigated area can be expanded.[87] In some isolated cases, higher temperatures could make cultivation newly possible in higher altitude areas that have arable soils and will in the future have sufficient precipitation for good productivity; several mountainous areas will be receiving more precipitation and growing warmer in the Northeast, western Lake Sevan basin, Syunik, and Aragats. Of course, many of these areas are forested and some have limited road access. Far more commonly, the combination of higher temperatures and lower precipitation across most of Armenia will result in productivity losses as the demand for irrigation – already unmet on more than half of the lands that currently require irrigation – outstrips supply. The expansion of irrigation will be limited both by infrastructure and by a loss in river flow over the next century.

Third, changing weather patterns may cause damage to crops and agricultural lands in ways that cannot be predicted by average temperature increases or changes in annual precipitation levels. As climate change progresses, weather patterns are expected to become more erratic with more severe storms. High winds and heavy rains can damage crops, reducing yields. Severe storms can also trigger natural disasters like landslides, mudflows, and floods, which can cause damage to agricultural lands and irrigation infrastructure.

3.3.3. Climate change and pasture-land

Among the agricultural lands that may be the hardest hit by climate change are Armenia's alpine and sub-alpine pastures. Thirty-seven percent of all pastures and hayfields are located above 2,300m in elevation and are classified as alpine or sub-alpine (see Table 14).[88] Many of the plant species endemic to the nation's high-altitude meadows could not grow at higher temperatures. These meadows may be replaced by crops or repopulated with other fodder species but the ecological loss is irreplaceable and unquantifiable.

Table 14: Armenian pastures and hayfields by altitude

Category of hayfields & pasture	Altitude (meters)	Hectares	Share of total
Semi-desert	400-1,200	33	0.003%
Steppe	900-1,700	519,000	53%
Post-forest	1,800-2,700	88,000	9%
Sub-alpine	2,300-2,800	257,000	26%
Alpine	2,700-3,500	116,000	12%

Source: Nazaryan 2008

[85] Fayvush and Nalbandyan 2008, Ministry of Nature Protection of the Republic of Armenia 1998: 46
[86] Khachatryan 2008
[87] Khachatryan 2008, Ministry of Nature Protection of the Republic of Armenia 1998: 46
[88] Sargsyan 2008

Table 15: Distribution and prevalence of pastures

	Current distribution and prevalence		Distribution and prevalence in the climate change scenario	
Climatic zones	**Of total pastures (%)**	**Prevalence (1000 ha)**	**Prevalence (1000 ha)**	**% change**
1. Semi-deserts	8.5	95.6	111.8	17.0
2. Steppe	20.7	232.9	232.9	0.0
3. Meadow-prairie	15.5	174.4	214.5	23.0
4. Post-forest	12.4	139.5	139.5	0.0
5. Sub-alpine	28.3	318.4	257.9	-19.0
6. Alpine	13.7	154.0	120.1	-22.0
Other (non-defined zones)	0.9	10.0	10.0	0.0
Total		1,125.0	1,086.7	-3.4

Source: Sargsyan 2008

Total pasture lands in Armenia are expected to decline by 3 percent; with 19 to 22 percent losses in sub-alpine and alpine areas (see Table 15). In terms of total productivity, pastures are projected to produce 5 percent less livestock feed in total across Armenia, but only if the remaining pastures maintain the same level of productivity as in the past. Pasture productivity, however, is expected to decline with climate change (see Table 16 below).[89] Little data is collected in Armenia on the productivity of pasture lands; the latest data is for 1992, and projections are based on the best guesses of local agronomists. Because of the importance of livestock (which relies part of the year on grazing) in the Armenian diet and agricultural economy, and the likely vulnerability of pastures to climate change, this is a high priority area for new research.

Table 16: Productivity of pastures and feed resources

Natural zones	**Average for 1987-1992 years**		**Feed resources under expected climate change scenario (1000 metric tons)**
	Productivity (100 kg/hectare)	**Feed resources (1000 metric tons)**	
1. Semi-deserts	4	38	45
2. Prairie	9	210	210
3. Meadow-prairie	17	297	365
4. Post-forest	15	209	209
5. Subalpine	19	605	490
6. Alpine	10	154	120
Other (non-defined zones)	6	6	6
Total		**1,518**	**1,444**

Source: Sargsyan 2008

[89] Sargsyan 2008

3.3.4. Droughts

Armenia has historically been highly susceptible to drought, a phenomenon that is very likely to increase with climate change. The Trans-Caucasus region is listed as an area specifically vulnerable to drought and desertification in the United Nations Convention to Combat Desertification. Over the last 15 years, the Armenian State Hydromet Service has improved its ability to forecast droughts, but little progress has been made towards expanding the reach of Armenia's irrigation system. In drier years, the chance of a drought in the south-east Ararat Valley is almost 100 percent. As temperatures increase and precipitation declines throughout the next century, an increased frequency of prolonged droughts is almost a certainty.[90]

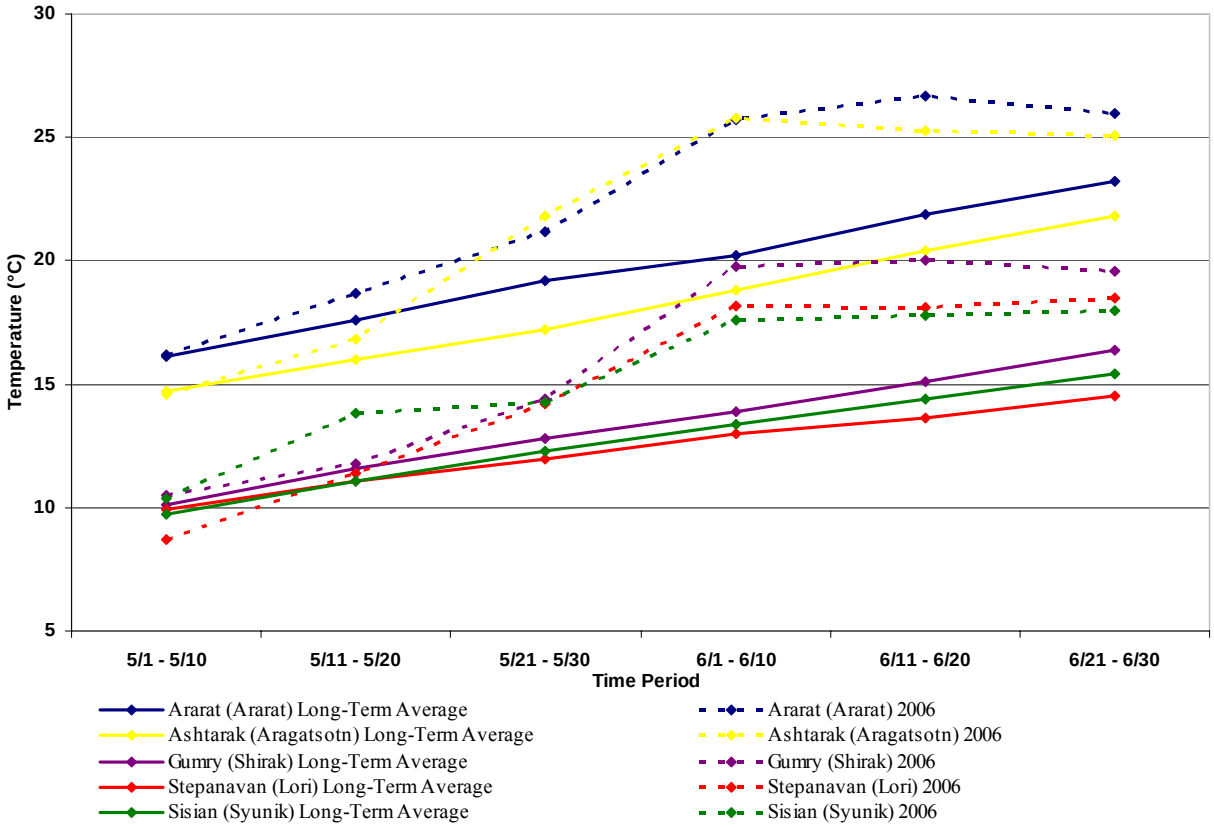
Droughts in the arid regions of Armenia generally occur each summer beginning in mid-June. Since 1990, however, the entire country has experienced more frequent and widespread droughts. Although droughts are generally always destructive, the amount of damage caused depends on the timing of the drought. Droughts occurring in the spring overlap with the first phase of growth and development of crops, summer droughts occur during the harvest, and autumn droughts slow the growth of vegetation, which can affect crops' frost-hardiness. The greatest demand for water for agriculture comes in March, April and May, making spring droughts the most harmful.[91]

Between 1998 and 2006, Armenia experienced five droughts. In August 1999, Armenia daily average temperatures were 6-8°C above normal. Although this drought was severe, it caused less damage than the longer-term drought of 2000 during which precipitation and river output decreased 55-80 percent and 40-50 percent, respectively. By the end of August 2000, the drought had caused 38 billion AMD (US$110 million) in total damages, nearly 24 billion AMD (US$70 million) of which were in the agriculture sector.[92] The 2000 drought reduced potato yields by 35 percent, cereal harvest by 20 percent, and vegetable production by 16 percent. In 2001 and 2004 Armenia suffered shorter, less severe droughts before another longer, more damaging drought in 2006.[93]

The 2006 drought caused approximately 1.1 billion AMD (US$3.1 million) in damages, accounting for 25 percent of all damages from natural disasters in that year.[94] This drought was especially destructive because of its timing; whereas most droughts begin in mid-June, the 2006 drought began in mid-May, usually the rainiest month of the year, which is followed by the drier summer. The drought affected Aragatsotn, Ararat, Lori, Shirak, Syunik, Tavush, and Vayots Dzor marzes.[95] Figure 16 and Figure 17 report the sharp increases in temperature and decreases in precipitation in specific regions across Armenia. Figure 16 shows a rapid warming above the average for each city beginning in mid-May; Figure 17 shows a sudden drop in precipitation compared to the long-term average over the same time period. In all regions, the temperature stayed above average, while precipitation remained below average through the end of June.

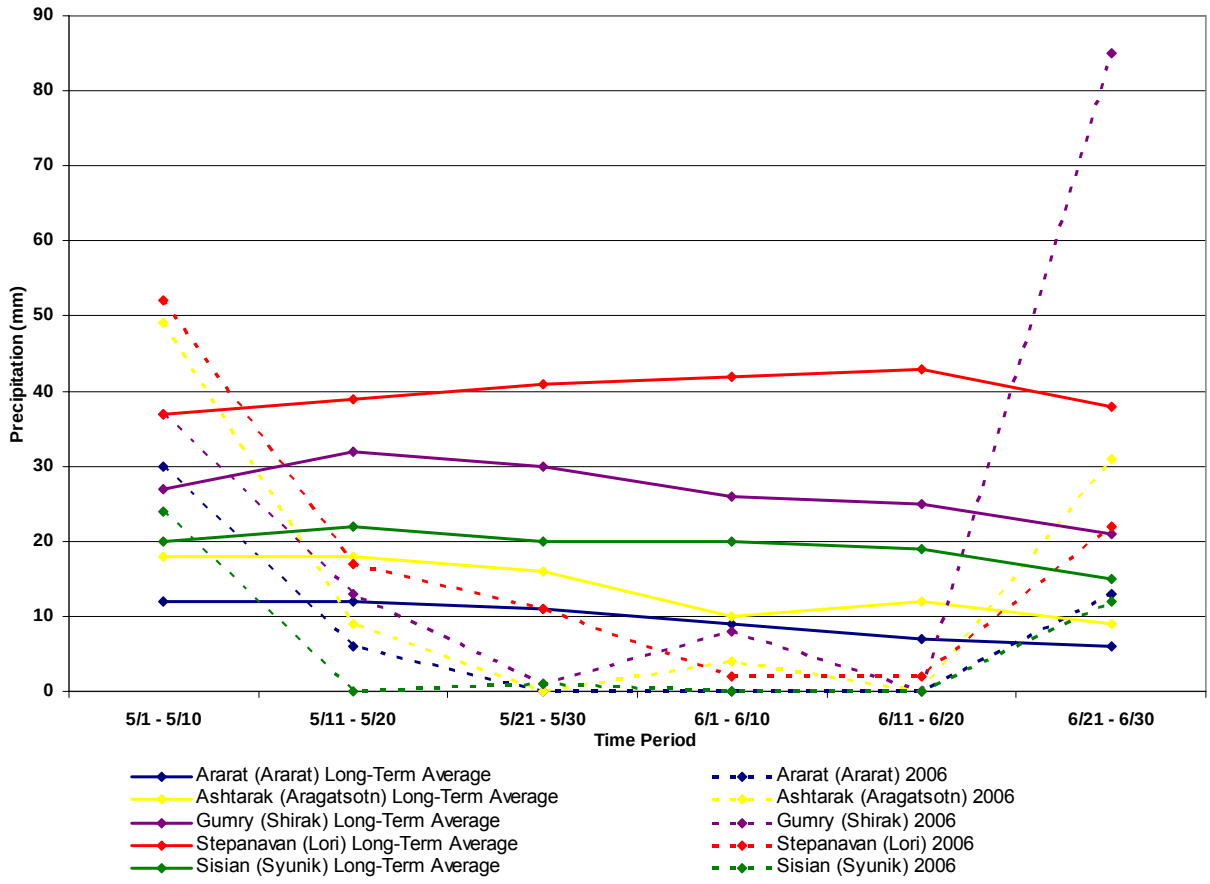
[90] Khachatryan 2008
[91] Khachatryan 2007
[92] Agricultural damage estimates from the 2000 drought vary from US$40 million (Khachatryan 2007) to US$66.7 million (Armenian State Hydrometeorological and Monitoring Service 2009).
[93] Armenian State Hydrometeorological and Monitoring Service 2009
[94] Armenian Rescue Service 2009
[95] Armenian Rescue Service 2009

Figure 16: May-June 2006 temperature compared to the long-term average by marz



Source: Khachatryan 2008

Figure 17: May-June 2006 Precipitation Compared to Long-Term Average, by marz



Source: Khachatryan 2008

3.3.5. Social impact of food shortage

As noted earlier, Armenia's 340,000 very small farms – many less than 1 hectare in size – produce 98 percent of all crops and livestock. The rural population is highly dependent on a stable climate for both food and income. The urban population, meanwhile, relies on family farms' agricultural productivity to avoid food shortages, limit food imports, and keep food prices stable. More than 40 percent of Armenia's agricultural production is for self-consumption on farms and is essential to food security in rural areas.

Only half of the lands requiring irrigation were receiving it in 2006 due to inefficiencies in the water delivery system.[96] With less precipitation (especially in Shirak, Aparan-Hrazdan, Ararat Valley, and Vayk marzes), more rapid evaporation, and lower levels of soil moisture, a greater share of Armenia's farmland will likely need irrigation, and each hectare will need more water for productivity. Many rural Armenian families are extremely vulnerable to any reduction in natural resources or income. Unless basic needs are met by the state, climate change may result in worsening health outcomes in rural areas.

As discussed above, Armenia's pasture-lands are extremely vulnerable to climate change. Present day alpine and sub-alpine areas will become too warm for their current ecosystems and will lose one-fifth of their productivity under the different climate scenarios. Lower elevation pastures will become much warmer and much drier, again reducing productivity. Armenia's farm families rely on these pastures to feed livestock, a key component of the Armenian diet. The current and projected health of Armenia's pastures is an under-studied area that should be a priority for new research.

3.3.6. Anticipatory adaptation – preparing for future food shortages

Private measures:

- Farmers can improve their irrigation and cultivation techniques to preserve soil moisture, and can invest in low-water irrigation equipment. Farmers can also update water distribution and irrigation systems to improve efficiency.
- Farmers can improve pasture management techniques to improve the health and resilience of pasture ecosystems, thereby reducing these areas' vulnerability to climate change.
- As climate changes, autonomous "private" adaptation efforts including changing crop rotations, changing inputs of fertilizer, changing the crops grown and diversifying farm income generating activities (perhaps to include producing other goods or services) are possible.

Public measures:

- The state can facilitate improvements to irrigation efficiency and pasture husbandry by means of training programs, demonstration projects, community meetings, and the provision of funding in the form of grants or loans to pay for new irrigation equipment. A failure to provide state facilitation of private adaptation measures (for example, the provision of loans) will very likely result in one-sided distribution of these measures. Richer farmers will be able to afford adaptation measures but poorer farmers will not.
- The state can initiate programs to improve forecasting of precipitation, temperature, evaporation, soil moisture and other climate conditions. These programs would include an appropriate means of promptly distributing this information to farmers.
- The state can support research in the area of pastures' current productivity and vulnerability to climate change.
- Where the state controls the system, it can upgrade the irrigation water distribution system to reduce losses.

[96] Ministry of Agriculture 2006: 7 and Republic of Armenia 2008b

- The state can also subsidize the extension of the existing irrigation water distribution system to cover more arable land (depending on the cost/benefit in terms of tax revenue or loans, as well as policy choices regarding how scarce water will be allocated across uses)
- The state can introduce conservation laws limiting the use of water by farms. These laws could specify the use of particular irrigation techniques or equipment.

3.3.7. Reactive adaptation – managing food shortages in real time[97]

Private measures:

- Farmers can change their composition of crop species, replacing plants that are appropriate for cooler temperatures with plants that thrive in the new warmer, drier climate.
- If irrigation water is available and distribution systems have been improved, farmers can react to drought condition with the application of irrigation water.

Public measures:

- The state can facilitate a large-scale change in Armenia's crop structure. Any such change would require careful consideration of property rights: as climatic conditions change the use of some arable lands will become untenable while other lands, once inappropriate for agriculture because of temperature or access to water, will become viable farmland. Some farmers will lose their livelihoods, while other property owners will suddenly control good farmland. The issues involved are complex and will require careful and equitable judgments by policy makers.
- The state can provide re-training programs for farmers, assisting in their ability to engage in an alternative career in fields of work that lack adequate numbers of skilled workers.

3.4. Reduced electricity production and price increases

Power generation and energy supply is an important area of climate change impacts, especially in countries or regions where the energy supply is especially vulnerable or where little redundancy exists in generation capacity. Decreased river flows affect hydropower generation. Higher temperatures and lower river and lake levels threaten the cooling mechanisms of nuclear and thermal electricity plants. Armenia has no domestic sources of fossil fuels; its electricity generation relies on hydropower and the import of natural gas for thermal generation and uranium for nuclear generation.

Before independence, Armenia was part of the Trans-Caucasus electrical grid and produced only 1 percent of its own energy.[98] Since 1991, Armenia has operated an independent electrical system, with limited linkages to some of its neighbors. With electricity already in short supply because of the 1988 post-earthquake closure of the Medzamor nuclear plant and the destruction of the country's largest non-nuclear thermal plant by the earthquake,[99] Armenia suffered a serious electricity shortage in the early 1990s. In 1992, a blockade imposed by Azerbaijan and Turkey reduced Armenia's access to natural gas and oil, and in 1993 a new gas pipeline built through Georgia was damaged in an act of sabotage. During this period, the country's electricity supply dropped from 24-hour service to just 2 hours of service each day.[100]

In the mid-1990s, Armenia's energy crisis was mitigated by adding more productive capacity and reorganizing the entire electricity system, from generation to delivery. Relief from electricity

[97] Harutyunyan 2008, IPCC 2007, Ministry of Nature Protection of the Republic of Armenia 1998
[98] Curtis 1995
[99] Curtis 1995
[100] Hovhannisyan 2003: 1 and Sargsyan, Balabanyan and Hatkinson 2006: xi

shortages began in 1995 when one of the two Medzamor reactors was re-activated. Armenia's energy reform included the decentralization and privatization of the energy system. The former Armenian Energy Regulatory Commission (currently Public Services Regulatory Commission) was established in1997 and since then electricity generation, distribution, transmission and dispatch each have been implemented by separate private firms.[101]

Armenia's demand for electricity and heating fuels will grow as its level of economic development increases. At today's level of demand, Armenia has very little power generation redundancy in the form of surplus electricity exported to other countries. In years when a small surplus exists it is far less than the power generated by just one Armenian facility – the aging Medzamor nuclear plant. Any loss of generation, however temporary, at Medzamor – whether from problems with its cooling mechanism in hotter, drier conditions under climate change, from depreciation, or from another seismic event – would have very serious consequences for the nation's ability to meet its domestic demand for electricity. This important vulnerability in Armenia's power generation system must be taken into consideration when examining the consequences of climate change to hydro-generation capacity and the international market for fossil fuels.

3.4.1. Electricity generation

Armenia depends on three main sources for electricity generation: nuclear, thermal, and hydro-electric (see Figure 18). The country's generation capacity relies on consistent supplies of river water: nuclear and thermal generation require water for cooling, and hydro-electric plants requires a high rate of flow to achieve their capacity-levels of production. If its current economic growth continues in the decades to come, demand for electricity will increase, as will the demand for competing uses of water – for agriculture and industry. As river flow rates decline with climate change, the country's ability to meet is full domestic electricity demand will be at greater risk. Armenia's distribution of river flow is seasonal. Severe river flow shortages are most likely to occur in the hottest summer months and least likely to occur in the spring, during the run-off of melting snow and ice.[102]

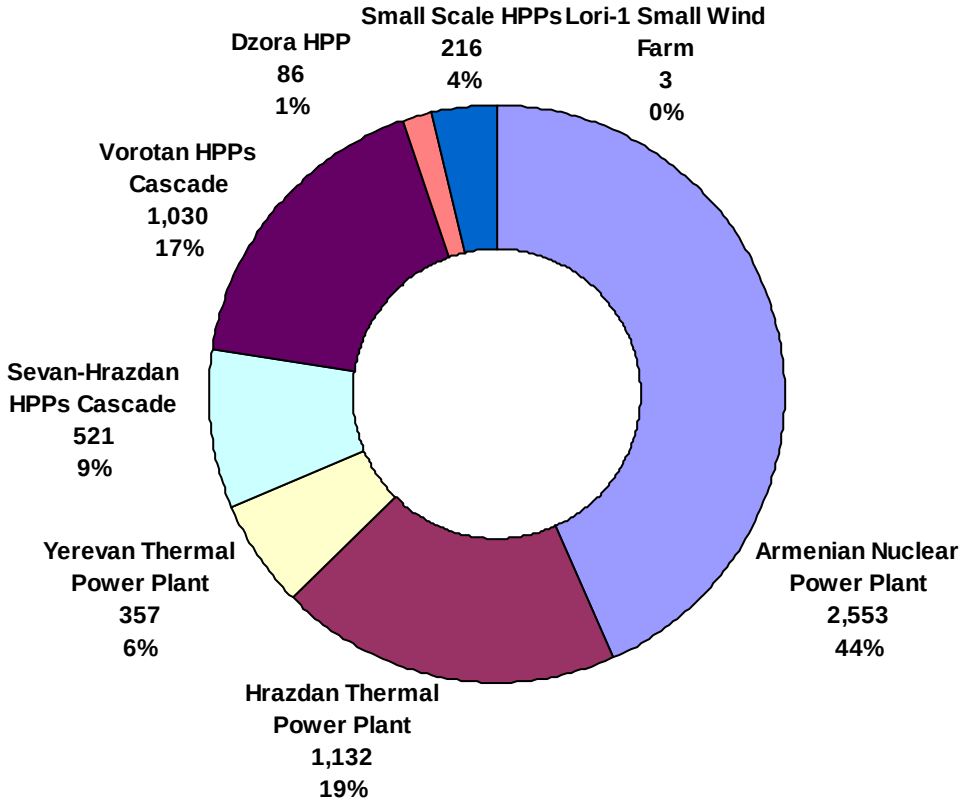
3.4.2. Nuclear generation

The single reactor at Medzamor, the Armenian Nuclear Power Plant, is the country's only source of nuclear generation; it produced 43 percent of Armenia's electricity in 2007.[103] The Medzamor plant's two pressurized-water reactors were built in 1976 (the first reactor) and 1980 (the second reactor) to supply energy for local aluminum and copper refineries; all nuclear fuel used at the Medzamor plant is imported from Russia.[104] Following an earthquake in 1988, both units were de-activated until 1995, when the second unit was re-activated after passing through several safety upgrades with financial support from Russia, France and the International Atomic Energy Agency.[105]

Local seismic instability, the age of the reactor, and its lack of a containment vessel to prevent accidental radiation release make the safety of the Medzamor nuclear plant an ongoing controversial issue for neighboring countries. Armenian and Russian nuclear scientists have argued that the reactor is safe and can continue operation until 2016. The European Union has promised €100 million to build alternative generating facilities in an effort to convince Armenia to shut down the reactor. In 2003, the operation of the nuclear plant was transferred to the Russian Ministry of Nuclear Energy, while the Armenian state maintains ownership of the physical plant.[106]

[101] Sargsyan, Balabanyan and Hatkinson 2006: xi-xii, 62
[102] Zakaryan et al. 2008
[103] Ministry of Energy of Republic of Armenia 2008a
[104] Sargsyan, Balabanyan and Hatkinson 2006: 2
[105] Hovhannisyan 2003: 18-19 and U.S. Department of Energy 2002
[106] Hovhannisyan 2003: 19

Figure 18: Armenian electricity production by plant, 2007 (in Million kWh, and percentage)



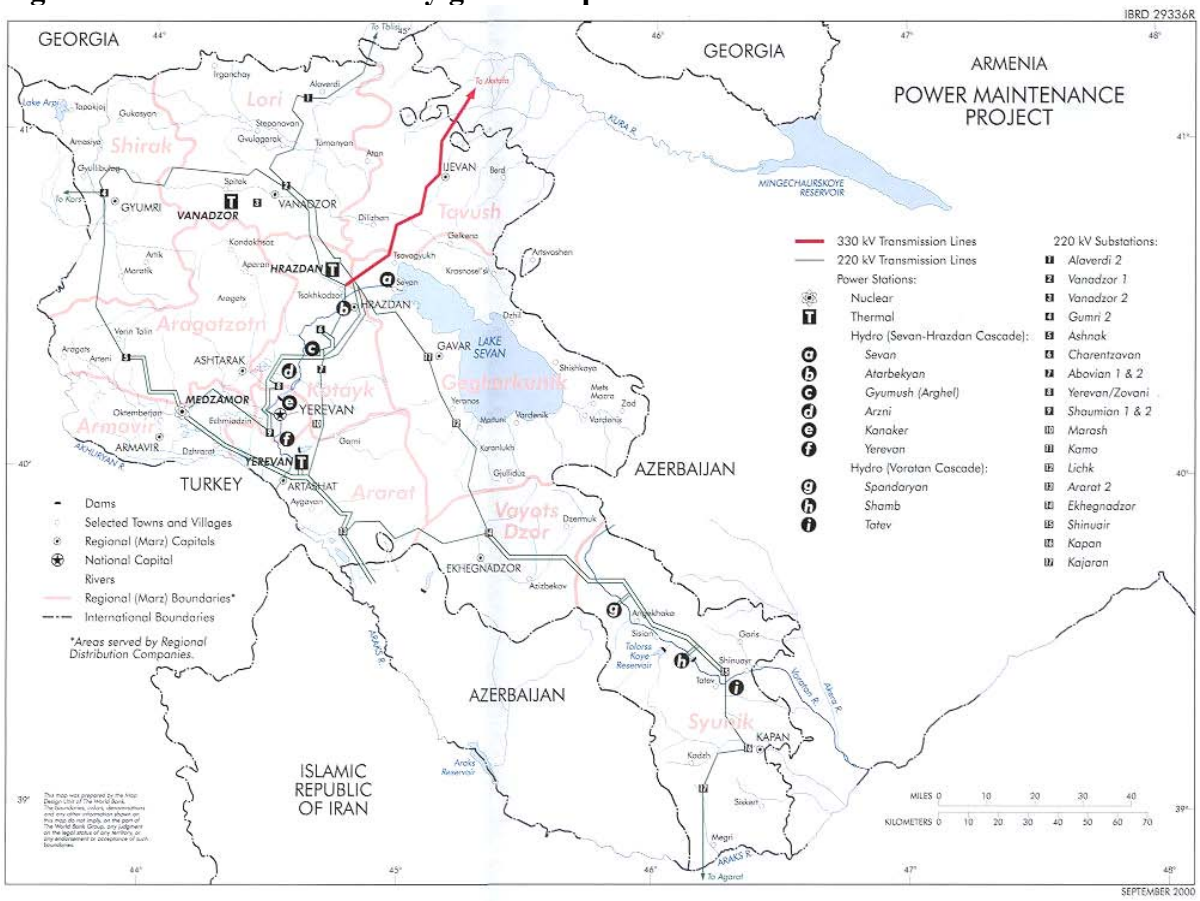
Source: Ministry of Energy of Republic of Armenia 2008a

Medzamor's planned decommissioning is scheduled for 2016. This is also the year in which a new Armenian nuclear facility, with a far greater capacity, is scheduled to begin operation. At the time of this writing, an initial feasibility study for the new nuclear plant was in progress. A preliminary assessment indicates that construction of the new plant will cost US$2 billion. The construction of a new nuclear plant would greatly reduce the nation's vulnerability to any climate change impacts on hydro-generation or the world market for fuels. At the same time, the use of nuclear power carries with it addition environmental and social risk factors – especially related to disposal of waste, potential for accidents, and (important for climate change) extensive use of water resources for cooling and electricity production. It will be essential, of course, that changes in atmospheric temperature and river flow and water temperatures over the next century are taken into consideration in the planning and construction of the new plant.[107]

The existing nuclear plant uses water drawn from the Metsamor River for cooling; after passing through the reactor and the cooling towers, much of this water is returned – somewhat warmer – to its source. Precipitation in the Metsamor basin has declined by 10 percent, and river flow has declined by 3 percent over the last 15 to 20 years. The flow of the Metsamor is projected to decline a further 21 percent by 2100 as a consequence of climate change (see Table 17).[108] If the Medzamor plant is decommissioned in 2016, as planned, these long-term impacts should have little effect during the lifetime of the plant. Locating the new plant in the Metsamor river basin as planned[109] could entail a risk from declining availability of cooling water over the new plant's lifetime – or, if power plant cooling has the first claim on river water, there is a risk to others dependent on the same river for irrigation and other uses.

[107] Republic of Armenia 2007
[108] ArmStateHydromet 2008
[109] Republic of Armenia 2007

Figure 19: Armenian electricity grid with power stations



Source: Global Energy Network Institute 2008

Table 17: River Flow Projections for Metsamor, Hrazdan, and Vorotan Rivers

River-Observation station	Scenarios	Flow	Change in the flow		Period
		Million m^3	Million m^3	%	
Metsamor-Taronik	Baseline	466.9	0	0	
	T+0.9,0.895Q	432.9	-34	-7.3	2030
	T+2.2,0.793Q	398.2	-68.7	-14.7	2070
	T+3.6,0.712Q	369.2	-97.7	-20.9	2100
Hrazdan-Hrazdan	Baseline	248.9	0	0	
	T+1.5,0.91Q	218.1	-30.8	-12.4	2030
	T+3.3,0.82Q	185.8	-63.1	-25.4	2070
	T+5.0,0.75Q	159.1	-89.9	-36.1	2100
Vorotan-Vorotan	Baseline	376.8	0	0	
	T+0.6,1.112Q	450.3	73.5	19.5	2030
	T+1.7,1.223Q	510.6	133.7	35.5	2070
	T+2.9,1.305Q	545.5	168.7	44.8	2100
Total rivers	Baseline	4,994.4	0	0	
		4,660.9	-333.5	-6.7	2030
		4,269.9	-724.5	-14.5	2070
		3,777.6	-1216.8	-24.4	2100

Sources: Zakaryan 2008, Zakaryan et al. 2008

3.4.3. Hydro-electric power generation

Hydro-power provided 31 percent of Armenia's electricity production in 2007. Two large cascades (or series of small generation units) provide the bulk of this power. The Sevan-Hrazdan Cascade, located between Lake Sevan and Yerevan on the Hrazdan River, generated 521 million kWh in 2007; the Vorotan Cascade, on the Vorotan River in the Syunik Marz of southern Armenia, generated 1030 million kWh. As of 2006, there were an additional 29 smaller hydropower plants in operation, eleven under construction, and six in the process of being licensed; those small plants that are currently operational together generated 300 million kWh in 2007.[110]

Armenia's historically abundant water resources and steep changes in elevation make it an ideal location for hydro-electric generation. However, there is significant competition for water between power generation and irrigation, especially on the Sevan-Hrazdan Cascade. Aging, and sometimes poorly maintained, equipment is another limiting factor for current hydro-electric generation; many plants produce less than their technical capacity, even when water flow is abundant.[111]

As river flows decline with climate change, many of Armenia's hydro-electric plants will likely lose generating capacity. The flow of the Hrazdan River, for example, is expected to decline 36 percent by 2100; on average, Armenian rivers are expected to lose 24 percent of their flow over the next century.[112] The loss in power generation is roughly proportional to river flow (at any given facility).[113] Given this scenario:

- The Hrazdan River's power generation capacity would fall from 521 to 334 million kWh per year, a loss of 188 million kWh.
- The smaller Dzora hydropower plant would lose 25 percent of power generated, or 21 million kWh per year.
- Many of the other small hydropower plants would also lose, on average, 24 percent of their power generation capacity (see Table 18).[114]
- Hydroelectric losses in 2100, assuming no additions to capacity, would total 261 million kWh per year, or 14 percent of today's generated electricity.

With existing infrastructure, the reduction in river flow expected from climate change could cause a loss of 261 million kWh annually in hydro-electric generation by 2100. At 30 AMD per kWh (the most common day-time residential tariff), those losses amount to 7.8 billion AMD, or US$23 million in lost electricity revenue each year.[115]

[110] Ministry of Energy and Natural Resources of Republic of Armenia 2008a, Sargsyan, Balabanyan and Hatkinson 2006: 56-57

[111] U.S. Department of Energy 2002

[112] Zakaryan et al. 2008

[113] For basic references on this relationships see: Wisconsin Valley Improvement Company website, http://new.wvic.com/index.php?option=com_content&task=view&id=8&Itemid=45; Wikipedia, The Free Encyclopedia website, "Hydropower" webpage, http://en.wikipedia.org/wiki/Hydropower; HowStuffWorks? Website, "How Hydropower Plants Work" webpage, http://science.howstuffworks.com/hydropower-plant1.htm

[114] Settlement Center SNCO, 2008

[115] As of February 27, 2009, Armenia's day-time tariff was 30 AMD/kWh and its night-time tariff was 20 AMD/kWh (Republic of Armenia 2009).

Table 18: Projected hydroelectric losses from climate change

	Power generated in 2007[a]	Projected Change in River Flow in 2100[b]	Projected 2100 Power Generation	Decrease from Current Generation
	(million kWh)	(from baseline)	(million kWh)	(million kWh)
Sevan-Hrazdan HPPs Cascade	521	-36%	334	188
Vorotan HPPs Cascade	1,030	45%	1,030	0
Dzora HPP	86	-25%	64	21
Small Scale HPPs	216	-24%	164	52
Total	**1,853**		**1,592**	**261**

Sources: Ministry of Energy 2008b and Zakaryan et al. 2008

One important exception to the expected losses in river flow is the Vorotan River, which is projected to have a significant increase in flow with climate change. Additional water cannot increase the Vorotan Cascade's generation capacity (without an investment in additional infrastructure), but this does suggest that water supply will not be a limiting factor in generation on the Vorotan. Large-scale water transfers already take place from the Vorotan and the Lake Sevan basin, and even larger transfers are one potential solution to declining river flows on the Hrazdan. Increases in flow to the Vorotan would not fully compensate for losses in other rivers – net losses to river flow for Armenia as a whole are 24 percent by 2100 and net losses to the Sevan basin (including the Hrazdan) together with the rivers that provide transfers into Lake Sevan (the Arpa and Vorotan) are 19 percent of current flow.

Only the Vorotan and Voghji river basins are projected to increase in river flow due to climate change. There are a combined 171 million kWh per year of potential, unexploited hydro-power on the Vorotan and Voghji. That's just 20 percent of all of Armenia's potential new hydro-power capacity. The remaining 80 percent is located on rivers that are projected to decrease in flow with climate change.[116]

It is important to note, however, that efficiency improvements and installation of infrastructure that are utilized for hydro-electric power production could offset some of the losses in generation capacity. In looking at the mix of energy which will be required in the coming two to three decades, new, unbiased analyses should be carried out in order to ensure that the most cost effective, culturally acceptable energy sources are used and planned for. If the true unexploited potential for hydro-power is 855 million kWh per year, and additional efficiency improvements can be made, this could mean a dramatic increase in electrical energy available on the national grid. Further cost estimations which include the impact of climate variables are necessary.

3.4.4. Thermal power generation

Armenia's natural gas thermal power plants provided 25 percent of Armenia's electricity generation in 2007. Armenia's natural gas is imported by pipeline from Russia via Georgia; a second pipeline from Iran via Azerbaijan was incapacitated in the Nagorno-Karabakh conflict and is still not operational.[117] Since 2001, the distribution and transmission of natural gas has been the responsibility of Armrosgazprom, an 80 percent Russian (privately-owned) and 20 percent

[116] Republic of Armenia 2008d
[117] Sargsyan, Balabanyan and Hatkinson 2006: 2

Armenian (state-owned) company.[118] Construction on a new 140 km Iran-Armenia gas pipeline with a 2.3 billion cubic meter capacity began in March 2007 with an expected completion date in 2009. The agreement between Armenia and Iran is in effect for 20 years and requires that each cubic meter of gas imported from Iran into Armenia be traded for a kilowatt-hour of electricity exported to Iran from Armenia.[119]

Thermal power is used primarily to cover seasonal peaks in demand during the historically low-water fall and winter, when hydro-power is restricted and demand for electricity used in heating is high.[120] Assuming that hydro-power declines and these declines are not offset by increased/more efficient infrastructure in hydro-power or in nuclear energy production, thermal generation may be required to take on a larger role in Armenia's energy mix.

A number of concerns arise from the possibility of increasing reliance upon natural gas as a fuel source for electricity production:

- First, thermal generation produces GHGs that in turn contribute to climate change. International agreements and domestic environmental ethics may, in the long run, impede Armenia's ability to increase thermal generation.
- Second, thermal generation has a higher cost per kWh of electricity than hydro-electric generation – due to the fact that the fixed costs of constructing the existing hydro-electric power plants have already been incurred. Higher production costs may cause pressure for an increase in the nation's tariff structure, which is set by the Public Services Regulatory Commission.[121] However, to draw this conclusion definitively, a more detailed analysis of the costs of hydro-power production (including construction and replacement of infrastructure), the likely future energy demand, and the cost of other potential energy sources (including nuclear power and other alternative energies) would be necessary.
- Third, international agreements to mitigate GHG emissions are very likely to have the effect of increasing the price of fossil fuels by relatively small amounts in the next decade, but could increase by potentially large amounts over the coming century. An increase to fuel prices will also cause upward pressure on Armenia's electricity tariffs.
- Fourth, because natural gas is imported from other countries, an increased reliance on natural gas for electricity production may cause less favorable balances of trade and may also carry political risk.

Two new thermal electricity plants are scheduled to be operational by 2010 and 2011, with a combined generation capacity of 4,200 million kWh per year. While production prices for thermal generation are higher than those for hydro-electric generation (16 AMD/kWh in comparison to 0.2 to 1.2 AMD/kWh), this new capacity should more than compensate for losses of hydro-electric generations due to climate change in the long run. The new thermal capacity would also be larger than Medzamor's contribution to total supply; production prices for nuclear are also much lower than thermal, 3.2 AMD/kWh, (although production prices for a new nuclear plant would be much higher).[122] As thermal generation increases as a share of total electricity, an increase in electricity tariffs is very likely.

Thermal plants, like nuclear plants, will require more water for cooling as temperatures increase. Older thermal plants may suffer temporary shut-downs during the driest summer months, especially where there is increased competition with irrigation water. New plants must be planned keeping in mind future changes to river flows from climate change.

[118] U.S. Department of Energy 2002. *Arka News Agency* website, "Armrosgazprom Licensed to Construct Hrazdan-5 Power Plant in Armenia", June 17, 2009. http://www.arka.am/eng/energy/2009/06/17/15351.html
[119] UNDP/GEF 2008a
[120] Sargsyan, Balabanyan and Hatkinson 2006: 54, 56
[121] Republic of Armenia 2009, UNDP Armenia 2009b
[122] Ministry of Energy of Republic of Armenia 2008b

3.4.5. Electricity consumption

Armenia produced 5.9 billion kWh of electricity in 2007 but only 4.6 billion kWh was available for use due to distribution losses.[123] In past years, Armenia has had small net exports of electricity to Iran and Georgia; data for 2007 indicate small net imports (see Table 19). Surplus electricity production capacity would be a great asset to Armenia as reductions in river flows from climate change cause a decline in electricity production over the next century. At present Armenia has no excess capacity in part due to its 22 percent distribution losses.

Table 19: Armenian electricity sector, 1992-2007

	Net Generation ***(billion kWh)***	**Net imports** ***(billion kWh)***	***Imports***	***Exports***	**Distribution Losses** ***(billion kWh)***	**Net Consumption** ***(billion kWh)***	**Installed Capacity** ***(million kW)***
1992	8.6	0.3	*0.3*	*0.1*	2.5	6.4	**2.8**
1993	6.1	0	*0.1*	*0.1*	2.4	3.7	**2.8**
1994	5.5	0	*0*	*0*	2.2	3.3	**2.8**
1995	5	0	*0*	*0*	2.2	2.9	**2.8**
1996	5.8	0	*0*	*0*	2.3	3.5	**3.1**
1997	5.7	-0.1	*0*	*0.1*	1.3	4.3	**3**
1998	5.8	-0.4	*0*	*0.4*	1.8	3.7	**3**
1999	5.6	-0.2	*0.5*	*0.7*	1.4	3.9	**3**
2000	5.6	-0.4	*0.4*	*0.8*	1.5	3.7	**3**
2001	5.6	-0.4	*0.3*	*0.7*	1.5	3.7	**3.2**
2002	5.2	-0.4	*0.3*	*0.7*	1.4	3.4	**3.3**
2003	5.2	-0.3	*0.3*	*0.6*	1.2	3.7	**3.3**
2004	5.7	-0.8	*0.3*	*1*	1	4	**3.3**
2005	6	-0.8	*0.3*	*1.2*	0.8	4.4	**3.2**
2006	5.6	-0.4	*0.4*	*0.8*	0.7	4.5	**3.2**
2007	5.5	0.1	*0.4*	*0.3*	NA	NA	**3.2**

Source: U.S. Energy Information Administration 2009

The relationship between supply and demand of energy is complex. Neither Armenia's electricity production nor its electricity consumption are evenly spaced across the year. At present, times of low production and high demand are managed by swapping electricity with its neighbor: Iran's extra winter electricity is traded for Armenia's extra summer electricity.[124] As climate change progresses, the winter gap between supply and demand may grow in size, and new gaps may develop in other seasons; the increase in thermal capacity from the two planned plants should greatly reduce any vulnerability to shortages.

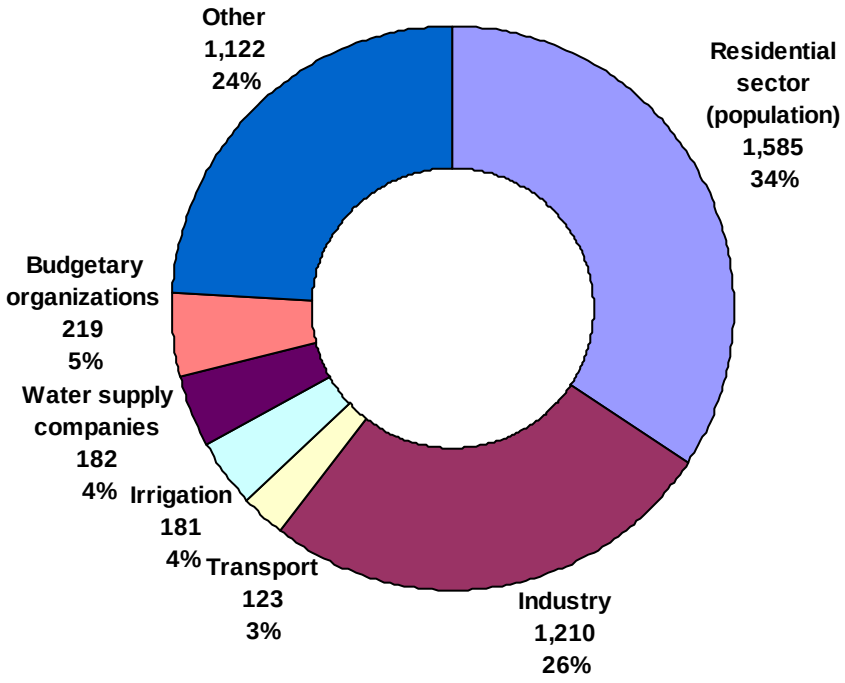
Armenian industry represents 26 percent of total domestic electricity consumption (see Figure 20). Industrial demand for electricity declined steeply after Armenia's independence from the Soviet Union and has yet to return to its former level; the unfulfilled potential of the nation's industrial sector raises an additional concern in the context of climate change.[125] Decreases in river flows will likely reduce the capacity of existing hydro-electric plants; the result may be short-term shortages when times of high demand coincide with times of low supply. Armenia's greatest demand for electricity comes in winter, because of the use of electricity for heating, and its lowest demand comes in summer. The most severe reductions in river flow are expected in summer, when demand is low. Armenia exports its seasonal surplus in return for winter imports.

This analysis only takes into account current demand – any development of Armenia's industrial sector and increase to GDP would require an increase in industrial energy use. Similarly, summer-

[123] Ministry of Energy of Republic of Armenia 2008a
[124] U.S. Department of Energy 2002
[125] Sargsyan, Balabanyan and Hatkinson 2006

time increases to electricity demand from increased economic development and higher incomes, and from an increase in the use of air conditioning as both temperatures and incomes rise – could potentially cause domestic electricity generation to fall below demand. However, given the increase in capacity envisioned over the next decade, it seems likely that demand will not outstrip supply in the nearer term. This would especially be the case if energy efficiency is introduced as a major national priority in building design, heating systems, and in electricity production and transmission.

Figure 20: Armenian electricity consumption by sector, 2007 (in million kWh and percentage)



Source: Ministry of Energy of Republic of Armenia 2008a

The largest share of Armenia's electricity is consumed by homes for lights, appliances, and – for 35 percent of households – heating.[126] Average winter temperatures are low throughout the country and frigid at the highest elevation. Measured in heating degree days,[127] Armenia can be divided into four distinct zones (see Table 20). With climate change, the national annual average temperature will increase, including expectations of warmer winters. Thus, electricity consumption in winter for heating may decline while electricity demand for cooling in the summer would increase.

Table 20: Armenian regions by heating degree days

Regions	"Degree x Days" Parameter
Sub-alpine zone of Syunik, North-eastern regions (Tavush, Alaverdi, etc)	Less than 2,300
Ararat valley with neighbouring areas	2,300-2,700
Lori-Pambak, Dilijan, Goris	2,700-3,400
Shirak, Gegharkunik marzes Alpine zones of Kotayk and Aragatsotn marzes	More than 3,400

Source: Adapted from UNDP/GEF 2008a

[126] Share of electric heat from 2006/2007 data (Economic Development and Research Center 2007).

[127] According to UNDP/GEF (2008a), the "degree x days" parameter is calculated be multiplying the number of days when heat is used by the difference between the indoor temperature in heated buildings (18°C) and the outside temperature.

3.4.6. Social impact of reduced electricity production

Chronic reductions in river flow will interfere with Armenia's ability to produce electricity using its existing infrastructure. Twenty-seven percent of domestic electricity supply, 1,853 million kWh per year, comes from hydro-electric power plants (see Figure 18 above) many of which will be affected by decreasing river flow. The Sevan-Hrazdan cascade and the smaller hydro-electric power plants, which together supply 18 percent of Armenia's domestic demand, are extremely vulnerable to reductions in river flow over the next century. If water reserves and releases are well managed, small changes in precipitation and evaporation need have little impact on hydro-electric generation. Regrettably, the projected changes to Armenia's river flows are neither small in scale nor temporary. Reduced river flow coupled with an increased demand for irrigation water is very likely to reduce electricity generation from these plants.

A possible exception to the reduction in hydro-electric generation capacity is Armenia's largest hydro-electric cascade, Vorotan, which is very unlikely to suffer a drop in river flow sufficient to affect electrical generation, but water availability is also affected by competition for resources, especially for irrigation water. Higher temperatures, more rapid evaporation, and lower levels of soil moisture will increase the need for irrigation throughout Armenia. In the Vorotan river basin, flows are expected to increase 45 percent by 2100 which will very likely be enough to provide sufficient irrigation water to the local area – if irrigation infrastructure can be adapted to accommodate higher rates of flow – and maintain current hydro-electric generation at the Vorotan cascade – securing 17 percent of Armenia's current domestic supply.

At present, Armenia's lowest demand, lowest supply and highest exports of electricity all coincide in summer. Future increases to summer demand from more industrial production, more general domestic use, and especially more air conditioning use could combine with lower hydro-electric capacity to cause temporary shortages – or at least decrease exports. Any shortage in electricity has serious implications for households and businesses. New thermal generation capacity planned to come on line in 2010-2011 should prevent the occurrence of shortages, but will cause strong upward pressure on electricity prices.

Armenia's winter temperatures are expected to become warmer with climate change. Armenian households use a variety of fuels for home heating: 53 percent natural gas, 35 percent electricity, and 10 percent firewood.[128] The scarcity of firewood is likely to increase as a consequence of desertification of forested areas and the ecologically destabilizing effects of rapid climate change; at the same time the incidence of illegal logging could increase if the price of other fuels grows higher.

The world market price of natural gas is likely to increase due to scarcity on the global market and international agreements on GHG abatement. Because Armenia trades much of its excess summer electricity to Iran in return for additional winter electricity (and, beginning in 2009, will trade electricity with Iran in return for natural gas used in thermal electricity generation and home heating), there is the potential for a domino effect, where a reduction in summer electricity leads to the loss of both electricity and natural gas imports used for winter heating. With extreme cold winter temperatures in Armenia's higher elevations, lack of electricity, firewood, or natural gas for heating could have serious consequences to health.

3.4.7. Economic impact of reduced electricity production

The economic impacts of reduced electricity production in Armenia are complex. Actual impacts will depend on the season in which production is reduced, and the reaction of prices to electricity and energy shortages at home and abroad. A shortage of electricity could impede both industrial production and Armenia's energy-intensive irrigation delivery systems. The most likely immediate result, given two new thermal plants becoming operational in 2010-2011 and a new nuclear plant

[128] Economic Development and Research Center 2007: Data are for 2006/07.

becoming operational in 2016, is an increase in electricity tariffs and the avoidance of any shortages.

Estimated losses of hydro-electric generation over the longer term are 261 million kWh per year in 2100, given current demand and existing infrastructure.[129] At 30 AMD per kWh (the most common day-time residential tariff), those losses amount to 7.8 billion AMD, or US$23 million in lost electricity revenue each year.[130]

At present, there is no surplus electricity generated in Armenia, however, planned additions to Armenia's thermal and nuclear generation capacity are substantial and competition for domestic use of electricity is only likely under three circumstances:

1) If summer demand increases significantly due to greater air conditioning use with higher temperatures and higher incomes;
2) If economic development causes significant increases to industrial production and household electricity demand; or
3) If the new thermal plants are not built on schedule or a new nuclear plant is not built to replace Medzamor by 2016.

If electricity production falls below demand, some category of use will be curtailed or more electricity will have to be imported at a (likely) higher cost. If Armenian electricity rates were set by the market, shortages would very likely drive up the market price of electricity; if this were the case, the market would in effect allocate electricity according to which end-users could best afford it, and poorer households would feel the worst effects. Because electricity rates are instead set by the Public Services Regulatory Commission, the allocation of this scarce resource will likely be a political choice if the management of prices remains the same. The generation costs for hydro-electricity are currently lower than those for existing nuclear generation, which are far lower than those for thermal generation, again suggesting that a change in electricity tariffs is likely if hydro-power is a declining share of total power. In the coming decades, however, new capacity will mean a different electricity production mix – resulting in different prices for production. Further analysis into the energy strategy for Armenia seems necessary which takes climate change into account in planning for the 20-30 year time frame.

The economic cost of an (unlikely) electricity shortage is the lost revenue from electricity sales plus the lost revenue from any reductions in industrial or agricultural production caused by the shortage. There may also be additional macro-economic ripple effects throughout the economy. Armenia's nuclear plant, the Sevan-Hrazdan Cascade, and the Electric Network of Armenia (which handles all sales and distribution) are all owned by foreign states or companies.

Table 21: Armenian power plants and networks

Power Plants and Networks	Ownership Status
Armenian Nuclear Power Plant	The Government of Armenia is the owner of ANPP which is operated by the Russian company Inter RAO UES (a joint subsidiary of RAO UES and Rosenergoatom) as part of a five year term to help pay off Armenia's debts. The power plant has been a trust asset of JSC INTER RAO UES since 2003. Under an agreement with the Armenian government, the Company has acquired rights to manage 100 percent of the NPP's stock for 5 years.

[129] Power generation is roughly proportional to river flow (for any given plant). These calculations assume a 36 percent reduction on the Hrazdan River, a 25 reduction on the Dzoraget River, and a 24 percent reduction for all other small capacity hydro-electric plants. See previous subsection for a more detailed methodology.
[130] As of February 27, 2009, Armenia's day-time tariff was 30 AMD/kWh and its night-time tariff was 20 AMD/kWh (Republic of Armenia 2009).

Hrazdan Thermal Power Plant	A state-owned asset of the Russian Federation. The ownership was transferred through debt-for-asses swap.
Yerevan Thermal Power Plant	YTPP is a closed joined-stock company with 100 percent state ownership.
Sevan-Hrazdan HPPs Cascade	The plant is owned by International Energy Corporation, a subsidiary of Inter RAO UES (Russian Federation).
Vorotan HPPs Cascade	The owner is the Government of Armenia.
Small Scale HPPs	Private ownership (local).
Lori-1 Small Wind Farm	The owner is the Government of Armenia.
Electric Network of Armenia CJSC (distribution and sales of electric energy)	The company is "ENA" CJSC is a subsidiary of "RAO UES INTERNATIONAL" CJSC (Russian Federation).
"High Voltage Electrical Networks" CJSC (power transmission)	The owner is the Government of Armenia.

Source: UNDP Armenia 2009b

The economic impact to Armenia of this loss would be slightly mitigated: while the exact share cannot be calculated with the available data, a portion of Armenia's electricity sales revenue does not remain in Armenia under any circumstances. Instead, these profits are expatriated to the foreign owners of Armenia's electric plants and distribution network. By the same logic, economic losses from electricity sales would be experienced, in part, by foreign owners of Armenia's electric system infrastructure.

3.4.8. Anticipatory adaptation – preparing for future shortages and price increases

Private measures:

- Households and businesses can reduce electricity demand by practicing conservation measures and investing in energy efficient lighting, appliances and equipment.
- Many Armenian households rely on electricity for heating; these households can invest in energy efficient heaters and better insulation for their homes. They can also incorporate usage of passive solar heating systems, better windows, etc. Where distribution systems exist, households can switch to natural gas heat.

Public measures:

- In the case of planning for reduced electricity availability and higher prices, mitigation measures (which reduce net GHG emissions by reducing energy consumption) are actually also adaptation measures. As such, the state can encourage more efficient building management through:
  - Creating regulatory requirements or increasing incentives for more efficient building designs.
  - Encouraging more efficient lighting and appliance use through a mix of public education, regulation and pricing.[131]
  - Improving the efficiency of state-owned assets and of the electricity/energy grid.
  - Initiating public education and training programs on energy.
- Over the coming decades, the state can also invest in large-scale infrastructure projects to increase Armenia's capacity to generate electricity, especially in times of reduced river flow by:
  - Building additional hydro-electric plants on rivers that are projected to increase in flow with climate change.
  - Building additional electricity generation plants that do not rely on water resources. These might include natural gas combined-cycle thermal plants

[131] The European Union, for example, will soon cease the manufacture of incandescent light bulbs in favor of energy efficient compact fluorescent light-bulbs.

(depending on generators' cooling mechanisms); geothermal; wind; or solar generation. This is a high priority area for new research.

3.4.9. Reactive adaptation – managing shortages and price increases in real time

Private measures:

- If electricity shortages occur or tariffs increase significantly, more profound conservation measures may be necessary. Households and businesses can further limit electricity use in response to current conditions.

Public measures:[132]

- In periods of electricity shortage, the state can adopt regulations enforcing tighter restrictions on electricity use by households and businesses. Public information campaigns on conservation measures can accompany these new regulations.
- If electricity demand exceeds electricity supply, even temporarily, the state can and must allocate electricity among different users including households, industry, and water distribution systems. However, if the plans to increase electrical production capacity are realized, this is unlikely to be necessary in the nearer term (in the coming 20-30 years).

3.5. Damage to Forests

3.5.1. General information about Armenia's forests

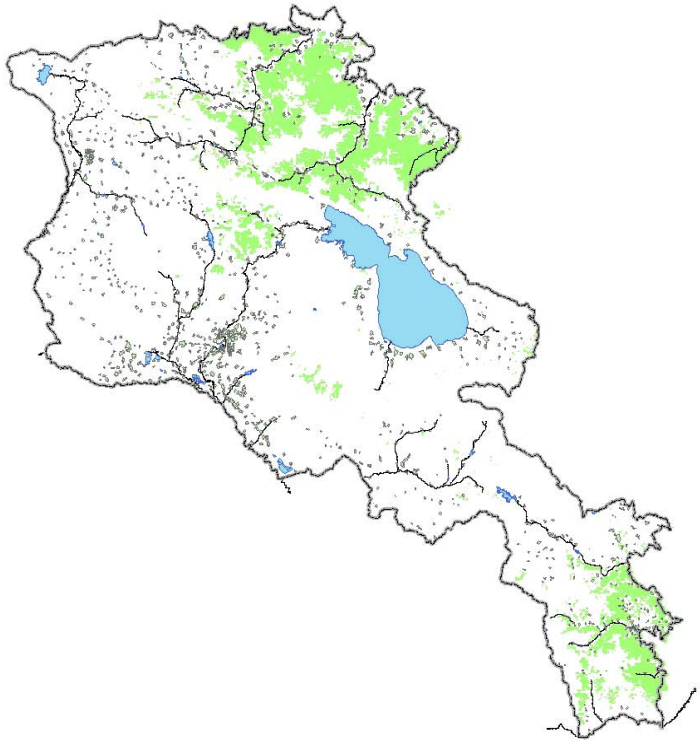
With higher temperatures and big changes to precipitation levels, climate change can have a serious impact on forests. Because of Armenia's wide variations in elevations and sub-climates, existing forest species may not be appropriate to their new climate as climatic zones move upwards in altitude 100 m by 2030 and 200-400 m by 2100.[133] Forest species, both flora and fauna, can migrate to new, more appropriate zones, but tree species migrate slowly, and may be unable to keep up with changing climatic zones without human intervention. Forest species in Armenia's highest elevations will have nowhere to migrate to – with climate change there will be no appropriate climate within the country for some alpine species.

Forests cover 11.4 percent of Armenia's land area, accounting for 334,000 ha. Most of the nation's forests, sixty-two percent, lie in the north-east in Lori and Tavush marzes (see Figure 21and Table 22). The remaining forests are divided between the central marzes (18 percent in Aragatsotn, Ararat, Kotayk, Gegharkunik, and Vayotz Dzor), and the south-most Syunik marz (20 percent).[134]

During the energy crisis of the early 1990s, illegal logging was rampant as households turned to firewood as a heating fuel. As a result Armenia's forested area was reduced by one-quarter in the 1990s, and many remaining forests are now less dense and have a different mix of tree species that previously.[135] Illegal logging has since decreased in scale, down from more than 2,000 ha destroyed in 2002 to 350 ha in 2006.[136] According to a 2008 survey, most illegal logging takes place in Lori, Tavush, and Syunik provinces (see Table 23). More illegal logging is for sale than for self use. By region, 76 percent of the illegal logging that takes place in Syunik Marz is sold, whereas only 28 to 32 percent of timber illegally logged in Lori and Tavush Marzes is sold.[137]

[132] Republic of Armenia 2008g, IPCC 2007
[133] Fayvush and Nalbandyan 2008, Ministry of Nature Protection of the Republic of Armenia 1998: 46
[134] Gevorgyan 2008 and Nalbandyan 2008
[135] Forest Monitoring Center SNCO 2008, Kura Aras Stakeholder Advisory Group 2007
[136] National Statistical Service of the Republic of Armenia 2007d: 186-189
[137] Forest Monitoring Center SNCO 2008

Figure 21: Forest cover of Armenia, 2006



Source: UNDP/GEF 2008b

Table 22: Armenian forests (in hectares)

	2002	2003	2004	2005	2006
Forest land					373,800
Covered by forest					308,500
Area undergoing reforestation	726	700	801	3017	8,925
Felling of forest (main use & reforestation)	2686	2940	737	1293	1,807
Maintenance and sanitary fellings	3,366	3,683	764	1781	2,446
Illegal forest fellings	2,065	1,732	926	713	345
Forest area affected by fire	19	0.4	1.5	20	299

Source: National Statistical Service of the Republic of Armenia 2007e

Table 23: Illegal logging in Armenia

	Number of illegally logged trees	Share for sale	Share for subsistence	Share for reprocessing	Share unknown
Yerevan	0	57%	25%	15%	3%
Aragatsotn	0	58%	39%	0%	3%
Ararat	0	45%	30%	9%	16%
Armavir	0	39%	27%	13%	22%
Gegharkunik	11	3%	4%	4%	89%

Lori	168	32%	30%	10%	29%
Kotayk	0	38%	41%	3%	18%
Shirak	0	35%	37%	11%	16%
Syunik	76	76%	17%	2%	5%
Vayots Dzor	12	31%	20%	4%	45%
Tavush	126	28%	28%	12%	33%

Source: Forest Monitoring Center SNCO 2008

3.5.2. Climate change and forests

Climate change will alter the distribution and composition of forests, but may also increase forests' vulnerability to pests and wildfires. Because trees are long-lived perennials, rapid changes in climate can be extremely disruptive to forest ecosystems; as an ecosystem shifts upward in elevation with climate change, the migration of trees may have greater difficulty keeping pace than would shorter lived (and more quickly reproducing) plant species. Many of the forested areas are expected to suffer losses in precipitation with climate change; the occurrence of drought will shrink forested areas and shift the species mix towards more drought-resistant plants.[138]

Climate change projections for Armenia that forecast the consequences of approximately 5°C higher temperatures and 9 percent less precipitation in 2100 (under the business-as-usual emissions growth scenario) predict a loss of 5 percent of the nation's forests by the end of the century. In this scenario, forests will suffer a reduction in area at the lower end of their elevation range that is not made up for by smaller and slower expansions to forests at the upper end of their elevation range as zones increase in altitude by 200 to 300 m. In the northeast, 5 percent of forests will be lost due to drought and the encroachment of semi-desert and steppe plants, mostly at lower elevations. In the central marzes, 3 percent of lower elevation forests will be lost to drought and encroachment of mountainous and steppe species. In Syunik Marz, the pattern is reversed: eight percent of Syunik's forests will be lost to drought and encroachment by semi-desert plants. In total, about 17,000 ha of forest, or 5 percent of the total forest area, will be destroyed by drought and zone-change effects on plant species composition.[139]

Reduced precipitation and increased evaporation will cause an encroachment of drought-tolerant species into existing forests. Where drought-tolerant species do not migrate quickly enough, dead zones or areas of extremely limited vegetation may develop. These dead zones will reduce the recharge of underground aquifers and promote run-off, which can result in landslides and mudflow. Arid conditions also make forests more vulnerable to wildfires.

Climate change will also make many ecosystems more vulnerable to pests. Large areas of Armenia's central and southern forests are already infested with the bloody-nosed, or leaf-cutting, beetle. From the 1990s to the present day, this beetle infestation covered between 19,000 and 30,000 ha, rising and falling depending on the incidence of drought and pest control measures. With climate change, the area of bloody-nosed beetle infestation is expected to grow to more than 70,000 ha by 2090, a potential destruction of an addition 21 percent of Armenian forests. Syunik Marz is likely to be the area most vulnerable to an expanded presence of these pests.[140]

Finally, Armenia's forest will become more vulnerable to forest fires with climate change. Wildfires are most likely to occur in years with low precipitation and high temperatures. In recent

[138] Kura Aras Stakeholder Advisory Group 2007 and Nalbandyan 2008
[139] Nalbandyan 2008
[140] Nalbandyan 2008

years, most of Armenia's forest fires (84 percent) have taken place in arid Syunik Marz.[141] In 2006, forest fires destoyed over 300 ha causing 500 million AMD (US$2 million) in damage (see Table 24).[142] If 2006 drought levels and forest fire incidence were to become the annual norm, 27,000 ha – 8 percent of total forests – would be lost by 2100.

Table 24: Forest first incidence in Armenia (2001-06)

Year	Number of forest fires	Total area burned (ha)	Area burned (ha) including	
			Forest-covered	Not forest-covered
2001	1	20.0	20.0	-
2004	2	13.5	1.5	11.5
2005	11	55.4	25.1	30.3
2006	10	333.6	299.2	34.4
2001-2006 Total	24	422.5	345.8	76.7

Source: Hayantar SNCO 2008

3.5.3. Social impacts of forest damage

While total potential losses of forest area from climate change – including damages from changing climatic zones (a 5 percent loss of total forests), beetle infestation (21 percent), and forest fires (8 percent) – cannot be estimated with any precision given existing data, the potential territory at risk from climate change lies somewhere between 21 and 34 percent of Armenia's forested lands, a devastating loss. Armenia's cold winters are unlikely to change noticeably with climate change, and such large scale losses to the nation's forests would very likely reduce the availability of firewood, at present the source of heating fuel for 10 percent of Armenian households.[143] A consistent supply of heating fuel, especially at higher elevations, is essential to maintaining good health and well-being.

3.5.4. Economic impacts of forest damage

While total potential losses in forest area from climate change – including damages from changing climatic zones (a 5 percent loss of total forests), beetle infestation (21 percent), and forest fires (8 percent) – cannot be estimated with any precision given existing data, the potential territory at risk from climate change lies somewhere between 21 and 34 percent of the nation's forested lands, a devastating loss. Such large scale losses to its forests would very likely reduce the availability of firewood, at present the source of heating fuel for 10 percent of Armenian households[144]. At the same time, according to climate models discussed in Section 2, Armenia's cold winters are likely to become warmer, which may reduce demand for wood for heating.

Armenia's national forest authority, Hayantar SNCO, estimates the average value of Armenian forest land – in timber and firewood values – at 1,115,000 AMD per hectare.[145]

The average stock of 'natural wood' per hectare is 123 condensed cubic meters, including about 20 percent (25 cubic meters) timber and about 80 percent (98 cubic meters) firewood:

- 1 cubic meter firewood costs 5,000 AMD
- 1 cubic meter timber costs 25,000 AMD

The loss per hectare in fire is thus:

- 98 cubic meters * 5,000 AMD = 490,000 AMD
- 25 cubic meters * 25,000 AMD = 625,000 AMD

[141] Nalbandyan 2008
[142] Kura Aras Stakeholder Advisory Group 2007
[143] Economic Development Research Center 2007. Data are for 2006/07.
[144] Economic Development Research Center 2007
[145] Hayantar SNCO 2009

The total loss if one hectare of forest is burnt is thus:

- 490,000 AMD + 625,000 AMD = 1,115,000 AMD

The loss of 21 to 34 percent of Armenian's forests, or 70,000-114,000 hectares, can be valued at 78-127 billion AMD or US$230-370 million. The average annual cost over the period 2010 to 2100 would be 0.03 to 0.04 percent of today's GDP. This calculation does not include any value for the ecological losses of such large-scale deforestation, or the economic value of other forest industries, primarily hunting, gathering of plants and mushrooms, and grazing.

3.5.5. Anticipatory adaptation – preparing for forest damages[146]

Private measures:

- Households can decrease their use of firewood by switching to other fuels for heating, like electric or natural gas, or by using more efficient wood-heating systems. These changes in heating fuels would require some household's to invest in new heaters; in the case of natural gas heating, such a change is only possible in combination with the public adaptation measure of expanding the existing natural gas network. Reducing the demand for firewood would help to limit illegal logging and thereby improve forest resilience.

Public measures:

- The state can initiate programs to replant degraded forest areas and promote aforestation in deforested areas.
- The state can initiate programs to improve forest maintenance, increase ecosystem resilience, protect forests from illegal logging, preserve genetic diversity, and protect endangered species. These programs would include both restoration and long-term monitoring to identify and address problems as they develop.
- The state can improve on existing fire safety measures, including public education on the importance of fire safety.
- The state can improve on existing pest management measures, including funding additional research on sustainable pest management in Armenia.
- The state can expand the number of households with access to natural gas and implement programs (including short term subsidies and loans) to encourage more efficient wood heating and better insulation; this may have the effect of reducing the use of firewood – whether legal or illegal – as a heating fuel.

3.5.6. Reactive adaptation – managing forest damages in real time

Private measures:

- As forested areas shrink and degrade, the importance of reducing logging will grow. Households can restrict their use of firewood by switching to other fuels.

Public measures:

- The need for forest maintenance and protection will increase as Armenia's forests become more vulnerable with climate change. The state can assure the proper functioning of systems that monitor the well-being of forest ecosystems.

[146] Sources include: Forest Monitoring Center SNCO 2008, IPCC 2007, Ministry of Nature Protection of the Republic of Armenia 1998, Nalbandyan 2008, and UNDP/GEF 2008b

3.6. Natural Disasters

Climate change will increase the incidence of severe storms, flooding and other natural disasters. These kind of costly impacts are, however, the most difficult to predict. It is impossible to say where or when storms will strike; it can only be said that weather will become more erratic and that, on average, Armenia will suffer more frequent severe storms leading to natural disasters. While the term "natural disaster" can refer to any number of events, the primary climate related natural disasters discussed in this section are landslides, mudflows, and floods.[147]

3.6.1. General information about natural disasters in Armenia

Armenia suffers an average of 10 billion AMD or US$33 million in damages from natural disasters each year (see Figure 22).[148] Landslides and mudflows are among the most devastating of these disasters. Landslides are caused by erosion, changes in subterranean water levels, and earthquakes. There are more than 2,500 active landslide areas in the country totaling 1,200 square km, or 3.9 percent of all land area (see Table 25). Over one-fifth of all communities are affected by active landslides as are 3 percent of roads.[149]

Table 25: Prevalence of landslides by marz

Marz	Area of the marz (m^2)	Number of landslides	Total landslide area (m^2)	Relative landslide area (%)
Aragatsotn	2,763	19	76	3%
Armavir	1,192	0	0	0%
Yerevan	222	152	13	6%
Kotayk	2,034	110	78	4%
Tavush	2,741	151	211	8%
Shirak	2,683	23	21	1%
Ararat	2,090	142	144	7%
Gegharkunik	5,370	126	203	4%
Lori	3,852	217	235	6%
Syunik	4,492	289	247	5%
Vayots Dzor	2,288	184	242	11%

Source: Sadoyan 2008

Mudflows are saturated deposits of water, silt, stone and mud that flow like slow rivers. Mudflows are caused by deforestation and arid soils, which reduce the ability of the land to absorb water into underground aquifers. Instead, rainfall, snowmelt, and improperly applied irrigation waters run off the surface causing erosion and picking up dirt and stones as it flows. Both landslides and mudflows occur primarily on areas with steep grades – mountain slopes and hillsides. Much of Armenia's land area, including 100 percent of Vayots Dzor Marz, is prone to mudflows (see Table 26).[150]

[147] Other climate related natural disasters include (but are not limited to) droughts, heat waves, and cold spells
[148] Beglarashvili and Elizbarashvili 2006, Hovsepyan 2008a, Vermishev 2003
[149] Japan International Cooperation Agency and Ministry of Urban Development – The Republic of Armenia 2006, Mori et al. 2007, Sadoyan 2008
[150] Sadoyan 2008, UNDP 2007

Figure 22: Extreme events in Armenia

Source:UNDP/GEF 2008a

Table 26: Prevalence of mudflow prone areas by marz

Marz	Area of the marz (m^2)	Number of Mudflow Prone Areas	Total Mudflow Prone Area (m^2)	Relative Mudflow Area, (%)
Aragatsotn	2,763	8	1,441	52%
Armavir	1,192	0	0	0%
Yerevan	222	0	0	0%
Kotayk	2,034	7	867	43%
Tavush	2,741	8	2,147	78%
Shirak	2,683	8	1,102	41%
Ararat	2,090	6	1,034	49%
Gegharkunik	5,370	10	1,551	29%
Lori	3,852	17	2,495	65%
Syunik	4,492	13	3,154	70%
Vayots Dzor	2,288	10	2,277	100%

Source: Sadoyan 2008

Armenia is also subject to numerous floods each year. Almost every marz suffers some flooding each year, but some marzes are by far the most susceptible. From 1994 to 2007 the marzes with the highest cumulative incidence of floods were: Gegharkunik (159 floods); Lori (85); Shirak (72); and Aragatsotn (71).[151]

According to the Ministry of Emergency Situations' Armenian Rescue Service, every year natural disasters cause billions of drams of material damage to the population as well as causing numerous injuries. Much of the nation's territory is especially vulnerable to one or more type of natural disaster[152] (see Appendix Table E.6 for a more complete listing of Armenia's recent natural disasters):

- Active landslide territories – about 1.16 percent of Armenia's territory is vulnerable
- Non-active landslide territories – about 1.015 percent
- Collapses (stone falls) – about 0.5 percent
- Highest mudslide vulnerability – about 0.17 percent
- Lower mudslide vulnerability and flood-prone territories – about 20-30 percent
- Agricultural areas subject to frost – 10-12 percent
- Agricultural areas subject to drought – about 15 percent
- Agricultural areas subject to hail – 15-17 percent
- Areas with excessive moisture – 20 percent
- Areas subject to erosion – about 50 percent

3.6.2. Climate change and natural disasters

Climate change will increase the incidence of landslides, mudflows and floods.[153] Arid conditions, increased deforestation and forest damages, and heavy rainfall in extreme storms can create the exact conditions in which landslides, mudflows, and flooding are most likely to be generated. Both the increase in the incidence of landslides, mudflows and floods and the portion of damages for which climate change will be responsible are highly unpredictable. These natural disasters are extremely destructive causing costly damage to homes, businesses and public infrastructure but their future impacts have not been calculated with any precision. This is an important area of further research; while these impacts can never be predicted with any precision, much more can be done towards identifying the most vulnerable areas and the types of adaptive measures that would protect property and lives all around Armenia.

3.6.3. Anticipatory adaptation – preparing for natural disasters[154]

Private measures:

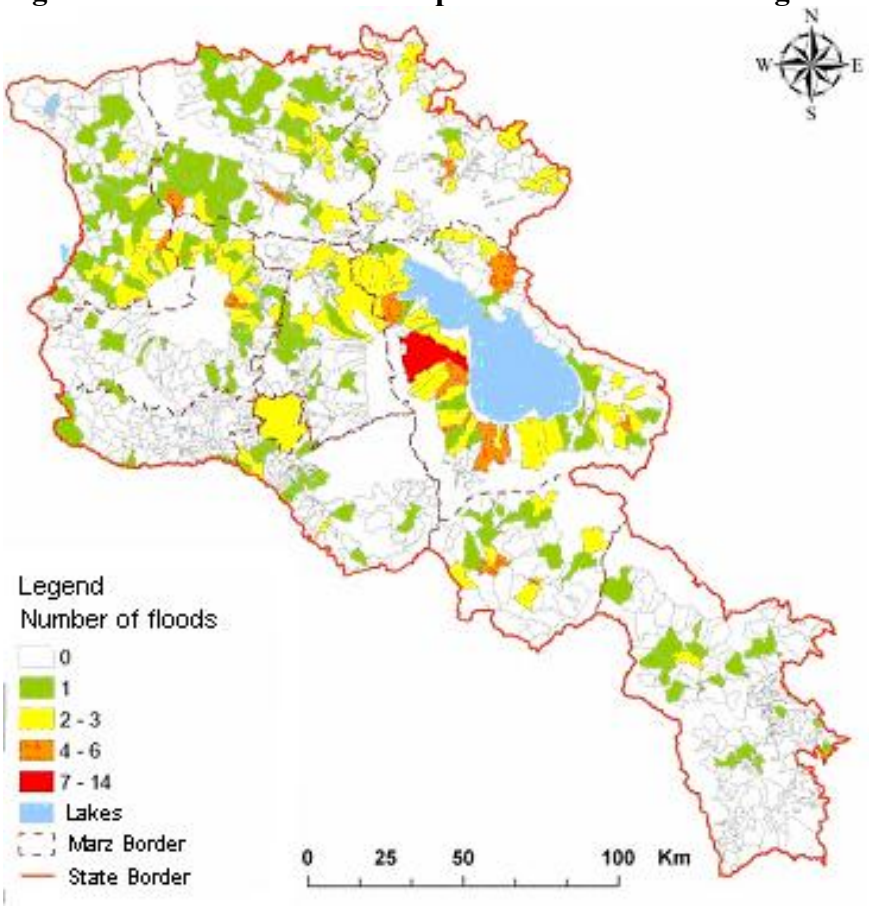
- Carrying insurance against certain natural disasters (e.g. flood insurance).
- Incorporating the possibilities of natural disaster risk management into planning for investments and purchases.

Public measures:

- The state can provide funding to research the factors responsible for triggering natural disasters.
- The state can initiate monitoring programs to forewarn local communities of imminent threats of landslides, mudflows and floods, and to create preventative action plans for rapid action to evacuate people from harm's way.

[151] Sadoyan 2008
[152] Armenian Rescue Service 2009
[153] Sadoyan 2008, UNDP Report
[154] The following are adapted from IPCC 2007, Ministry of Nature Protection of the Republic of Armenia 1998, and Sadoyan 2008, UNDP Report.

Figure 23: Number of floods reported in Armenia during the 1994-2007 period



Source: Sadoyan 2008, UNDP report

- The state can initiate preventative measures including:
  - Effective land-use planning and building codes to guard against natural disaster impacts.
  - Facilitating insurance schemes to guard against acute risk.
  - Planting trees, thereby reducing erosion and creating natural barriers to landslides and mudflows.
  - Building dams and walls to protect settlements and infrastructure.
  - Improving water collection and removal systems.
  - Maintaining the river beds and strengthening the river banks.

3.6.4. Reactive adaptation – managing natural disasters in real time

Public measures:

- The state can facilitate rapid response and warnings to citizens before and during natural disasters.
- The state can facilitate clean up after natural disasters, and provide restitution to those who have lost property in the disaster. This would include farmers, home-owners, and businesses.

4. CONCLUSIONS AND POLICY RECOMMENDATIONS

If current world GHG emissions continue to grow, Armenia will experience important and unprecedented climatic change. Over the coming century, the increase to Armenia's average annual temperature is expected to be dramatic; it will affect the entire country throughout the year. Average river flow is expected to decrease by 24 percent. Even if global emissions are kept at the lowest levels considered "likely" by the IPCC, Armenia's average annual temperature will climb 4.8-5.1°C while its precipitation falls 8-24 percent by 2100. The largest reductions to precipitation are projected for the most arid areas; if emissions continue to grow, the area surrounding the capital Yerevan will lose 30 percent of its precipitation by 2100.

The social and economic impacts of these changes will be serious; to avoid these damages, rapid action on strategic adaptation measures is essential. This section describes the conclusions of this report, discusses key policy recommendations, and provides a list of the most urgent adaptation measures.

4.1. Conclusions

Several sectors of the Armenian economy will experience damages from climate change. The areas of the greatest concern with regards to climate damage are:

Reduced water availability and increased water demand: By 2100, Armenia's precipitation will decline by 7 to 19 percent in the winter and summer, the driest months, and 8 percent in spring, the wettest months. Almost all Armenian river basins will decline in flow over the next century. The average reduction will be 24 percent, but the Marmarik, Martouni, Vedi and Dzknaget Rivers will lose more than three-quarters of their flow while the Vorotan and Voghji Rivers will increase in flow. Twenty to 40 percent of Armenia's river flow is the result of snow and ice melt; with less winter precipitation and somewhat warmer winter temperatures the Akhuryan, Arpa, Azat, Hrazdan, and Kasakh Rivers are at special risk from reduced spring run-off.

Together with a decrease in water supplies, Armenia will experience an increase in water demand as hotter temperatures and increased evaporation rates make both household operations and farming more water intensive. Today, there is enough water for all uses in Armenia – even with its current 84 percent distribution losses. As supplies decrease and demand increases, however, competition for water resources may become a concern especially in the most populous and arid areas like Yerevan and the Ararat Valley. In particular, competition between the use of river water for irrigation and for hydro-generation has the potential to become acute in summer when the need for irrigation water is high and river flows are at their lowest. Thermal and nuclear electric generation plants' need for cooling water, especially in the warmest months, also has the potential to conflict with other uses.

Falling water levels in Lake Sevan: A special category of damages from reduced water availability – worth emphasizing here because of its cultural and economic importance – is the effect of reduced snowmelt and river flows on water levels in Lake Sevan. The natural inflow into Lake Sevan from rivers and streams is expected to decline 41 percent by 2100. Even taking into consideration the Lake Sevan river basin, the Arpa, and the Vorotan (from which water is transferred by tunnel to the Arpa and from there to the Lake), the total potential flow of water to Lake Sevan will decline 19 percent by 2100.

Lack of irrigation water and lower agricultural productivity: Armenia's agricultural and food processing sectors are the cornerstone of its economy, together contributing the largest share of GDP. Today, more than half of the farmland that requires irrigation is not receiving it due to aging infrastructures and inefficiencies in the water distribution system. Without a fundamental increase in irrigation infrastructure, more farmland is expected to fall out of production as the climate becomes hotter and drier. Under these circumstances, further development of the agricultural sector

would be more challenging and even Armenia's current level of exports (of which 12 percent is food and agriculture products[155]) is likely to decline.

Reduction in hydro-generation and increase in electricity prices: Fourteen percent of Armenia's current electricity is hydro-electricity generated on rivers that are projected to decline in flow with climate change. While an additional 17 percent of total electricity production is generated on the Vorotan River, where flow is projected to rise, the electricity generated cannot increase from this added flow without an investment in new infrastructure. The projected overall decrease in electricity generated from today's hydro-electric plants amounts to 4 percent of Armenia's total supply.

Plans for increasing generation capacity center on a two thermal plants scheduled to come on-line in 2010-2011. Generation costs for thermal electricity are 16 AMD/kWh in comparison to 0.2 to 1.2 AMD/kWh for hydro-generation. Electricity from the new nuclear plant scheduled to replace Medzamor in 2016 is also likely to be more expensive to generate than electricity from the older plant. These changes in generation costs together with a shift from hydro-electric to thermal generation will be a strong incentive for regulators to increase electricity prices to consumers. At the same time, however, exploiting new sources of hydro-electric energy and increasing efficiencies at existing plants could mean a large increase in energy from hydro-electric sources. Despite decreases in river flows, small hydro-electric power production might yield lower-cost energy production – even when climate change is considered.

Decline in the size and quality of forests: As climatic zones migrate with increasing temperatures, the flora that can most successfully keep pace will be drought-tolerant desert and steppe species. In some areas, no plants will be able to adapt quickly enough and as current species die off, erosion-prone dead zones will be created. Decreased precipitation and increased evaporation also will increase forests' vulnerability to bloody-nosed beetle infestation and forest fires: in total one-quarter to one-third of all forested lands are at risk from climate change. Damage to Armenia's forests impacts on the revenues of forest industries and on the availability of firewood as a heating fuel.

Increased incidence of natural disasters: In addition to increasing average temperatures and decreasing average precipitation levels, climate change is expected to change existing weather patterns in less predictable ways and increase the incidence of heat waves, floods, droughts, and extreme storms. Arid soil conditions together with deforestation will also increase the incidence of landslides and mudslides. Armenia's homes, farms, and public infrastructure are all at risk from these natural disasters.

4.1.1. Reductions to GDP from climate damages

While economic damage in the form of lower GDP and exports, job losses and lower incomes can be expected from all of the damages described above, data was available to estimate the scale of this damage for only a few sectors. Damage values presented in this report should be treated as a partial accounting and not as an estimate of the total or maximum level of economic losses.

While this study does not attempt to predict what the economy will look like in 2100, the scale of the impact becomes apparent when compared to today's level of economic activity (i.e. GDP):

- By 2100, lack of irrigation water will undermine crop production. The climate projected for 2100, if it occurred today, would result in a 2 to 5 percent decrease in GDP solely from the agricultural sector and an additional 2 to 3 percent in the food processing sector.
- On the same basis, the climate projected for 2100, if it occurred today, would cause lost electricity revenues of 0.25 percent of GDP and loss of forestry revenues of 0.04 percent of GDP.

[155] Food exports were 12.4% of all exports for the years 2001-2005, Ministry of Agriculture 2006

- In total, for this partial accounting of potential climate damages, the climate projected for 2100, if it occurred today, would cause annual losses of 4 to 9 percent of Armenia's 2007 GDP.
- Losses in the most climate-sensitive sectors would have compound effects on the rest of the economy and society. For example, a decrease in crop production could mean an increase in food prices leading to decreased economic well-being and economic activity well beyond the direct agricultural losses.

4.1.2. Important non-market damages

Some of the most important climate damages projected for Armenia will have only limited or indirect effects on its economy. These non-market impacts include ecosystem losses, health concerns, and a decrease in food, fuel, power, and water security.

Ecosystem losses: The rapidly changing climate will negatively impact some of Armenia's unique and irreplaceable ecosystems. Wetland, riparian, and lake ecosystems, especially in the area of Lake Sevan, will be replaced by plants and animals more suitable to drier, warmer conditions. Alpine and sub-alpine meadows are likely to disappear altogether. In many areas, desert and steppe flora will take the place of existing forest species. Natural disasters – droughts, floods, mudflows, landslides and extreme storms – will also take their toll on Armenia's ecosystems.

Heat waves and health: Climate change will increase the incidence of heat waves in Armenia. If these heat waves are not countered by better adaptive systems – including heat wave management plans, adjusted building codes, and better ventilation and air conditioning, there could be serious negative health effects.

Insecurity of access to food, heating fuel, power, and water: For households or communities that are already economically vulnerable – low-income and rural populations in particular – the stresses caused by climate change damages can mean the difference between having just enough and suffering interruptions in access to food, heating fuel, power, or water. In Armenia, low-income farmers are especially vulnerable to this type of insecurity because of their reliance on subsistence agriculture.

4.1.3. Armenia's key vulnerabilities

Armenia's experience of damages from climate change will be determined in part by its existing economic vulnerabilities. Five areas of vulnerability stand out as being of particular importance with regard to Armenia's ability to respond and adapt to climate change:

1) Armenia lacks redundancy in its power system. Today's electricity supplies meet demand, but any reduction in generation – whether from a failure of the existing aging infrastructure or from a delay in bringing planned additions or replacements on-line – would result in disrupted access to power for some segment of the population. Climate change threatens to both decrease electricity supply and increase demand. Without sufficient redundancy in generation, climate damages will be much more serious in terms of the effects electricity shortages on industry, irrigation delivery and household operations.

2) Aging and poorly maintained water infrastructure results in 84 percent distribution losses. Repairing, rebuilding and extending water distribution systems throughout Armenia would greatly reduce vulnerability to water shortages. Even with the losses to river flow expected with climate change, a modern, efficient water infrastructure would significantly mitigate the potential vulnerability to water shortages, including damages from droughts on Armenia's farms. More efficient irrigation water delivery could also reduce the amount of electricity needed for pumping systems.

3) The health of the Armenian economy is dependent on its agriculture sector, which both contributes a large share of GDP and feeds farm families. Climate change, in combination with a lack of access to irrigation, threatens Armenia's agricultural productivity and therefore the economy as a whole.

4) Because of its climate, steep geography, and recent history of deforestation, Armenia is today vulnerable to drought, floods, mudslides and landslides. The effects of climate change will increase this vulnerability along with the incidence of natural disasters.

5) One in four Armenian citizens is poor and one in 25 is very poor. While richer households have income and assets with which to protect from themselves from climate damages, poorer households do not. Economic vulnerability coincides with climate vulnerability and impedes households' potential for climate adaptation.

The climate damages and vulnerabilities discussed in this report have been analyzed in the context of the current economy. Armenia's current rate of economic growth, however, is 14 percent. At a more conservative long-term growth rate of 5 percent, Armenia will reach today's average income levels in Western Europe in four decades. (Economic damages in this report are year 2100 losses as a share of 2007 GDP – these damage estimates, therefore, assume that GDP and the absolute value of damages will grow more or less proportionally throughout the century.)

The Armenian state will have difficult choices to make regarding the best investments to make for today and for the future. The good news is that economic development and climate adaptation are rarely in conflict; instead, they substantially overlap, the needs of one serving the goals of the other. The key messages of this report can offer some guidance towards choosing investments that serve both goals:

- Rural and low-income communities are vulnerable today and they will be more vulnerable with climate change.
- Repairs to existing vulnerabilities in water infrastructure and power generation redundancy have enormous potential as economic development and climate adaptation measures.
- If shortages in water or power develop the state will have to make allocative decisions. Choosing to increase water or electricity tariffs would be a decision to allocate these essential utilities according to income – poorer households will not be able to afford rate increases.

Finally, while Armenia's emissions mitigation efforts are important, they alone cannot have a significant impact on global GHG emissions, although Armenia can join with other small countries to influence climate negotiations. The greatest effect that Armenia can have on reducing its future climate damages is through strategic, early implementation of adaptation measures – some of which will also have an impact on the net GHG emissions from Armenia. The final sections of this report discuss policy recommendation and urgent measures for adaptation.

4.2. Policy recommendations

Policy recommendations

Many of the best climate adaptation measures that Armenia can pursue are also important steps for economic development; these are "no-regrets" adaptation measures – no extra cost is imposed by climate change. In other words, they are measures that will improve economic and social outcomes regardless of climate change. Even some adaptation measures that do not directly aid economic development can be characterized as no-regrets because of their low or negative costs and high probability of leading to much larger positive economic outcomes given changes in climatic conditions. "Low-regrets" measures are those for which the benefits of avoiding climate damages outweigh the costs of new infrastructure or other responses. In the context of climate change, there

should be no regret about funds spent to avoid what would have been costly future damage. Key policy recommendations include:

Repair and expand poor infrastructure: Aging water and power generation infrastructure must be replaced, rebuilt and expanded. The results will be profound: an expansion of irrigated agricultural land; increased economic security for farmers during times of drought; additional water and power capacity with which to expand Armenia's industrial sector; redundancy in the event of failures of electricity supply or short-term increases in demand; and protection from future climate impacts that will decrease the supply of water and electricity while increasing the demand for these utilities.

Integrate climate change adaptation in current plans for economic development – especially for energy production: Perhaps the most important case in point is that of planned increases to (and replacements of) power generation infrastructure. The new nuclear plant and thermal plants must be planned in the context of higher temperatures and decreased river flow for cooling water. Hydro-generation plans must take into consideration predicted river flow throughout the lifetime of this infrastructure.

Plan for economic development: Public investment, infrastructure development and climate adaptations must all be planned in the context of a growing economy. If Armenia sustains its high growth rate without increasing the efficiency of resource use, it will need more water and power infrastructure to accommodate both increasing industrial use and the higher rates of consumption that come with higher incomes. Choices regarding climate adaptation, too, should be viewed through this lens: the future Armenian economy will be much larger and so too will some of the potential climate damages. This is particularly important for land-use planning and building codes. The likely increased risks from natural disasters such as floods, mudslides, and landslides can be diminished by effective infrastructure and urban planning. Furthermore, adjusting building codes to create well-insulated, and energy efficient buildings will not only decrease net greenhouse gas emissions and decrease energy costs for consumers, but also lead to better adapted buildings for a future climate.

Plan for a low-carbon economy: Investments made today in fossil-fuel-intensive power generation or other energy-intensive infrastructure appear to be short-sighted. While Armenia is unlikely to be called upon to reduce its greenhouse gas emissions in the next one or two decades, longer term global mitigation efforts may require lower per capita emissions from Armenia by the middle of this century if not sooner. A perspective that includes the lifetime of planned infrastructure is essential for making choices today that will save money in the long run.

Protect rural and low-income communities: Planning for the average climate impact on the average Armenian citizen will do little to protect those most vulnerable to climate damages. In order to protect all Armenians, adaptation measures must explicitly consider the needs and vulnerabilities of rural and low-income households. In effect, this means that the state must take an active role in all adaptation measures through policy setting, appropriate subsidization, price signals, climate risk reduction programs, and public education. It is the role of the state to ensure that poorer families are not left without defenses against negative climate change impacts.

Urgent adaptation measures

To offer the best protection for Armenian households, farms and other businesses, significant climate adaptation must take place in advance of climate damages. Climate changes have already begun, and their effects will become more pronounced over the next few decades. Rapid implementation of climate adaptation measures is essential to prevent the worst effects of climate damages. Ten adaptation measures discussed in this report stand out as the most urgent.

1) *Support essential research needs with state funding.* There are numerous gaps in Armenian research that – if filled – would reduce uncertainties about likely climate impacts and, therefore, would reduce the costs of climate adaptation. Among the most important research

gaps are: health costs of heat waves and other potential health effects of climate change; the impacts of climate change on water quality; the extent of current ground-water reserves and the likely changes to these reserves with climate change; the current health and productivity of pasture lands and the likely climate impacts to these ecosystems; the potential for low-carbon power generation consistent with falling river flows; and the current impacts of natural disasters and the likely effect of climate change on their incidence and costs.

2) *Improve existing water infrastructure in the context of current and future temperatures, precipitation levels, and river flows.* This is likely a "no regrets" measure because the advantages of investment appear to be justified in the current climate conditions and would help with adaptation to future climate change. At the same time, this is a large-scale project that may require additional water diversion between rivers, the replacement of much existing infrastructure, and the expansion of the irrigation water delivery system. In planning such a project, the viability of future agricultural products (during the lifespan of the infrastructure) given likely future climate conditions should be taken into account.

3) *Promote water and energy efficiency in households, farms and other businesses.* Reducing demand is an important step towards avoiding the water and power shortages made more likely by climate change. The state can promote efficiency using monetary incentives, free equipment, public education, regulations on new building designs, and providing technical support. This is a "no regrets" measure because it would save money and resources in the near and long term as well as increase the well-being of people living and working in energy efficient buildings with greater thermal comfort.

4) *Prepare farms for a changing climate.* As temperatures and precipitation levels change, the state can provide agricultural extension services (public education and technical support) to help farmers adjust planting seasons, choose new crops, install irrigation equipment, or adopt a more efficient use of water.

5) *Build redundancy into the existing power generation system.* Redundancy will protect the electricity supply in the event of: a generation failure; a delay in the construction of planned replacements to the power plants; the seasonal cycle of high and low periods of demand; and an increase to demand caused by higher temperatures and increased use of air conditioning. At the same time, any large infrastructure project that will last more than 20 to 30 years should account for expected variability in the climate and input (fuel) prices.

6) *Protect Armenia's forests by funding projects for stewardship, reforestation, pest management, erosion control, and fire-risk reduction.* As climatic zones shift, careful management and replanting can prevent the creation of dead zones. This will also help to prevent natural disasters such as mud slides; it may even be a way to reduce net greenhouse gas emissions.

7) *Prepare for natural disasters through prevention and emergency response readiness.* Drought damages can be reduced by improving and expanding irrigation infrastructure or farming techniques. Some floods, mudslides and landslides can be avoided through erosion control, reforestation, and river bed or irrigation canal maintenance. Effective urban and infrastructure planning is also important when controlling for the risk of floods, mudslides and landslides. When disasters do occur, a well-funded and efficient emergency response system – including early warning systems involving close contact between emergency services and hydro-meteorological services – can greatly reduce loss of life and damages to infrastructure.

8) *Mandate and encourage (through building codes, subsidies and information campaigns) that new buildings are built and older buildings are retrofitted to be acclimated to Armenia's existing and likely new climate.* Warmer temperatures may require better ventilation and/or air conditioning for the good health of their occupants. At the same time,

improved building designs and materials can help structures withstand the existing cold winters and hot summers in a cost efficient way. State-funded incentives such as interest rate subsidies for climate-proofing homes can make these changes accessible to all regardless of income.

9) *Provide public education to prepare the population for climatic changes and retraining programs for workers who may lose jobs due to climate change.* Public education regarding the health impacts of climate change and the need for water and power conservation can protect Armenian citizens while enlisted their support in adaptation measures. Job retraining may be necessary if industries like agriculture, food processing or forestry decline with climate change.

Appendix A. Examples of climate adaptation projects

Climate adaptation is already occurring in countries around the world. This appendix examines some of the projects underway in various countries to reduce climate vulnerability. According to UNDP,[156] climate change adaptation should be part of the public policies of all countries, including policies to reduce poverty and increase human development. The *2007/2008 Human Development Report*, categorizes successful adaptation in terms of four essential types of projects:[157]

1) information for effective planning;
2) infrastructure for climate-proofing;
3) insurance for social risk management and poverty reduction; and
4) institutions for disaster risk management.

1. Information for effective planning includes access to weather forecasting, and storm and emergency predictions; obtaining and maintaining equipment; and training experts to act on the information generated. A good example of this type of initiative comes from Mali. To predict the soil and precipitation conditions, Mali's national meteorological agency has developed a program that helps local farmers predict conditions for agriculture; results from project evaluations showed that income from agriculture improved after the establishment of this program. The governments of Finland and the United Kingdom have funded programs to improve to meteorological systems in African countries.

2. Infrastructure for climate-proofing improves protections against extreme weather conditions such as intense storms, floods and sea-level rise. The costs of national plans to build this kind of infrastructure vary from US$10 million in Cambodia to US$128 million in Bangladesh. These kinds of investments can have a valuable return, even in the short run. In China, costs equivalent to US$3 billion were spent on flood defenses, avoiding US$12 billion in flood related losses.

3. Insurance for social-risk management and poverty reduction helps to empower people against climate change risks. Governments create social insurance and public policies to promote the reduction of poverty and inequality. Such policies can take the form of financial support to help manage risks (see Table A.1 below**)**.

4. Institutions for disaster risk management strengthen national and local agencies so that they are better able to deal with climate disasters. The consequences of climate disasters are always serious, but in cases where public institutions at all levels of government are not prepared to deal with emergencies, the impacts can be far greater. UNDP cites the example of Haiti and the Dominican Republic's different responses to the Hurricane Jeanne in 2004. The death toll in Haiti was 2,000, compared to 23 in the Dominican Republic. Due to national laws on deforestation limits and the existence of a bigger staff to deal with emergencies, the Dominican Republic was better prepared than Haiti to face the hurricane.

[156] UNDP 2007

[157] UNDP 2007: 173. Much of the rest of this section is taken from this same report.

Table A.1: Examples of existing social policies reducing climate change vulnerability

Policy name	Policy description	Country/Region	Approximate costs
Employment Guarantee Scheme in Maharashtra	This scheme provides employment in irrigation, agriculture and forestry to people living in rural areas	India	US$10 billion annually (1% of GDP)
Productive Safety Net Program	Provides cash transfers for households to guarantee food supply and increase purchasing power of communities	Ethiopia	-
Oportunidades	Provides cash transfers to guarantee children's consistent education and health assistance	Mexico	US$2.2 billion annually
Kalomo	Provides cash transfers to guarantee food supply and overcome poverty	Zambia	US$16 billion annually (0.2% of GDP)
-	Subsidization of seeds and fertilizers to support small-sale farmers affected by droughts and floods	Malawi	US$70 million
Windward Island's Crop Insurance	Covering losses from 267 storms from 1988 to 2004	The Caribbean	-
Afat Vimo/Regional Risk Transfer Initiative	Insurance coverage against climate disasters for low-income families	India	-

Sources: Government of Maharashtra 2009 and UNDP 2007: 178-182

Appendix B. Adaptation funding

Appendix B describes what funding sources are generally available to address climate change risks. At present, Armenia receives funding for environmental protection and poverty reduction projects from a wide range of sources, both bilateral and multilateral. Appendix F summarizes Armenia's current and planned environmental protection and poverty reduction projects and plans in table form, along with the cost of these projects, where available, and sources of funding. Further information and analysis regarding existing projects, the potential for existing sources to fund future projects related to climate change adaptation, and the potential for "climate proofing" existing projects, thereby transforming environmental protection and poverty reduction projects into climate adaptation projects, is not currently available from national Armenian sources. This is an important area for future research.

In more general terms, adaptation funding is available bilaterally – on the basis of both economic and historical ties to various high-income countries – and from a few multilateral agencies. Of these, the agency with the most developed programs for funding adaptation measures is the United Nations.

According to the United Nations Framework Convention on Climate Change (UNFCCC), all countries participating on the Convention must plan and implement programs to facilitate adaptation to climate change in their countries, including the development of plans for coastal management, water resources and agriculture. In addition, developed countries participating in the UNFCCC are required to assist developing countries to meet the costs of adaptation to climate change impacts.[158]

To facilitate adaptation in developing countries, a financial mechanism was established by the UNFCCC through which developed countries could assist developing ones.[159] The global costs of implementing adaptation measures can vary considerably but are estimated in the range of US$9 to $109 billion per year.[160] Table B.1 below summarizes projections of the total cost of adaptation worldwide from the UNFCCC Secretariat, the World Bank (WB), Oxfam International and the United Nations Development Program (UNDP).

Table B.1: Projections of adaptation costs from different sources

UNFCCC Secretariat	World Bank	Oxfam International	UNDP
US$28-67 billion per year by 2030	US$9-41 billion per year	More than US$50 billion per year	US$86-109 billion per year by 2015

Source: Klein 2008b

It is the responsibility of the Conference of Parties (COP), the governing body of the UNFCCC, to provide guidance about the policies, priorities and eligibility criteria for adaptation funds. The Global Environment Fund (GEF) operates the UNFCCC's financial mechanism for adaptation following guidance from the COP and reporting to it about the operation of the adaptation funds every year.[161] According to COP guidelines, funds allocated to less developed countries' needs should be on a grant basis; funded projects should correspond to each country's national development priorities; and the technologies transferred should be environmentally sound and well suited to local conditions.[162]

GEF, established in 1991, is a partnership among 178 countries, as well as international institutions, NGOs and the private sector that supports environmental and sustainable development initiatives.[163] GEF is divided into six "operational programs," one of which acts as the financial mechanism for adaptation and mitigation

[158] UNFCCC 2008c
[159] Klein 2008a, Mohner and Klein 2007: 1, UNFCCC 2008b
[160] Klein 2008a
[161] UNFCCC 2008d
[162] Conference of Parties 1995: 34, UNFCCC 2008b. Further information about COP adaptation funding guidelines and the relationship between COP and GEF can be found in the "Report of the Conference of the Parties on its First Session", held at Berlin from 28 March to 7 April 1995 (Decision 11) and the "Report of the Conference of the Parties on its Second Session", held at Geneva from 8 to 19 July 1996 (Decision 12) – Conference of Parties 1995, Conference of Parties 1996.
[163] GEF 2004

of climate change under the UNFCCC. GEF provides adaptation funding to developing countries who are meeting their obligations under the UNFCCC.[164]

GEF provides resources for adaptation through three funds, the Special Climate Change Fund (SCCF), the Strategic Priority on Adaptation (SPA), and the Least Developed Countries Fund (LDCF).[165] While the SCCF and SPA can be utilized by Armenia, the LDCF cannot.

Special Climate Change Fund: Operating since 2005, the SCCF invests in technology transfer and adaptation planning.[166] This fund receives its resources on a voluntary basis, for example, in 2007, twelve countries (Canada, Denmark, Finland, Germany, Ireland, Italy, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom) pledged a total of US$60 million to the SCCF.[167]

Strategic Priority on Adaptation: The SPA – operational since 2004 – is part of the GEF Trust Fund (GET) and supports demonstration projects focusing on biological diversity, climate change, land degradation and other areas of development.[168] The SPA is supported by US$50 million from GET, consisting primarily of contributions received by UNFCCC member countries.[169]

Currently, a total of US$283 million is pledged by multilateral adaptation funds, US$133 million already has been received, and US$33 million already has been disbursed. The World Bank has estimated that approximately US$100 to 500 million will be generated through the SCCF alone.[170]

In addition, the new Strategic Framework of the World Bank prioritizes the resilience of communities and economies to climate change impacts. For this reason, the World Bank will be providing assistance for projects that increase resilience in the agriculture sector and food security, water resource management, and sustainable management of coastal areas. One of the programs under the World Bank is the Pilot Program for Climate Resilience (PPCR) which will allocate US$500 million to pilot projects that integrate climate risks into core development planning. Moreover, the World Bank was a pioneer in addressing adaptation and climate risk in regions such as Latin America, the Caribbean and South Asia. PPCR was approved in November 2008; it will be aligned with the United Nations' funding measures, building on each country's NAPA.[171]

The World Health Organization has also launched the project "Climate Change and Adaptation Strategies for Human Health in Europe" which focuses primarily on:[172]

(i) health effects of heat and cold;
(ii) health effects of extreme weather events;
(iii) infectious diseases transmitted by insects and ticks; and
(iv) infectious diseases transmitted in the water supply.

Additional financing for adaptation is available through bilateral and regional channels. Some prominent examples of bilateral adaptation funding include the following:[173]

- The Canadian International Development Agency has assisted countries in the South Pacific, the Caribbean, China and Nigeria either by providing vulnerability assessments or identifying strategies for adaptation at the national level.

[164] GEF 2007a. A complete list of the GEF Member Countries can be found under GEF website, on the link: http://www.gefweb.org/interior.aspx?id=210.
[165] Fleming 2005. Under the Kyoto Protocol, there is a fourth GEF fund called the Adaptation Fund that is yet not operational. According to the "Report of the Adaptation Fund", the fund will likely become operational in 2009 (Conference of Parties 2008). This fund is financed by 2 percent of the resources generated by Clean Development Mechanism (CDM) projects, but CDM projects will be only become monetized in 2009. The World Bank will serve as the Trustee for this Adaptation Fund (Conference of Parties 2008, UNFCCC 2008a).
[166] Oxfam International 2007: 30
[167] GEF 2007b
[168] Flam and Skjaerseth 2009, GEF 2005: 2
[169] Oxfam International 2007: 30
[170] Flam and Skjaerseth 2009: 110-111, World Bank 2006: 40
[171] World Bank 2008, World Bank 2009
[172] WHO 2009
[173] Oxfam International 2007: 29

- India and Tunisia have received assistance from Germany, through the agency Gesellschaft für Technische Zusammenarbeit.
- The Swedish International Development Cooperation Agency and the UK's Department for International Development have also contributed to the development of vulnerability and policies assessment in developing countries.

Armenia received bilateral funding for environmental protection and poverty reduction from the European Union, Germany, Japan, Sweden, and the United States. Prominent examples of Armenian projects funded by bilateral aid include (see Appendix F for more detailed information):

- The construction of 70 MW of small hydro-electric power plants, a $75 million project partially funded by the German Bank for Reconstruction and Revolvement (KfW).
- The construction of 25 MW of wind power plants funded by private sources.
- A water governance project for Eastern European countries (US$2.7 million) and regional water project for South Caucasus Countries (€5.0 million) funded by the European Union.

In addition to these examples of bilateral aid, Armenia has received SPA funding towards forest adaptation.

Appendix C. Overview of climate economics methodologies

Climate change impact valuation is a relatively new field that differs to some extent from most environmental evaluation. Climate change impact valuation tends to be more based on tangible economic effects. The bulk of economic valuation is much more esoteric, focusing on the value of environmental goods as measured by surveys or "revealed preferences" (this means looking at what people buy or own to deduce what sorts of things are valuable to them).[174] Thus climate change impact valuation is a new and expanding area of analysis that is not at all settled in terms of standard methodologies or data requirements.

There are three general categories of climate-economic models exist in the literature:

1) Top-down models: PAGE, DICE, and many others

Top-down models – often called "integrated assessment models" – report generalized results for the world, sometimes broken down to several world regions. Results are strongly dependant on assumptions regarding climate sensitivity, shape and size of damages over time, how human society feels about these damages, and scientific uncertainty in parameter values.[175]

2) Bottom-up models: Most country-level impact studies, including this report

Bottom-up models begin with specific information about current conditions and costs, and the local pace of climate change. A relationship between the pace of climate change, of adaptation, and of damages is assumed. From this, it is possible to extrapolate future costs.

In very general terms, bottom-up climate economics analysis begins by establishing a baseline projection for economic and population change over time in the absence of damage, mitigation and adaptation costs. (In principle, more than one such baseline can be analyzed.) The most detailed analyzes – appropriate only for countries with especially rich data sources and existing detailed economic projections – would account for projected changes in the sectoral contribution to GDP over time in order to examine questions like: Will tourism, or exports, or agriculture change in importance over time?

Analysts then construct or adopt from the literature one or more scenarios for local climate change, at a minimum temperature and precipitation changes. The most complex models attempt a feedback mechanism between emissions and economic and population growth; these results are more detailed, but are also much more difficult to interpret.

Next, a baseline for each economic sector to be covered is determined from current and historical data: What is the history of this sector? What does it look like today? This description needs a qualitative component to give sufficient detail, and a quantitative component for use in modeling. Using the water sector as an example, how much water is supplied? How much is demanded? What are the sources of water? To what uses is it put? Are some sources dedicated to certain uses? Has supply or demand of water been responsive to changes in weather or climate? How is the price of water set? Are there exports and imports, or trans-boundary flows of water? Can the data on water be differentiated by sub-national region?

Finally, bottom-up models project the costs of climate change damages. There are as many methodologies for this step as there are types of climate impacts and local experiences. In some cases, it will be possible to adopt a methodology from the literature. In other cases, the methodology must be created to suit the available data. The essence of this step is to use the socioeconomic projections and climate projections to forecast the likely change in baseline costs for each sector. Complications include: price responsiveness to changes in supply or demand; changes in values over time; and an absence of complete or reliable data.

Some bottom-up climate economic analyses study adaptation costs, in addition to damage costs. Of course, the most important negative cost (i.e. benefit) of climate adaptation is the savings from averted damages. Projected costs of climate change damages should be indicative of where adaptation is most necessary. Ideas regarding measures to avoid these damages are generally taken from the existing international literature as well as local experience. The cost of adaptation measures may likewise come from the literature (although

[174] Ackerman and Heinzerling 2004

[175] For a detailed discussion of the current literature of integrated assessment models see Stanton, Ackerman, and Kartha (2009).

extensive conversion would be necessary to adjust prices to the local context) or from in-country experience with similar programs. Estimation of adaptation costs is the least developed area of climate valuation. Both climate damage and mitigation valuation are much more advanced in the literature.

3) A third type of model is a hybrid of the bottom-up and top-down models which combine the economic structure of the top-down model with the specific components yielded from bottom-up models (e.g. The WITCH – World Induced Technical Change Hybrid – model).

Appendix D. Tables: Population, Poverty, Labor and Unemployment, Industry and Trade

Table D.1: Armenia population and poverty

Marz	Population 2008 (In Thousands)[a]	Percent Poor* 2006[b]	Percent Very Poor** 2006[b]	Per Capita GDP 2005 (US$)[b]	GDP Growth Rate 1999-2005 (In 2008 Prices)[b]	Poverty Reduction Rate*** 1999-2005 (In 2008 Prices)[b]
Armenia	3,230	26.5%	4.1%	$2,278	126.8%	88.3%
Aragatsotn	141	27.5%	2.6%	$1,252	27.5%	87.3%
Ararat	277	27.0%	5.5%	$1,429	63.5%	69.3%
Armavir	282	30.8%	3.4%	$1,436	25.2%	32.0%
Gegharkunik	240	29.8%	2.6%	$1,363	70.6%	35.6%
Kotzyk	278	32.0%	8.1%	$1,710	64.7%	78.8%
Lori	282	27.0%	5.5%	$1,272	77.4%	117.4%
Shirak	281	37.3%	3.7%	$1,049	41.6%	78.4%
Syunik	153	25.3%	2.1%	$3,688	276.7%	83.7%
Tavush	134	23.5%	3.3%	$1,104	65.3%	13.6%
Vayots Dzor	56	11.4%	1.3%	$2,014	123.1%	80.7%
Yerevan	1,108	21.0%	3.5%	$3,706	201.1%	144.4%

*Poor population is the population whose average per capita income is more than the food poverty threshold, but less than the general poverty threshold (Republic of Armenia 2003).

**Very poor population is the population whose average per capita income is less than the food poverty threshold (Republic of Armenia 2003).

***The poverty reduction rate is the rate of change in poverty from 1999 to 2005, using 2005 as a baseline (Republic of Armenia 2008a).

[a] National Statistical Service of the Republic of Armenia 2008e

[b] Republic of Armenia 2008a

Table D.2: Armenia labor

Marz	Unemployment 2007[a]	Employment by Sector within Each Marz (% of total employed)[b]				Average Monthly Wage 2007 (US$)[c]
		Agriculture, hunting, and forestry	Industry	Construc-tion	Services	
Armenia	**3.8%**	**46.0%**	**12.3%**	**2.8%**	**38.9%**	**$209**
Aragatsotn	1.6%	77.8%	4.1%	0.5%	17.6%	$180
Ararat	1.6%	74.0%	7.4%	1.8%	16.8%	$191
Armavir	1.6%	74.0%	4.7%	1.7%	19.7%	$217
Gegharkunik	3.4%	73.6%	2.8%	1.4%	22.1%	$189
Kotzyk	3.1%	41.4%	26.5%	2.0%	30.1%	$225
Lori	6.9%	53.7%	11.3%	2.9%	32.0%	$186
Shirak	7.8%	57.0%	5.1%	3.0%	34.9%	$182
Syunik	9.0%	45.2%	17.5%	3.7%	33.8%	$304
Tavush	4.8%	68.3%	3.9%	2.8%	25.0%	$171
Vayots Dzor	2.6%	68.3%	5.6%	3.0%	22.8%	$180
Yerevan	2.5%	0.2%	21.7%	4.5%	73.6%	$272

[a] Authors' calculations from "Distribution of Labour Resources," National Statistical Service of the Republic of Armenia 2008d.
[b] Authors' calculations from "Employed Persons by Spheres of Economy." National Statistical Service of the Republic of Armenia 2008d
[c] Authors' calculations from "Average Nominal Monthly Wages/Salaries of Employees," National Statistical Service of the Republic of Armenia 2008d.

Table D.3: Armenia industry and trade

Marz	Exports 2007 (Million US$)[a]	Imports 2007 (Million US$)[a]	Industrial Output 2007 (% of total)[b]	Freight Transported 2007 (Thousand Tons)[c]	Gross Agricultural Output 2007 (Million US$)[d]
Armenia	**$1,121.2**	**$3,052.6**	**100.0%**	**46,201**	**$2,071.6**
Aragatsotn	$3.0	$34.6	1.3%	164	$157.2
Ararat	$54.5	$72.3	7.3%	2,379	$269.3
Armavir	$23.3	$50.6	4.2%	535	$315.0
Gegharkunik	$9.4	$14.7	1.3%	416	$294.1
Kotzyk	$176.2	$224.1	10.5%	1,581	$207.2
Lori	$77.3	$19.2	6.0%	1,099	$209.2
Shirak	$4.9	$51.3	2.3%	1,322	$207.2
Syunik	$119.6	$135.0	17.2%	31,317	$188.6
Tavush	$1.3	$12.0	0.6%	777	$116.0
Vayots Dzor	$4.1	$22.8	0.8%	461	$89.2
Yerevan	$647.8	$2,416.0	48.5%	6,151	$18.6

[a] National Statistical Service of the Republic of Armenia 2008b.
[b] Authors' calculations from "Volume of Industrial Output," National Statistical Service of the Republic of Armenia 2008c.
[c] Authors' calculations of short tons from National Statistical Service of the Republic of Armenia 2008f.
[d] Authors' calculations from "Gross Agricultural Output," National Statistical Service of the Republic of Armenia 2008

Appendix E. Additional Tables

Table E.1: Characteristics of the five State water companies, 2005

	Yerevan Djur	AWSC	Lori	Shirak	Nor Akunk
Number of water customers	317,000	260,000	25,800	45,500	14,800
Number of sewer customers	315,000	120,000	24,000	30,000	10,500
Total billed revenue in 2005 (US$1000)	14,807	10,301	757	1,874	464
Customers metered (%)	92	40	60	20	80

Source: USAID 2007: 10 - Table 1

Table E.2: Area under fruit orchards, vineyards and grain crops in 1990, 2000 and 2004

	Area, 1000 ha				Gross harvest, 1000 metric tons				Yield per hectare		
Year	fruits	grapes	grain		fruits	grapes	grain		fruits	grapes	grain
1990	50	29	138		156	144	271		43	58	20
2000	23	15	181		129	116	224		59	78	14
2004	39	15	207		114	195	457		39	102	23

Sources: Khachatryan 2008

Table E.3: Livestock raised in different types of farms in 1991, 2000 and 2007

Year	Cattle head	Of which cows	Pigs	Sheep and goats	Horses	Poultry
1991	640,070	250,920	310,869	1,186,264	6,531	9,352,000
2000	478,730	262,095	70,556	548,580	11,502	4,255,000
2007	620,460	307,535	152,658	632,672	12,621	4,954,000[a]

Sources: Sargsyan 2008
[a]2006 data for poultry.

Table E.4: Production of main animal products in 1990, 2000, and 2007

Year	Livestock and poultry		*Including*				Milk	Eggs	Wool
	(live weight; 1000 metric tons)	(slaughter weight; 1000 metric tons)	**Beef and veal**	**Pork**	**Mutton and goat**	**Chicken**	*Thousand metric tons*	*Million units*	(physical weight; metric tons)
1990	145	93	35	15	9	34	432	518	2,831
2000	89	49	31	9	8	1.2	452	385	1,310
2007	122	56[a]	34[a]	9[a]	8[a]	5[a]	642	464[b]	1,306[a]

Sources: Sargsyan 2008
[a]Data for 2005; [b]Data for 2006.

Table E.5: Top 20 Armenian agricultural products by weight and value, 2005

	Metric Tons			Million AMD	Million US$
Cow milk, whole, fresh	573800		Cow milk, whole, fresh	57343	172.029
Potatoes	564211		Potatoes	49122	147.366
Wheat	265700		Indigenous Cattle Meat	24469	73.407
Tomatoes	234948		Wheat	23222	69.666
Vegetables. Fresh	170000		Tomatoes	13325	39.975

Grapes	164353		Vegetables fresh	8583	25.749
Apples	155300		Barley	8370	25.11
Watermelons	117798		Indigenous Pigmeat	8101	24.303
Barley	110771		Grapes	7811	23.433
Cabbages and other brassicas	107172		Watermelons	6440	19.32
Cucumbers and gherkins	64407		Indigenous Sheep Meat	5725	17.175
Pears	59000		Apples	5248	15.744
Onions. Dry	48787		Cabbages and other brassicas	4806	14.418
Cattle meat	34400		Indigenous Chicken Meat	4304	12.912
Peaches and nectarines	31700		Cucumbers and gherkins	3964	11.892
Plums and sloes	30500		Onions, dry	3311	9.933
Hen eggs. In shell	28784		Natural honey	2527	7.581
Sheep milk, whole, fresh	17500		Pears	2518	7.554
Carrots and turnips	17075		Sheep milk, whole, fresh	2500	7.5
Apricots	15000		Garlic	1749	5.247

Source: Food and Agriculture Organization 2008a
Note: conversion rate from Armenian Drams to US Dollars = 0.003 AMD

Table E.6: Natural disasters recorded since 2004 in ARS database

Year	Types of natural disaster	Marzes (Regions)	Extent of damage	
		(the number of injured communities)	AMD (000s)	US$ (000s)
2004	Spring floods, inundations, mudslides, high waters	Aragatsotn (32), Ararat, Gegharkunik (64), Lori (49), Kotayk (13), Shirak (52), Syunik, Vayots Dzor (1), Tavush	1,420,662	$4,262
	Hail	Aragatsotn (8), Armavir (11), Gegharkunik (34), Lori (31), Kotayk (1), Vayots Dzor (13), Tavush (5)	1,656,387	$4,969
	Strong wind	Aragatsotn (39), Kotayk (1), Syunik (16), Vayots Dzor (20), Tavush (1)	112,406	$337
	Snowfall, landslide, fall	Yerevan (2), Atagatsotn (1), Kotayk (2), Vayots Dzor (3), Tavush (2)	-	
	Frost-bitten	Gegharkunik (13)	40,210	$121
	Total		**3,229,664**	**$9,689**
2005	Spring floods, inundations, mudslides, high waters	Yerevan (1), Aragatsoton (10), Ararat (7), Gegharkunik (5), Lori (1), Kotayk (3), Shirak (5), Vayots Dzor (9)	159,088	$477
	Hail	Ararat (10), Armavir (1), Lori (10), Kotayk (3), Vayots Dzor (6)	1,294,770	$3,884
	Strong wind	Lori (3), Shirak (3), Syunik (1), Vayots Dzor (10), Tavush (1), Kotayk (2)	49,620	$149
	Stone-fall, landslide, fall	Aragatsotn (1), Kotayk (1), Vayorts Dzor (3), Shirak (1), Tavush (3)	295,078	$885
	Water coverage	Aragatsotn (1)	3,000	$9
	Heavy snow precipitations	Vayots Dzor (the whole territory of the region)	3,165	$9

	Total		**1,804,720**	**$5,414**
2006	Spring floods, inundations, mudslides, high waters	Yerevan (1), Aragatsotn (15), Ararat (11), Lori (3), Tavush (22)	35,689	$107
	Hail	Aragatsotn (13), Lori (5), Shirak (49), Vayots Dzor (4)	2,343,460	$7,030
	Frost-bitten	Aragatsotn (23), Gegharkunik (10), Lori (19), Shirak (4), Vayots Dzor (41)	842,020	$2,526
	Drought	Aragatsotn (53), Ararat (8), Lori (94), Shirak (118), Syunik (72), Vayots Dzor (43), Tavush	1,138,489	$3,415
	Heavy rain	Shirak (3), Lori (2)	71,100	$213
	Snowstorm, heavy snow	Shirak (6), Vayots Dzor (29)	57,284	$172
	Fire	Vayots Dzor (1)	400	$1
	Stone-fall, landslide, fall	Yerevan (3), Lori (4), Shirak (1), Syunik (2), Vayots Dzor (2), Tanush ()	-	
	Total		**4,622,652**	**$13,868**
2007	Spring floods, mudslides	Aragotsotn (24), Ararat (6), Armavir (3), Kotayk (8), Shirak (22), Gegharkunik (25), Vayots Dzor (18), Tavush (5), Lori (3), Syunik (2)	2,180,760	$6,542
	Hail	Shirak (26), Aragatsotn (24), Ararat (8), Armavir (5), Kotayk (1), Lori (48), Gegharkunik (9), Tavush (8), Vayots Dzor (15)	5,102,600	$15,308
	Strong wind	Shirak (13), Ararat (1), Vayots Dzor (9), Gegharkunik (10), Aragatsotn (20), Syunik (11), Lori (4), Yeravan (1)	5,026,700	$15,080
	Heavy rain	Kotayk (2), Tavush (2), Lori (2), Vayots Dzor (1), Ararat (1), Gegharkunik (4), Shirak (4), Aragatsotn (3)		
	Snowstorm, heavy rain	Aragatsotn (5), Lori (1), Gegharkunik (1), Shirank (1), Yerevan (2)		
	Stone fall, landslide, fall	Gegharkunik (1), Kotayk (1), Lori (4), Vayots Dzor (5). Tavush (3), Ararat (3), Aragatsotn (1), Yerevan (2)		
	Lightening	Yerevan (1), Lori (1)	1 injured	
	Total		**12,310,060**	**$36,930**

Source: Armenian Rescue Service 2009
Note: conversion rate from Armenian Drams to US Dollars = 0.003 AMD

Appendix F. Development Projects

Note: All measures described in Appendix F were envisaged according to strategy documents, however, not all funds are ensured and measures implemented.

Table F.1: Ministry of Nature Protection funded projects

Project Name	Cost in US$	Time Period	Agency in Charge/Funding Source
Support to awareness raising and preparedness of population living in the zones of impacts of industrial accidents	44,737	2008-2009	German Federal Ministry of Environment
Caucasus Initiative within the regional project "Protection of Nature and Biodiversity" – Establishments of Protected Areas in Javakhq Plateau	8,947,402	2007-2009	German Federal Ministry of Cooperation and Development, KfW/AHT International
Water Governance Project for EECCA countries (Belarus, Moldova, Ukraine, Armenia, Azerbaijan, Georgia)	2,684,220	2008-2010	EU
Transboundary Management of Kura River – Phase II (Armenia, Azerbaijan, Georgia)	6,391,000	2008-2010	EU
Natural Resources Management and Poverty Reduction	16,000,000	2002 – 2008	WB, GEF, IDA, SIDA, RA Government
Armenia: Improving the Energy Efficiency of the Urban Heating and Hot Water Supply	3,160,000	2005-2009	GEF, UNDP, RA Government
Developing Institutional and Legal Capacity to Optimize Information and Monitoring System for Global Environmental Management in Armenia	47,500	2008-2011	GEF, UNDP, RA Government
Country Programme on Phasing-out Ozone Depleting Substances	1,927,772	2005-2009	GEF, UNDP, UNEP
Swedish Trust Fund Grants – Armenian Forest Development	1,162,153	2007-2008	SIDA
Enabling Activities for the Preparation of Armenia's Second National Communication to the UNFCCC	40,500	2007-2009	GEF, UNDP, RA Government
Capacity Building for Effective Participation in the Biosafety Clearing House (BCH)	39,954	2007-2008	GEF, UNEP
Registration, Monitoring and Assessment of the Obsolete Pesticides in Armenia for their Environmentally Safe Removal	319,550	2008-2010	NATO
Adaptation to Climate Change Impacts in Mountain Forest Ecosystems of Armenia	90,000	2008-2012	GEF, UNDP, RA Government
Developing the Protected Area System of Armenia	1,000,000	2009-2012	GEF, UNDP, RA Government
Strategic Approach to International Application of Chemicals Management (SAICM) in Armenia	24,568	2009-2010	UNDP, RA Government
Support to the Country's Activities under the CBD for Protected Areas	12,900	2009-2011	GEF, UNDP

Source: UNDP Armenia 2009b

Table F.2: Energy projects

Project Name	Cost in US$	Time Period	Agency in Charge/Funding Source
Construction of the Iran-Armenia gas pipeline	120 Million	2005-2010	"Soft" loans and special funding schemes
Safety enhancements at the Armenian Nuclear Power Plant	50 Million	2005-2010	State Project with technical support from USDOE, TACIS, GB, and ANPP
Total gasification of the country	40 Million	2005-2010	Commercial loans with support from ArmRosGasProm
Commencement of heat supply rehabilitation	100 Million	2005-2010	"Soft" and commercial loans
Completion of the heat supply rehabilitation project	100 Million	2011-2016	"Soft" and/or commercial loans
Construction of the first 208 MW combined cycle unit at Yerevan Thermal Power Plant	165 Million	2005-2010	Japanese and Armenian Governments
Construction of a 440 MW gas turbine Unit 5 at Hrazdan Thermal Power Plant	140 Million	2005-2010	Private Investments
Modernization of the underground gas storage	27 Million	2005-2010	Commercial loans
Construction of 140 MW Meghri Hydro Power Plant	120 Million	2005-2010	Commercial loans and/or special funding schemes
Construction of 70 MW of small Hydro Power Plants	75 Million	2005-2010	EBRD, WB, USAID
Construction of wind power plants with a total capacity of 100 MW	100 Million	2005-2010	Commercial loans, revolving fund (EBRD, WB, USAID)
Feasibility study for a new ANPP unit and negotiations for determination of financing schedule	10 Million	2005-2010	"Soft" and/or commercial loans
Preparation work for decommissioning of unit 2 of ANPP and development of legislative and normative documentation	2 Million	2005-2010	Technical Assistance from donors
Completion of the research of geothermal energy potential	10 Million	2005-2010	Technical Assistance from donors and "soft" loans
Implementation of oil and gas exploration activities		2005-2010	Private Investments
Construction of the 3rd Iran-Armenia electric transmission line	30-40 Million	2005-2010	Commercial loans or special funding schemes
Modernization and development of the transmission network, commencement of SCADA system implementation	70 Million	2005-2010	"soft" loans
Modernization and development of the electric distribution network	86 Million	2005-2010	State resources and commerical loans
Construction of the 60 MV Loriberd HPP	100 Million	2011-2016	Commercial loans and/or special funding schemes
Construction 65 MW of small HPPs	75 Million	2011-2016	Private investors, revolving fund (KfW/ EBRD, WB, USAID
Construction of 200 MW of wind power plants	200 Million	2011-2016	Private investors and revolving fund
Construction of the second 208 MW combined cycle units at Yerevan TPP	330 Million	2011-2016	"Soft" and/or commercial loans
Design works of two new ANPP units	90 Million	2011-2016	"Soft" loans

Project Name	Cost in US$	Time Period	Agency in Charge/Funding Source
Expansion of gas storage of 75 million cubic meters	20 Million	2011-2016	Commercial loans
Safety maintenance at the ANPP unit 2	20 Million	2011-2016	Technical support (US DOE, TACIS, GB etc.) and ANPP resources
Preparation works for decommissioning of ANPP unit 2	4 Million	2011-2016	Technical assistance from donors
Construction of the 6th 400 MW combined cycle unit at Hrazdan TPP	300 Million	2011-2016	Private investments
Continuous modernization and development of the electric transmission network (construction of inter-system transmission lines)	50 Million	2011-2016	"Soft" loans and state resources
Continuous modernization and development of the electric transmission network (construction of inter-system transmission lines)	50 Million	2017-2025	"Soft" loans and private resources
Modernization and development of the electric distribution system	80 Million	2011-2016	Private Investments
Construction of the 75 MW Shnogh HPP	100 Million	2017-2025	Private capital
Completion of phase 1 of ANPP decommissioning	40 Million	2017-2025	Technical assistance from donors
Commissioning of the new 640 MW ANPP unit 1	800 Million	2017-2025	"Soft" and/or commercial loans
Construction of small HPPs with 130 MW installed capacity	170 Million	2017-2025	Private investors
Construction of wind power plants with a total capacity of 200 MW	200 Million	2017-2025	Private investments
Expansion of gas storage of 75 million cubic meters	20 Million	2017-2025	"Soft" and/or commercial loans
Modernization and development of the electric distribution system	120 Million	2017-2025	Private investments
Construction of TPP combined cycle units	Unknown	2017-2025	Private Investments

Source: Republic of Armenia 2005

Table F.3: Poverty Reduction Strategy projects

Project Name	Cost in US$ (Annually in 2009 US$)	Time Period	Agency in Charge/Funding Source
General Public Services	213,398,693	Ongoing	Unknown
Defense, Public Order and Safety	316,993,464	Ongoing	Unknown
Education and Science	309,150,327	Ongoing	Unknown
Health	172,222,222	Ongoing	Unknown
Social Security and Social Insurance	470,588,235	Ongoing	Unknown
Culture, Information, Sports and Religion	44,444,444	Ongoing	Unknown
Housing and Public Utilities	162,745,098	Ongoing	Unknown
Fuel and Energy	0	Ongoing	Unknown
Agriculture, Forestry and Water,	61,437,908	Ongoing	Unknown

Project Name	Cost in US$ (Annually in 2009 US$)	Time Period	Agency in Charge/Funding Source
Fishing			
Manufacturing, Mining, Construction and Environment	13,071,895	Ongoing	Unknown
Transportation, Road Utility and Communications	107,843,137	Ongoing	Unknown

Source: Republic of Armenia 2003.

Table F.4: Ministry of Nature projects

Project Name	Cost in US$	Duration	Agency in Charge/Funding Source
Drafting the law of the RoA "On Environmental Protection"	200,000	12 Months	Ministry of Nature Protection of the Republic of Armenia
Classification of environmental (and adjacent) legal acts and preparing bulletins	140,000	10 Months	Ministry of Nature Protection of the Republic of Armenia
Localization of methodological documents for registering emissions of substances mentioned in Armenia's international commitments	250,000	3 Years	Ministry of Nature Protection of the Republic of Armenia
Assessment of environmental damage, introduction of effective economic and financial mechanisms for reducing pollution	300,000	1.5 Years	Ministry of Nature Protection of the Republic of Armenia
Developing a pilot project for integrated water resources management in a selected river basin or watershed	3,000,000	4 Years	Ministry of Nature Protection of the Republic of Armenia
Revising the current requirements for determining and protecting sanitary zones for protection of drinking water sources	500,000	1.5 Years	Ministry of Nature Protection of the Republic of Armenia
Establishing the national water program (NWP) management system	150,000	1 Year	Ministry of Nature Protection of the Republic of Armenia
Reformulation of water monitoring system and programs in one river basin	2,050,000	4 Years	Ministry of Nature Protection of the Republic of Armenia
Developing and implementing development strategy for Basin Public Councils (BPC)	400,000	3 Years	Ministry of Nature Protection of the Republic of Armenia
Establishing and operating a trans-boundary air pollution monitoring station in Armenia	220,000	3 Years	Ministry of Nature Protection of the Republic of Armenia
Improving the atmospheric air pollution monitoring in Yerevan	25,000	1 Year	Ministry of Nature Protection of the Republic of Armenia
Studying the negative impact of the main air pollutants on the environment	220,000	3 Years	Ministry of Nature Protection of the Republic of Armenia

Project Name	Cost in US$	Duration	Agency in Charge/Funding Source
Developing the soil monitoring system in Armenia	25,000 (preparatory phase)	PDF A 6 months (preparatory phase); MSP 24 months	Ministry of Nature Protection of the Republic of Armenia, "Environmental impact monitoring center" SNCO
The environmental factor in land zoning and cadastre assessment	48,000	2 Years	Ministry of Nature Protection of the Republic of Armenia
Anti-flood measures on Goris river in Syunik marz of Armenia	336,100	2 Years	Ministry of Nature Protection of the Republic of Armenia
Preservation, reproduction and restoration of threatened forest species	2,000,000	3 Years	Ministry of Nature Protection, National Academy of Sciences, Ministry of Agriculture, and Agrarian University
Monitoring of the impact of environmental pollution on crops in Ararat valley	420,000	3 Years	Ministry of Nature Protection of the Republic of Armenia
Monitoring of geological exogenous processes in Armenia	250,000	36 Months or more	Ministry of Nature Protection of the Republic of Armenia
Prospecting non-metal mines in Vayots Dzor	300,000	36 Months	Ministry of Nature Protection of the Republic of Armenia, "Geocomplex" SCJSC
Detailed geological work in Meghradzor-Hankavan-Melik mine site of Tzaghkuniats mountain range, preparing 1: 10 000 geological maps	500,000	2 Years	Ministry of Nature Protection of the Republic of Armenia, "Geocomplex" SCJSC
Further elaboration of the "Ecoeducation strategy for Armenia"	50,000	1 Year	Ministry of Nature Protection of the Republic of Armenia
Capacity building for preparing the first national registry on Pollutant Release and Transfer Registers in Armenia	300,000	18 Months	Ministry of Nature Protection, International Cooperation Department
Mitigation and neutralization of the negative impact of Geghanush tailings site in Syunik marz and Shamlugh tailings site in Lori marz of Armenia	1,634,901	1 Year	Ministry of Nature Protection of the Republic of Armenia

Source: Republic of Armenia Ministry of Nature Protection 2006.
Note: Starting and ending dates were not listed in the Ministerial Report.

Table F.5: Agricultural development projects

Project Name	Cost in US$	Time Period	Agency in Charge/Funding Source
Deepening of agrarian reforms, development of market infrastructures and improvement of the forms of economic activities	Unknown	Present-2015	State program/legislation
Increase in food security level, ensuring minimum level of self-sufficiency of basic food	Unknown	Present-2015	State program/legislation
Increase in competitiveness level of agricultural local produce and	Unknown	2006-2011	Unknown

Project Name	Cost in US$	Time Period	Agency in Charge/Funding Source
substitution of imported foodstuff by local production			
Food safety system development	Unknown	Unknown	Unknown
Zoning and rational distribution of production	Unknown	Unknown	Unknown
Land reclamation and reduction of negative impact on the environment	113 Million	2006-2011	Unknown
Establishment of conditions and legal basis for the development of organic agriculture	Unknown	Unknown	Unknown
Development of crop production	Unknown	2006-2009	Unknown
Development of livestock production	Unknown	Unknown	Unknown
Agricultural Processing	Unknown	Unknown	Unknown
Development of agricultural services and social sub-structures	67 Million	Starting in 2009	Unknown
Improvement of tax and credit system in the agrarian sector	Unknown	Unknown	Unknown
Improvement of academic, consultancy systems in the agrarian sector	Unknown	Unknown	Unknown

Source: Republic of Armenia 2006

Table F.6: Sustainable development projects

Project Name	Cost in US$	Time Period	Agency in Charge/Funding Source
National, regional and local urban development documents and designs	3,441,176	2009-2012	Unknown
Planning of specially regulated urban development objects	683,007	2009-2012	Unknown
Historic buildings, architectural and natural heritage conservation and recovery program development	326,797	2009-2012	Unknown
Implementation of a project on deployment of national urban cadastre	555,556	2009-2012	Unknown
Legal reforms in urban development sector	882,353	2009-2012	Unknown
Formulation of a program for preparation of apartment block technical documentation package	16,340	2009-2012	Unknown
Apartment block technical documentation packages for 10,000 buildings	3,464,052	2013-2016	Unknown
Prospecting and monitoring of most hazardous landslide areas	2,650,327	2009-2012	Unknown
Review of technical conditions of housing	457,516	2009-2012	Unknown
Development of a national program to combat landslides	29,412	2013-	Unknown
Development of a project on	228,758	2009-2012	Unknown

Project Name	Cost in US$	Time Period	Agency in Charge/Funding Source
provision of housing for homeless households			
Measures for management, conservation and maintenance of housing stock	18,872,549	2009-2012	Unknown

Source: Republic of Armenia. 2008f

Table F.7: Second National Environment Action Program projects
(the costs are not specified)

Project Name	Time Period	Agency in Charge/Funding Source
Drafting of the RA Law "On Environmental Expertise" and sublegislative acts to ensure the enforcement of the Law	2008-2010	RA Ministry of Nature Protection/State Budget, international funding
Drafting of the RA Law "On Self-Control over Meeting the Requirements of Environmental Legislation"	2008	RA Ministry of Nature Protection/State Budget, international funding
Drafting of the RA "Law on Environment Protection" and development of project package for draft sub-legislative acts to ensure the enforcement of the Law	2010-2012	RA Ministry of Nature Protection/State Budget, international funding
Implementation of measures not encompassed by this present Action Plan and those envisaged under the Chapter "Environment" in the National Program adopted by the Government of the Republic of Armenia within the framework of partnership and cooperation agreements signed between the Republic of Armenia and European Communities and their member states - development of relevant draft legal acts	2008-2012	RA Ministry of Nature Protection/State Budget, international funding
Elaboration of environment strategy and action plan for Yerevan city	2009-2010	Yerevan Municipality, RA State budget, international funding
Determination of format and principles for developing environmental action plans for the Marzes and communities of the Republic of Armenia	2009-2010	RA Ministry of Nature Protection/State Budget, international funding
Elaboration of project package for enhancement of environmental inspectional system capacities	2008-2009	RA Ministry of Nature Protection/State Budget, international funding
Development of project package on strengthening capacities and development of state environmental expertise, environmental impact assessment and strategic ecological assessment system	2008-2009	RA Ministry of Nature Protection/State Budget, international funding
Development of a project package on establishment of modern mechanisms for collection and exchange of environmental information	2008-2009	RA Ministry of Nature Protection/State Budget, international funding
Development of programme package on establishment of mechanisms for comprehensive and integrated prevention of harmful impacts on the environment	2008-2012	RA Ministry of Nature Protection/State Budget, international funding
Development of strategy on funding environmental programmes	2009-2012	RA Ministry of Nature Protection/State Budget, international funding
Development of a package of recommendations on improvement of procedures for development and implementation of environmental programs	2010	RA Ministry of Nature Protection, RA Ministry of Finance, RA Ministry of

Project Name	Time Period	Agency in Charge/Funding Source
		Agriculture, state budget
Development of a package of recommendations for introduction of economic stimulation mechanisms set by environmental legislation	2009-2011	RA Ministry of Nature Protection, RA Ministry of Finance, state budget, international funding
Development of recommendation on introduction of 7environmental insurance and audit institutions	2011-2012	RA Ministry of Nature Protection, RA Ministry of Finance, state budget, international funding
Development of recommendations on improvement of the system of implementation and funding of recultivation activities aimed at rehabilitation of lands damaged due to entrails use funded from the Environmental Protection Capital,	2009-2010	RA Ministry of Nature Protection, RA Ministry of Finance, RA Ministry of Energy and Natural Resources, state budget
Development of recommendations for the improvement of the funding systems provided for by the RA Law "On Targeted Use of Environmental Fees Paid by Companies", environmental fees and environmental nature use charges	2009-2011	RA Ministry of Nature Protection, RA Ministry of Finance, RA Ministry of Economy, RA State Tax Service, international funding
Development of programme package on establishment of Environmental Protection Funds	2010-2011	RA Ministry of Nature Protection, state budget, international funding
Introduction of periodical information collection system for calculation and classification of environmental expenditures	2009-2010	RA Minsitry of Nature Protection, RA Ministry of Finance, state budget
Development of proposals on economic assessment of bioresources	2010-2012	RA Ministry of Nature Protection, RA Ministry of Finance, RA Ministry of Agriculture, state budget, international funding
Development and introduction of economic stimulation mechanisms with the aim to reduce the quantities of generated waste and to involve those in the economic circulation	2008-2012	RA Ministry of Nature Protection, state budget, international funding
Inventory of actual water use	2009-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Setting up a system separated by republican and regional divisions which will assist the decision making in the water resources management field	2008-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Drawing up water and water-industry balances in five watersheds, comparison of water supply and water demand in terms of time-periods and territory	2010-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, RA Ministry of Territorial Administration, State Committee on Water Industry, state budget, international funding
Adoption of a regulation on transferring the licensing functions of local importance water use to Regional Watershed Management Units (RWMU)	2009-2010	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget
RWMU capacity building for issuing licenses for local importance water use and development of	2011-2012	RA Ministry of Nature Protection, RA Ministry of

Project Name	Time Period	Agency in Charge/Funding Source
watershed management plans		Healthcare, state budget, international funding
Review of the action plan for the restoration of Lake Sevan eco-systems	2010-2012	RA Ministry of Nature Protection, State Budget
Definition of minimum ecological flows for rivers of Armenia	2010-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Analysis of current conditions of flood control structures, renovation and construction of new ones	2009-2012	RA Ministry of Agriculture, RA Ministry of Healthcare, RA Ministry of Territorial Administration, State Committee on Water Industry, state budget, international funding
Elaboration of an action plan addressed to the prevention of harmful impact of water resources	2009-2012	RA Ministry of Agriculture, RA Ministry of Nature Protection, RA Ministry of Healthcare, RA Ministry of Territorial Administration, State Committee on Water Industry, state budget, international funding
Development and implementation of strategy for improving the water-supply and water sanitation services in communities not serviced by watersupply organizations	2009-2012	RA Ministry of Territorial Administration, State Committee on Water Industry, RA Ministry of Healthcare, state budget, international funding
Development and implementation of priority measures addressed to the improvement of services rendered by water supply (irrigation, potable, hydroenergy) and water disposal organizations	2009-2012	RA Ministry of Territorial Administration, State Committee on Water Industry, RA Ministry of Agriculture, RA Ministry of Energy and Natural Resources, RA Ministry of Healthcare, RA Ministry of Nature Protection, state budget, international funding
Assessment of water resource storages of Ararat valley	2010-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Drawing up and implementation of a program on development of other legal acts regulating the area of the new RA draft Code "On Entrails"	2008-2012	RA Ministry of Energy and Natural Resources, RA Ministry of Nature Protection, state budget, international funding
Development of a programme package for capacity building of entrails sector management system	2008-2009	RA Ministry of Energy and Natural Resources, RA Ministry of Nature Protection, state budget, international funding
Elaboration of action plan and strategy for	2009-2010	RA Ministry of Energy and

Project Name	Time Period	Agency in Charge/Funding Source
reproduction of the ore mineral basis		Natural Resources, RA Ministry of Nature Protection, state budget, international funding
Elaboration of environmental safety complex program aimed at elimination of adverse environmental impacts resulting from the use of entrails	2009-2010	RA Ministry of Energy and Natural Resources, RA Ministry of Territorial Administration, RA Ministry of Nature Protection, RA Ministry of Emergency Situations, RA State Committee on Real Estate Cadastre, state budget, international funding
Prepare a cadastre on emissions of harmful substances	2009-2012	Ministry of Nature Protection and state budget
Organization of activities targeting the introduction of development and transfer of best technologies favoring the reduction in emissions of hazardous substances, especially sulfur compounds	2009-2012	RA Ministry of Nature Protection, RA Ministry of Economy, state budget
Development and introduction of electronic governance mechanism, respective web-site and computer software aiming to favor the simplification of atmosphere protection management, implementation of emissions reduction process by applying regional principle and introduction of new technologies	2009-2012	Ministry of Nature Protection and state budget
Elaboration of methodology for registering hazardous emissions from motor transport	2009-2010	RA Ministry of Nature Protection, RA Ministry of Transport and Communication, state budget
Elaboration of measures favoring to the development of road traffic and safety in Yerevan city	2009-2012	Yerevan Municipality, RA Police, state budget
Encouragement of neutralizer use	2009-2010	RA Ministry of Transport and Communication, RA Ministry of Nature Protection, Yerevan Municipality, state budget
Development of respective legal framework and instruments for the implementation of Kyoto Convention, Clean Development Mechanism projects	2009-2012	Ministry of Nature Protection and state budget
Review the RA Government Decisions N1840-N	2008-2009	RA Ministry of Nature Protection, Other agencies, state budget
Development of public-private partnership principles	2009-2012	RA Ministry of Nature Protection, RA Ministry of Economy
Development of amendments of the RA Law "On the Protection of Atmospheric Air"	2009-2010	RA Ministry of Nature Protection, state budget, international funding
Organization and implementation of monitoring of hard particles PM2.5, PM10 in the atmospheric air for the purpose of impact assessment on the human health	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Preparation of program package for the development	2008-2010	RA Ministry of Nature

Project Name	Time Period	Agency in Charge/Funding Source
of state environmental monitoring system and capacity building and project implementation		Protection, stakeholder ministries and agencies, state budget, international funding
Implementation of waste monitoring	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Improvement of land monitoring system	2009-2010	RA Ministry of Nature Protection and stakeholder bodies
Inventory of more valuable areas of Armenia from the biodiversity perspective, determination of biodiversity protection mechanisms for those areas	2009-2012	RA Ministry of Nature Protection, RA territorial administration bodies, state budget, international funding
Implementation of state accounting of biodiversity and creation of state cadastre according to the marzes of Armenia, including preparation of the annotated lists of flora and fauna species and basic ecosystems	2009-2012	RA Ministry of Nature Protection, RA Ministry of Agriculture, RA territorial administration bodies, state budget, international funding
Establishment of biodiversity monitoring system and database	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Analysis of the RA SPAs, elaboration of proposals on the system improvement from the prospective of biodiversity and valuable ecosystems representation, creation of new protected areas, including protected biosphere areas and ecological corridors	2009-2010	RA Ministry of Nature Protection, state budget, international funding
Inventory and situation assessment for rare and endangered species of flora and fauna, amendment and publication of the Red Book of Armenia	2009	RA Ministry of Nature Protection, state budget, international funding
Identification of the most used and useful species of plants and species of hunted animals in the regions of the Republic, assessment of the resources of the most significant flora and fauna species, development of norms/quotas for collection/hunting of the most important plants and animals species	2009-2011	RA Ministry of Nature Protection, state budget, international funding
Examination and analysis of international experience in the assessment of impact of various branches and natural factors of the economy on the natural ecosystems, localization and piloting of impact assessment methodologies, development of methodological guidelines applicable for Armenia	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Development and introduction of mechanisms for fair distribution of the benefits obtained from the use of genetic resources and their availability	2009-2012	RA Ministry of Nature Protection, RA Ministry of Agriculture, state budget, international funding
Improvement of industrial fishing mechanisms and restoration of valuable populations of fish species	2009-2010	RA Ministry of Nature Protection, state budget, international funding
Clarification of 2009-2012 implementation time-scales designed for the measures stemming from and included in the RA National Forest Programme	2009	RA Ministry of Agriculture, Yerevan Municipality, state budget
To implement the development and introduction of pilot project on the fight against pests and fire prevention in the most vulnerable forests as a result of	2008-2012	RA Ministry of Nature Protection, RA Ministry of Agriculture, state budget,

Project Name	Time Period	Agency in Charge/Funding Source
climate change		international funding
Impact assessment of risks for the hazardous chemical substances on human health and environment	2009-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Development of risk assessment and reduction methodological approaches on for the impact of hazardous chemical substances	2009-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Development of national policy on the reduction of impact of hazardous chemical substances on human health and environment	2008-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Elaboration of the draft RA Law "On Chemical Substances"	2009-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, RA Ministry of Agriculture, RA Ministry of Economy, state budget, international funding
Implementation of action plan for the "Strategic Approaches for International Chemicals Management" (SAICM)	2009-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, RA Ministry of Agriculture, RA Ministry of Emergency Situations, RA Ministry of Agriculture state budget, international funding
Review and update of the "National Profile on Chemical Substances and Waste Management	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Development of Concept of "Clean Production"	2008-2012	RA Ministry of Nature Protection, state budget, international funding
Establishment of scientific-research laboratory for persistent organic pollutants (POP)	2008-2010	RA Ministry of Nature Protection, state budget, international funding
Improvement of waste reporting, norm-setting and inventory system	2008-2012	RA Ministry of Nature Protection, state budget, international funding
Strengthening of the control over waste importation, exportation and transit transportation, capacity enhancement for the Customs and environmental inspectorate officers	2008-2012	RA Ministry of Nature Protection, RA State Customs Committee, international funding
Categorization/passportisation of waste	2008-2012	RA Ministry of Nature Protection, state budget
Creation and running of state waste cadastre	2008-2012	RA Ministry of Nature Protection, state budget
Creation and running of registers for waste generation, processing and extracting objects and disposal locations	2008-2012	RA Ministry of Nature Protection, state budget
Implementation of environmental monitoring over the waste disposal locations	2008-2012	RA Ministry of Nature Protection, state budget, international funding
Establishment of the "Clean"/Waste-less and Low-waste Technologies Center	2008-2012	RA Ministry of Nature Protection, state budget,

Project Name	Time Period	Agency in Charge/Funding Source
		international funding
Development and introduction of separate waste collection system	2008-2012	RA territorial administration bodies, state budget, international funding
Establishment of manufacturing capacities for the secondary use of waste and complex processing of its raw material resources	2009-2012	RA Ministry of Economy, state budget, international funding
Public awareness and education on economized use of resources	2008-2012	RA Ministry of Nature Protection, RA territorial administration bodies, state budget, international funding
Involvement of population in the waste sorting and separated collection process	2008-2012	RA Ministry of Nature Protection, RA territorial administration bodies, state budget, international funding
Introduction of secondary use technologies for recycling of secondary raw materials (paper waste, polyethylene containers, etc) and organic wastes (bird dung, wastes of cattle-breeding complexes, wastes of wood-processing enterprises)	2009-	RA Ministry of Economy, RA Ministry of Agriculture state budget, international funding
Elaboration of ecologically safe usage rules for the nonferrous and ferrous metals scrap and waste	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Establishment and management of database on waste liquidation and disposal technologies	2008-2012	RA Ministry of Nature Protection, state budget, international funding
Development of manuals on safe disposal of hazardous wastes (chlorineorganic, mercury, lead containing, etc)	2008-2012	RA Ministry of Nature Protection, state budget, international funding
Development of methodological instructions, rules and regulations for the liquidation of medical wastes, expired and unusable medicines, pesticides, oils and equipment containing polychlorinated biphenyl (PCB)	2009-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Definition of safe tailing dams management principles	2009-2012	RA Ministry of Nature Protection, RA Ministry of Emergency Situations, state budget, international funding
Establishment of organized waste disposal areas and specialized landfills for hazardous wastes	2010-2012	RA Ministry of Urban Development, RA territorial administration bodies, state budget, international funding
Purification and remediation of polluted areas and landfills	2010-2012	RA territorial administration bodies, state budget, international funding
Preparation of respective program addressed to the restoration of degraded lands	2009-2012	RA Ministry of Agriculture, RA Ministry of Nature Protection, RA Ministry of Urban Development, RA territorial administration bodies, state budget, international funding
Development of respective program against land-slides	2009-2012	RA Ministry of Urban Development, RA Ministry of Emergency Situations, RA

Project Name	Time Period	Agency in Charge/Funding Source
		Ministry of Nature Protection RA territorial administration bodies, state budget, international funding
Development and introduction of program related to the distribution of lands located between adjacent communities outside their administrative boundaries:	2009-2015	RA Ministry of Agriculture, RA Ministry of Nature Protection, RA territorial administration bodies RA State Committee on Real Estate Cadastre, state budget
Development and approval of lands (land covers) protection concept and enabling set of measures thereof	2009-2012	RA Ministry of Nature Protection, RA Ministry of Urban Development, state budget, international funding
Elaboration of criteria and respective monitoring methodologies for the protection, restoration, sustainable use and assessment of the land cover condition	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Development of a proposal on their clarification based on the analysis of land use environmental criteria and indicators, and on adoption of relevant norms	2009-2012	RA Ministry of Agriculture, RA Ministry of Urban Development, RA Ministry of Emergency Situations, RA Ministry of Nature Protection, RA territorial administration bodies
Implementation of measures envisaged by the list of 2008-2012 measures ensuring implementation of Republic of Armenia Government Program, and not included in this plan of action	2009-2012	RA Ministry of Nature Protection, RA Ministry of Healthcare, state budget, international funding
Assistance in the processing and utilization of agricultural waste. Objective – energy and fertilizer production	2009-2012	RA Ministry of Agriculture, RA Ministry of Nature Protection, state budget, private funding, international funding
Assistance in the growth of the solar water heaters usage volume Objective – increase of renewable energy proportions in the energy production	2009-2012	RA Ministry of Energy and Natural Resources, RA Ministry of Nature Protection, private funding, international funding
Assessment of potential forest sector vulnerability in view of the projections related to the natural gas price increase and development of short-term and long-term prevention program	2009-2012	RA Ministry of Nature Protection RA Ministry of Energy and Natural Resources, RA Ministry of Agriculture, state budget, private funding, international funding
Study of the energy sources' harmful impact on the natural environment based on the renewable resources. Elaborate and approve respective environmental restrictions under the specifies procedure	2009-2012	RA Ministry of Nature Protection RA Ministry of Energy and Natural Resources, RA Ministry of Agriculture, state budget, private funding, international funding
Study and assessment of technical and economic	2009-2012	RA Ministry of Nature

Project Name	Time Period	Agency in Charge/Funding Source
potential of environmentally optimal use of bio-mass (timber and bio-fuel)		Protection RA Ministry of Energy and Natural Resources, RA Ministry of Agriculture, state budget, private funding, international funding
Development of sustainable development criteria, including for the assessment of projects on Clean Development Mechanism	2009-2012	RA Ministry of Nature Protection, RA Ministry of Energy and Natural Resources, RA Ministry of Agriculture, RA Ministry of Economy, state budget, private funding, international funding
Development of innovative pilot projects for irrigation systems	2009-2012	RA Ministry of Agriculture, RA Ministry of Nature Protection, RA territorial administration bodies, state budget
Elaboration of a regulation and an awareness program on provision of demand based information and its accessibility	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Elaboration of a program aimed at efficiency raise in the environmental education system	2009-2012	RA Ministry of Education and Science, RA Ministry of Nature Protection, RA Ministry of Economy, RA Ministry of Energy and Natural Resources RA Ministry of Agriculture, state budget, international funding
Development and introduction of efficient resource training program in the environmental sector	2009-2012	RA Ministry of Education and Science, RA Ministry of Labor and Social Issues, RA Ministry of Economy, RA Ministry of Nature Protection, state budget, international funding
Development of activities in Aarhus centers, provision of financial sustainability	2009-2012	RA Ministry of Nature Protection, RA Ministry of Territorial Administration, state budget, international funding
Development, amendment and implementation of action plans on fulfillment of commitments assumed under the ratified international environmental agreements	2009-2012	RA Ministry of Nature Protection, stakeholder ministries and agencies, state budget, international funding
Dissemination of available information on the provisions and objectives of the international environmental agreements ratified by the RA	2009-2010	RA Ministry of Nature Protection, stakeholder ministries and agencies, state budget, international funding
Study the issue of expediency for Armenia to join UN ECE The Convention of the Protection and Use of Trans-boundary Watercourses and International Lakes.	2009	RA Ministry of Nature Protection, RA Ministry of Foreign Affairs, state budget, international funding

Project Name	Time Period	Agency in Charge/Funding Source
Negotiations with international organizations, including donor organizations and negotiations with donor countries on obtaining financial assistance to implement environmental projects	2009-2012	RA Ministry of Nature Protection, RA Ministry of Finance, RA Ministry of Economy, state budget
Implementation of environmental provisions of the Partnership and Cooperation agreement signed between the Republic of Armenia and the European communities and their member states	2009-2012	RA Ministry of Nature Protection, state budget, international funding
Ensuring the participation of the Republic of Armenia in the international events and meeting	2009-2012	RA Ministry of Nature Protection, RA Ministry of Finance, state budget
Provision of mechanisms for promoting the introduction of environmentally preferable innovative products based on scientific elaborations, and competitiveness of those products	2009-2012	RA Ministry of Economy, RA Ministry of Nature Protection, state budget
Localization of the international experience in introducing "best accessible technologies"	2009-2012	RA Ministry of Economy, RA Ministry of Nature Protection, state budget, international funding
More active participation of Armenian scientists and scientific institutions in the international environmental processes	2009-2012	RA Ministry of Nature Protection, RA Ministry of Education and Science, state budget, international funding
Elaboration of a regulation ensuring availability and accessibility of the outcomes of environmental scientific elaborations	2009-2012	RA Ministry of Education and Science, RA National Academy of Sciences, RA Ministry of Nature Protection, state budget, international funding
Improvement of system for protecting copyrights	2009-2012	RA Ministry of Economy RA Ministry of Education and Science, state budget
Elaboration of mechanism for the development of environmental sciences as well as environmental component development in various scientific fields, which is based on the realistic and objective demand	2009-2012	RA Ministry of Education and Science, RA Ministry of Nature Protection RA Ministry of Economy RA Ministry of Energy and Natural Resources, state budget, private funding, international funding
Development of a concept and financial mechanism for introducing environmentally preferable innovative technologies	2009-2012	RA Ministry of Economy, RA Ministry of Education and Science, RA Ministry of Nature Protection, state budget, private funding, international funding
Development and implementation of a project targeting the determination of limitations (norm-fixing) of nature use and environmental impact based on scientific researches	2009-2012	RA Ministry of Nature Protection RA Ministry of Education and Science RA Ministry of Economy RA Ministry of Labor and Social Issues, state budget, private funding, international funding

Source: Republic of Armenia 2008e

Appendix G. Review of Existing Research and Data

This report is based on a detailed review of existing research on climate change and Armenia, and to some extend the broader Trans-Caucasus region. Extensive resources were provided to us by the UNDP/GEF climate change projects in Armenia. Many of the most useful, detailed, and up-to-date documents were background papers for Armenia's *Second National Communication under the UNFCCC*. These research papers were being completed and translated into English by UNDP Armenia even as our research was conducted.

Citations to original sources are provided throughout this report. In addition, Appendix G is an annotated bibliography of literature on climate change and Armenia. Included with each citation in the annotated bibliography is a brief description of topics covered and data presented in the respective document. The appendix is organized into the same section areas as the main report, for ease of reference.

Armenia Overview

AVAG Solutions Ltd. (2008). Country Development Situation Assessment for Armenia. Country Assessment to Prepare MDG National Progress Report and Develop MDG Regional Frameworks for Yerevan and Each of Marzes (Regions). Yerevan, UNDP.

- Topics
  - Demographic Data
- Data Points
  - Poverty and Economic Growth in 1996 and 1998 in %
  - GDP from 2001-2015 in USD
  - GDP by sector from 2003-2015 in USD

Hovsepyan, A. (2008). Model Simulations of Climate Change over Armenia Region: Final Report. "Enabling Activities for Preparation of Armenia's Second National Communication to the UN Framework Convention on Climate Change (UNFCCC)" UNDP/GEF Project.

- Topics
  - Forestry and climate
- Data Points
  - Average seasonal temperature and change in °C from 1998-2007
  - Average seasonal precipitation and change in mm from 1998-2007
  - Seasonal and annual precipitation anomalies from 1961-1990 compared to baseline in %
  - Observed distribution of precipitation in mm from 1961-1990 and 1998-2007
  - Model projections for the above data points through 2100

National Statistical Service of the Republic of Armenia. 2008. "Armenian Expenditures Calculation". From: Armenia, National Statistical Service of the Republic of Armenia (2003-2007). Socio-Economic Situation of the Republic of Armenia. Armenian NSS Publication Series. Yerevan.

- Topics
  - Table of Income and Expenditures of the Armenian State Budget

National Statistical Service of Republic of Armenia. (2008). Marzes of the Republic of Armenia in Figures (1998-2002).

- Topics
  - Geographic overview
- Data Points
  - Rivers Data
  - Lakes volume
  - Reservoir Volumes

National Statistical Service of Republic of Armenia. (2007). Statistical Yearbook of Armenia 2007. Yerevan, Republic of Armenia Statistical Service.

- Topics
  - Industry overview

- Data Points
  - Industry breakdown in % and total output in AMD from 2002-2006
  - Industry by marz from 2002-2006

Armenia FAO Statistical Yearbook - Country Profiles Republic of Armenia. (2005). Food and Agriculture Organization – FAO.

- Topics
  - Armenia overview by sector
- Data Points (All for 2004)
  - GDP, per capita GDP in USD
  - Imports, Exports in USD
  - Land use in % and ha

Poverty Reduction Strategy Paper of the Republic of Armenia (2003). Yerevan.

- Topics
  - Demographic Data
- Data Points
  - Poverty and Economic Growth in 1996 and 1998 in %
  - GDP from 2001-2015 in USD
  - GDP by sector from 2003-2015 in USD

Schucht, S. and E. Mazur (2004). Environmental Pollution and Product Charges in Armenia: Assessment of Reform Progress and Directions for Further Improvement Paris, OECD.

- Topics
  - Water and air pollution, climate impacts
- Data Points
  - GDP from 1998-2003 in AMD

Climate Projections

Beglarashvili, N. A. and E. Elizbarashvili (2006). Climate Change and Evaluation of Environment Vulnerability in Kura-Aras Basin. Reducing Trans-boundary Degradation of the Kura-Aras River Basin, UNDP/GEF.

- Topics
  - Environmental impacts on agriculture, water, and forests
- Data Points
  - Air temp. anomaly from 1910-1990
  - Change in river flows from 1938-1998

Fayvush, G. and A. Nalbandyan. (2008). A Method to Project Changes in Climatic Conditions for Different Types of Vegetation. "Enabling Activities for Preparation of Armenia's Second National Communication to the UN Framework Convention on Climate Change (UNFCCC)" UNDP/GEF Project.

- Topics
  - Climate overview of different regions
- Data Points
  - Characteristics of climate conditions for different regions in terms of temperature and precipitation for the present and 2030

Hancock, L., V. Tsirkunov and M. Smetanina (2008). Weather and Climate Services in Europe and Central Asia: A Regional Review. Washington, D.C., World Bank.

- Topics
  - Climatic changes

Hovsepyan, A. (2008). Model Simulations of Climate Change over Armenia Region: Final Report. "Enabling Activities for Preparation of Armenia's Second National Communication to the UN Framework Convention on Climate Chang" UNDP/GEF Project.

- Topics
  - Forestry and climate
- Data Points
  - Average seasonal temperature and change in °C from 1998-2007

- Average seasonal precipitation and change in mm from 1998-2007
- Seasonal and annual precipitation anomalies from 1961-1990 compared to baseline in %
- Observed distribution of precipitation in mm from 1961-1990 and 1998-2007
- Model projections for the above data points through 2100

Kura-Aras Stakeholder Advisory Group (2007). Kura-Aras River Basin Transboundary Diagnostic Analysis, UNDP/GEF.

- Topics
  - Water-related impacts, ecosystem and biodiversity impacts
- Data Points
  - Changes in flow of the Kura-Aras river from 1927-2002
  - Water use by sector in 2004

First National Communication of the Republic of Armenia under UNFCCC (1998).

- Topics
  - Overview of Energy
  - Energy
  - Adaptation
- Data Points
  - GHG Emissions from 1990-1995
  - Forecast of GHG emissions of Armenia through 2010
  - Land cover of Armenia in 1995 in ha
  - GDP from 1990-1995 in USD
  - GHG emissions by sector in % of total

Nalbandyan, A. (2008). Assessment of Forest Sector Adaptability. "Enabling Activities for Preparation of Armenia's Second National Communication to the UN Framework Convention on Climate Change" UNDP/GEF.

- Topics
  - Forest
  - Adaptation
- Data Points
  - Projected precipitation and temperature changes by % by region through 2090
  - Forest fires by marz from 2001-2006

Tonoyan, V. (2008). Armenia: Lusadzor Village Climate Change Impact Assessment. "Climate Change Impact Assessment" Project, UNDP.

- Topics
  - Agriculture
  - Climate
  - Adaptations
- Data Points
  - Economic losses due to climatic hazards in Lusadzor from 2004-2007 in AMD
  - Average Monthly Temperatures from 1960-2002 in °C
  - Average Monthly Precipitation from 1960-2002 in mm
  - Land use breakdown and income in USD

The Second National Environmental Action Programme of the Republic of Armenia. 2008. Yerevan.

- Topics
  - Land cover
  - Land tenure
  - Forest resources;
  - Water
  - Waste
- Data Points
  - Land cover/use in ha
  - Watershed area in km^2

UNDP/ SIDA. (2005). Technical Report: Preliminary Background Analysis of the Kura-Aras River Basin in Armenia. Reducing Trans-boundary Degradation of the Kura-Aras River Basin. Yerevan, Armenia.

- Topics
  - Water uses
  - Water supply
- Data Points
  - Water balance of Lake Sevan for 2004 in m3
  - Reservoirs data

UNDP/GEF project. 2008. "Adaptation to Climate Change in Mountain Forest Ecosystems of Armenia").

- Topics
  - Forest
- Data Points
  - Air temperature and precipitation anomalies in Syunik Marze
  - Predicted temperature change in °C from 2000-2100 in Syunik Marze

Water

Beglarashvili, N. A. and E. Elizbarashvili (2006). Climate Change and Evaluation of Environment Vulnerability in Kura-Aras Basin. "Reducing Trans-boundary Degradation of the Kura-Aras River Basin", UNDP/GEF.

- Topics
  - Environmental impacts on agriculture, water, and forests
- Data Points
  - Air temp. anomaly from 1910-1990
  - Change in river flows from 1938-1998

World Bank/GEF. 2008. The Update for the Existing Scheme for Small Hydro Power Stations of the Republic of Armenia. "Renewable Energy Project" WB/GEF TF 056211. Yerevan, Armenia Renewable Resources and Energy Efficiency Fund of Armenia.

- Topics
  - In depth investigation of current hydropower and future potential
- Data Points
  - Lots of water information: flows, etc.
  - Electricity generation information in U.S. dollars
  - Water energy indicators
  - Basically, anything about water in Armenia

Republic of Armenia. 2001. Final Stage II Report: Integrated Water Resources Management Planning. "Integrated Water Resource Management" Project, Armenia.

- Topics
  - Water Overview
- Data Points
  - Average River Flows
  - Average Water Balance for Armenia, Lake Sevan
  - Water Demand Projections through 2020

Republic of Armenia. 2005. The Law of the Republic of Armenia on Fundamental Principles of National Water Policies.

- Topics
  - Water use law
  - General provisions, guidelines

Republic of Armenia. 2002. Water Code of the Republic of Armenia. National Assembly of the Republic of Armenia.

- Topics
  - Definitions of water-related phrases
  - Explanation of water management entities and laws

Kura-Aras Stakeholder Advisory Group (2007). Kura-Aras River Basin Transboundary Diagnostic Analysis, UNDP/GEF.

- Topics
  - Water-related impacts, ecosystem and biodiversity impacts
- Data Points
  - Changes in flow of the Kura-Aras river from 1927-2002
  - Water use by sector in 2004

USAID. (2005). Short-term Priorities and Long-term Vision for Water Resources Monitoring in Armenia and Results of Ongoing Support to ASH and EIMC on Databases and Data Exchange Tools.USAID/ PA Consulting Group.

- Topics
  - Water overview
- Data Points
  - Water use by sector from 1988-2004 in m^3

Sheng, T. S. and A. Gevorgyan. 2005. Technical Design of the State Water Cadastre Information System, USAID/PA Consulting Group.

- Topics
  - Water modeling for adaptation

UNDP/ SIDA. 2005.Technical Report: Preliminary Background Analysis of the Kura-Aras River Basin in Armenia. Reducing Trans-boundary Degradation of the Kura-Aras River Basin. Yerevan, Armenia.

- Topics
  - Water uses
  - Water supply
- Data Points
  - Water balance of Lake Sevan for 2004 in m3
  - Reservoirs data

USAID. 2007). An Introduction to the Armenia Water Sector. Yerevan, Armenia,

- Topics
  - Water overview, uses
- Data Points
  - Socio-Economic Data
  - Water company, basin comparisons
  - Water withdrawal from 1988-2004 in m^3

USAID. 2005. Legal and Institutional Reviews of Water Management in Armenia. USAID Program for Institutional and Regulatory Strengthening of Water Management in Armenia.

- Topics
  - Background on how water is monitored

Republic of Armenia. 2003. "Capacity Building in the Republic of Armenia for Technology Needs Assessment and Technology Transfer for Addressing Climate Change Problems". Yerevan.

- Topics
  - Water
  - Energy
  - Adaptation
- Data Points
  - GHG emissions by sector for 1990
  - GHG emissions change from 1990-2000
  - Projected energy GHG emissions in tones through 2020
  - Deviation of air temp. and precipitation from 1935-1999

Zakaryan, B. (2008). Vulnerability Assessment of the Water Resources of the Republic of Armenia in the Climate Change Context. "Enabling Activities for Preparation of Armenia's Second National Communication to the UN Framework Convention on Climate Change" UNDP/GEF.

- Topics

    - Water resources overview
- Data Points
    - Change in Armenian river flows from 1961-2006 in m^3

Food and Agriculture

Khachatryan, L. 2008. The Assessment of Vulnerability of Agricultural Crops as a Result of Climate Change. "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC". UNDP/GEF Project, Yerevan.

- Topics
    - Agriculture overview
    - Temperature and precipitation data
- Data Points
    - Mean Temperature and Precipitation and changes in °C and mm
    - Precipitation from 1990-2006

Statistical Yearbook of Armenia. 2007. Yerevan, Republic of Armenia National Statistical Service.

- Topics
    - Agriculture Overview (Breakdown by sector)
- Data Points
    - Land area use in ha from 2002-2006
    - Output in AMD from 2002-2006
    - Harvest and Yield Capacity in weight from 2002-2006

Nazaryan, R. 2008. Assessment of Vulnerability/Adaptability of Pasture Lands and Grasslands of Armenia. "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC". UNDP/GEF Project, Yerevan.

- Topics
    - Agriculture crops
- Data Points
    - Structure of crops from 1950-2005
    - Gross Harvest and Yield Capacity of crops from 1998-2001

Sargsyan, K. 2008. Dynamics of the Livestock and Animal Productivity Change in the Republic of Armenia, "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC". UNDP/GEF Project, Yerevan.

- Topics
    - Analysis of the livestock population from 1991-2008
- Data Points
    - Type of Livestock raised by year
    - Production of animal products by year, weight
    - Per capita production of animal products by year
    - Distribution and productivity of pastures

Energy

Gabrielyan, A., D. Harutyunyan, A. Pasoyan, M. Vermishev. 2003. Recent Developments in the Climate Mitigation Policy and Practice in Armenia, "Renewable Energy in Armenia - Reality and Perspectives" Conference Proceedings, Yerevan.

- Topics
    - Energy changes
- Data Points
    - CO2 trends in Armenia 1990-2000

Hovhannisyan, K. 2003. "Sustainable Development and Energy Security in Armenia: a Step Towards Dilemma" Lund University International Master's Programme in Environmental Science.

- Topics
    - Energy overview, adaptations
- Data Points
    - Electricity production by fuel (GWh) from 1990-1997

Sargsyan G., A. Balabanyan and D. Hatkinson. 2006. From Crisis to Stability in the Armenian Power Sector. Lessons Learned from Armenia's Energy Reform Experience. Washington D.C., World Bank:

- Topics
  - Energy overview
- Data Points
  - Energy sources from 1990-2004
  - Energy consumption and demand from 1991-2004

UNDP/GEF. 1999. "Removing Barriers to Energy Efficiency in Municipal Heat and Hot Water Supply", Yerevan.

- Data Points
  - Climate by region
  - Population by region, distribution within region
  - Heat distribution issues in Armenia

Forestry

Gevorgyan, A. 2008. Adaptation to Climate Change in Mountain Forest Ecosystems of Armenia, "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC". UNDP/GEF Project, Yerevan

- Topics
  - Forest
- Data Points
  - Air temperature and precipitation anomalies in Syunik Marz
  - Predicted temp. change in °C from 2000-2100 in Syunik Marz

Kura Aras Stakeholder Advisory Group. 2007. Kura-Aras River Basin Transboundary Diagnostic Analysis, UNDP/GEF.

- Topics
  - Water-related impacts, ecosystem and biodiversity impacts
- Data Points
  - Changes in flow of the Kura-Aras river from 1927-2002
  - Water use by sector in 2004

Nalbandyan, A. 200). Assessment of Forest Sector Adaptability. "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC". UNDP/GEF Project, Yerevan.

- Topics
  - Forest Overview
- Data Points
  - Projected climate change scenarios through 2090
  - Temperature increase by region
  - Precipitation decrease by region

Statistical Yearbook of Armenia. 2007. Yerevan, Republic of Armenia National Statistical Service.

- Topics
  - Forest overview
  - land cover
- Data Points
  - Water abstraction from 2002-2006
  - Water discharge from 2002-2006

Natural Disasters

Kokusai Kogyo Co., L. and L. Nippon Koei Co. 2006. The Study on Landslide Disaster Management in The Republic of Armenia Final Report, Japan International Cooperation Agency; Ministry of Urban Development, The Republic of Armenia.

- Topics
  - Overview of Armenia climate, economy, terrain
- Data Points

- Indicators of economic growth 2001-2004
- Topography of the country
- Occurrence of landslides
- Damage incurred by landslides in USD

Sadoyan, T. 2008. Assessment of Vulnerability of Infrastructures of the Republic of Armenia to Climate Change, "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC". UNDP/GEF Project, Yerevan.

- Topics
  - Review of landslides, mudslides, floods, rockfall, precipitation
  - Steps for prevention/protection
- Data Points
  - Prevalence of events by year, marz
  - Damage caused by events in AMD
  - Many graphs/tables still in Armenian

Appendix H. Bibliography

Ackerman, F. and E.A. Stanton. 2008. A comment on 'Economy-wide estimates of the implications of climate change: Human health'. Ecological Economics 66 (1): p. 8-13.

Ackerman, F. and L. Heinzerling. 2004. Priceless: On Knowing the Price of Everything and the Value of Nothing. New York: The New Press.

Armenian Rescue Service. 2009. Natural disasters, their classification and brief characteristics. [Accessed 2009 March 23]; Available from: http://www.ema.am/En/ax.html.

Armenian State Hydrometeorological and Monitoring Service. 2009. personal communication, Developed under "Enabling Activities for the Preparation of Armenia's Second National Communication to the UNFCCC" UNDP/GEF/00035196 project. Armenian State Hydrometeorological and Monitoring Service.

ArmStateHydromet. 2008. Personal communication, developed under "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC." UNDP/GEF/00035196. Armstatehydromet SNCO.

Avagyan, A. and G. Manucharyan. 2008. Information collected for 2007 by Crop Production, Forestry, and Plant Protection Department, developed under "Enabling Activities for Preparation of Armenia's Second National Communication to the UNFCCC." UNDP/GEF/00035196. Ministry of Agriculture - Republic of Armenia.

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