

Building Wildfire Management Capacities to Enhance Adaptation of the Vulnerable Mountain Forests of Armenia - Lessons from Recent Experience



“Adaptation to Climate Change Impacts in Mountain Forest Ecosystems of Armenia”

UNDP/GEF/00051202 Project

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to Enhance Adaptation of the Vulnerable
Mountain Forests of Armenia
- Lessons from Recent Experience**

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Authors: Essi Ulander, M.Sc., Expert on Adaptive Forest Management
Aram Ter-Zakaryan, M.A., Project Task Leader

Editors: Keti Chachibaia, M.Sc., Regional Technical Advisor for Adaptation
UNDP Regional Centre for Europe and CIS
Diana Harutyunyan, Ph.D., Climate Change Programme Coordinator
UNDP Armenia

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Foreword

Armenia is a landlocked, disaster-prone country, with mountainous ecosystems particularly vulnerable to climate change. Since 1995, UNDP has assisted Armenia in building scientifically based measures and institutional capacities to address the challenges related to climate change.

With an economy in transition, Armenia is facing diverse challenges in developing a democratic society and a sustainable economy. The risks and threats posed by climate change, however, may significantly harm the sustainable development of the country and hamper continuation of the economic development achieved in the past decade. Climate aridification, for example, has already been observed with recorded losses in the climate-sensitive sectors of the economy, such as agriculture, hydropower production and forestry.

The rural communities of Armenia, constituting 36 percent of the entire population, are highly dependent on the natural resources and critical ecosystem services provided by the mountainous forests and their rich biodiversity.

These unique forests support rural communities by providing them with income and food security, maintaining suitable climate conditions for agriculture and protecting soils from erosion and degradation, as well as by buffering the local population from the effects of climatic extremes.

Since 2009 the UNDP-GEF “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project has assisted Armenia in addressing the threats posed by climate change on valuable forest ecosystems.

The wildfire management component of the project has contributed significantly to the capacity enhancement of local forest authorities and rescue service in the Syunik region by applying a multi-pronged approach to transfer knowledge and technologies for wildfire early warning and response, revise the legal framework, clarify institutional roles and responsibilities and increase public awareness in local communities. As a result 90,000 ha of forest land have been better protected from wildfire risk.

On behalf of UNDP, I would like to extend my sincere thanks to the Ministry of Nature Protection, the Ministry of Agriculture and the Ministry of Emergency Situations of the Republic of Armenia, as well as to the local authorities of Syunik region for their partnership in improving wildfire management in Armenia.



Patrice Coeur-Bizot

UNDP Resident Representative a.i.

Foreword

Armenia's mountain forest ecosystems are distinguished for rich biodiversity and the environmental services they provide are important for sustainable development of the country. The number of forest fire incidents has increased over the recent decade threatening forest ecosystems and biodiversity. The overwhelming majority of wildfire incidents are caused by the burning of dry vegetation and agricultural waste in the fields, as well as by human negligence. Burning of organic residues in the fields causes also emissions of harmful substances into the atmosphere, thus contributing to air pollution and undesirable climate change.

In 2011 the National Assembly of the Republic of Armenia passed an amendment to the Law on Atmospheric Air Protection according to which it is prohibited "to burn stubble, plant residues and dry vegetation areas, vegetation of pastures and meadows in the agricultural, forest neighbouring, forest and specially protected area lands".

Effective solution of the forest fire issue requires close collaboration of governmental bodies at national, regional and local levels, as well as implementation of well coordinated measures.

The assistance of international organisations is critical for ensuring the adoption of best available international experience in Armenia. Notably, the provision of forest fire early response equipment to Arevik National Park and Syunik and Kapan Forest Enterprises, as well as the large scale public awareness campaign implemented in the scope of the "Adaptation to Climate Change Impacts in Mountain Forest Ecosystems of Armenia" project supported by UNDP and funded by GEF, resulted in better preparedness to forest fires and improvement of forest protection in the Syunik region of Armenia.

Replication of this experience in other regions of Armenia is vital for ensuring effective administration and protection of forest ecosystems under changing climate conditions.

The Ministry of Nature Protection of Armenia highly appreciates the collaboration with UNDP and GEF towards enhancing the resilience and adaptation of forest ecosystems.



Simon Papyan

First Deputy Minister of Nature Protection of the Republic of Armenia,
Project National Director

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Summary

Against the backdrop of increasing risk of climate change induced impacts in the unique mountain forest ecosystems of Armenia and especially the intensifying forest fire problem under the aridifying climate conditions, the UNDP supported project “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” has since its beginning in 2009 carried out a range of activities to build the capacities of relevant stakeholders from the national to the local level to address the forest fire risk and to enhance the resilience of the forests under climate change. Importantly, by building the capacities of the forests to resist and respond to the changing climate conditions, the project has aimed also to protect the provision of ecosystem services critical for the adaptation of rural population to climate change. Funded by the Global Environment Facility’s Strategic Priority for Adaptation pilot programme, the project has significance in piloting and demonstrating globally relevant practical adaptation measures to increase the adaptive capacity and reduce the vulnerability to adverse impacts of climate change.

Armenia is characterised, in contrast to its small territory spanning only some 29 700 square kilometres, by rich biodiversity resulting from the intricate landscape and the microclimatic diversity in the mountainous country. Forests, which cover only about 11 percent of the country’s territory, harbour a large share of the unique biodiversity as well as of the numerous endemic and rare species found in Armenia. As a part of the Caucasus-Anatolian-Hyrcanian Temperate Forests Ecoregion, which is listed by WWF as a Global 200 Ecoregion, the forests of Armenia have been identified as a global conservation priority. Additionally, significant shares of Armenia’s territory belong to the Caucasus and the Irano-Anatolian biodiversity hotspots identified by Conservation International.

Armenia’s forests, which are located on the steep and fragmented mountain slopes of the country, provide critical ecosystem services in the mountainous areas, such as stabilisation of soils and regulation of erosion as well as protection from gravitational hazards, such as landslides, mudflow and rock fall. The provision of these and other ecosystem services, such as biodiversity support, regulation of climatic conditions and provision of food, wood, traditional herbs and medicinal plants, has been threatened by the large-scale deforestation and forest degradation which took place during an energy crisis in the 1990’s. Despite success achieved in recent years in curbing illegal logging, unsustainable practices are still observed and recovery of the forests is slow as reforestation activities are limited and natural regeneration is hampered by overgrazing and unfavourable climate conditions. Increasingly the forests are put under pressure by human-induced wildfires, which are becoming more intense under climate change and aridification of the climate in Armenia. The continued forest degradation is leading to losses of biodiversity and the reduced forest integrity is hindering the resilience of forest ecosystems to resist and recover from further pressures, such as adverse impacts induced by climate change.

Changing climate conditions will induce various impacts on forest ecosystems. Many climatic factors such as changes in temperature and precipitation or more frequent heat waves and droughts, as well as the rising atmospheric CO₂ concentration itself, will affect tree eco-physiology under climate change. As a mountainous country with arid climate conditions, Armenia is vulnerable to climate change. Under the observed and expected changes in Armenia’s climate, the most important impact factor in the Armenian forest ecosystems is expected to be further climate aridification: temperatures are expected to increase in Armenia by over 5 degrees in the spring and summer months by the end of the century, which is combined with pronounced reductions in precipitation also expected in the summer months. This can lead to significant water stress in Armenia’s forests reducing growth rates and success in regeneration and tree establishment as well as decreasing forest vitality making trees more susceptible to pests and pathogens. In addition to these direct impacts of the drying climate on the forests, climate aridification importantly creates conditions for more frequent and more intense wildfires. Under changing climate conditions, the rapidly changing fire regimes can become a major factor affecting natural ecosystems and leading to loss of species and biodiversity especially in the short term.

In Armenia, like many other regions of the world, severe forest fires and numerous grassland fires have caused extensive damage in the recent years. Climate extremes have played an important part in the increased wildfire occurrence - an increase in the number of wildfires has been observed in Armenia over the past decade following prevailing drought conditions and continued hot temperatures. In the recent two extreme fire years, 2010 and 2011, the number of forest fires grew rapidly from an average of under ten fires in the previous years to over 50 forest fire cases in both 2010 and 2011 burning together over 1 300 hectares of forest lands. The damage caused by forest fires is significantly worsened by insufficient post-disturbance recovery in the burnt forests under the unfavourable climate conditions. Furthermore, in both 2010 and 2011 the number of grassland fires grew five-fold compared to the average of the previous six years, reaching over 2 700 grassland fire cases in both 2010 and 2011.

The forests in Armenia's southernmost region, the Syunik Province, have observed some of the most damaging forest fires in the country over the past decade. The Syunik Province – and its mountain forests – has been identified as one of the most vulnerable regions of the country to climate change and climate variability. In the region the damage caused by single forest fire incidents in terms of area burnt has been three times higher compared to the rest of the country. In the recent record, the most devastating year in Syunik was 2006 when four fire incidents burned over 320 hectares of forest lands in the region. Also extended outbreaks of leaf-eating pest species have been observed in Syunik. The consequent drying of trees and increase in dead wood matter in the forests following the pest outbreaks have also contributed to forest fires in the region. The most notable case took place in the Arevik National Park in the Meghri region, where approximately 80 hectares of forests which had suffered from pest outbreaks in the previous years, were burnt in 2001. The loss of forests in the province, which contains some of the most arid regions of Armenia, has devastating environmental consequences.

Despite the leading role played by climate and weather in creating the setting for increased fire risk and extensive wildfires, the most important causes for the ignition of wildfires in Armenia, however, are of anthropogenic origin. More specifically, wildfires are ignited as a result of burning of agricultural waste, stubble fields and fallow and pasture lands as well as negligent use of fires for recreational purposes. Over the past five years, 60 percent of forest fires in Armenia were identified to have been ignited by humans, with an overwhelming majority of these cases having been caused by the burning on agricultural lands. In the remaining 40 percent of forest fires the cause was not identified. Uncontrolled fires escaping from the fields are not one of the main causes of wildfires only in Armenia, but also globally: according to the Global Forest Resources Assessment 2005, majority of forest fires globally stem from uncontrolled agricultural burning for land management in forest adjacent areas and areas outside of the forest itself. The threat of human ignited fires on agricultural lands escaping to forests and causing extensive damage is significantly increased under the conditions of greater aridity under climate change.

Wildfire management in Armenia is described by many short-comings at the systemic, institutional and individual levels. The adverse impacts of the failure to implement effective wildfire management will become intensified as the fire problem is becoming more severe under the drying climate. Currently climate change risks are not incorporated into policies and strategies concerning natural resource management in Armenia. Systemic fire prevention and control of the anthropogenic causes of fires are insufficient in the country. Wildfire management is hindered by the lack of a clear command chain and explicitly defined roles and responsibilities between the different involved authorities. Furthermore, institutional and individual capacities of the responsible authorities are constrained by limited technical knowledge, which has prevented the implementation of suitable fire extinguishing techniques and best practices in the mountainous terrain. Financial constraints are also a major limiting factor preventing forest management units from implementing adequate fire prevention and pre-suppression as well as limiting the amount of personnel to be mobilised for fire suppression.

The analysis of the key shortcomings of wildfire management in Armenia has been used as the basis for identifying critical approaches to improve the national capacities to prepare for the increasing wildfire risk under climate change. Specific measures have been identified based on international best practice especially from the Mediterranean and Balkan regions. Several

approaches have been adapted to the local context and have been demonstrated in the vulnerable Syunik Province.

The project's approach to address the increasing wildfire issue and to improve the national capacities to respond to the problem has been to build effective and efficient response to wildfires as well as to ensure appropriate proactive and institutionalised wildfire prevention in the country. Additionally, the project has been working to improve forest management so as to ensure resilience of forests both to the direct impacts of the changing climate as well as to threats related to the aridification of Armenia's climate, such as forest fires. In order to achieve the targets set for the improvement of wildfire management in Armenia, the project has taken actions to:

- Build the response capacities of forest managers by equipping forest fire early response teams,
- Strengthen and clarify the co-operation of all relevant institutions involved in wildfire management by establishing platforms for the development of improved coordination and a National Action Plan on wildfire management,
- Address the root causes of forest fires through revision of relevant legislation to improve the control of the burning of dry vegetation on agricultural lands as well as through raising public awareness of the importance of wildfire prevention and protection of forests and biodiversity by conducting targeted campaigns as well as by including the issues into national curricula, and
- Incorporate climate change risks into forest management through capacity building, improved monitoring and management planning as well as on the ground demonstration of adaptation options in forest rehabilitation to ensure sustainable utilisation of forests and to build forest resilience to added pressures under climate change.

Some of the key lessons learned across the project's wildfire management component and its various activities, which in the Armenian context were found to be especially successful in increasing preparedness in the forest and protected area sectors to incorporate climate change risks into forest management, are as follows.

Forest fires are becoming a significant threat to forest biodiversity, forest ecosystem functioning and forest resilience under Armenia's aridifying climate - controlling wildfires is of great urgency to reduce the vulnerability of forests to climate change

The project has established four forest rehabilitation pilot projects in the Syunik Province. The pilot projects represent the types of forest regeneration areas expected to increase under climate change: the target forest areas have been disturbed by forest fires, severe and continued pest outbreaks, forest fragmentation and a combination of these factors, and have been further affected by extreme climatic conditions including extended hot periods and droughts as well as by overgrazing and soil erosion. The on the ground forest rehabilitation pilot projects have highlighted the increasing difficulty and the more intensive tending required to achieve successful forest regeneration under climate variability in disturbed forest areas located in arid parts of the country. Rehabilitation of disturbed forests under a drying climate will demand increasing inputs and resources, which may not be available to forest management units. Thus, stand replacing fires are and will become an increasingly significant threat to forest biodiversity, forest connectivity as well as forest ecosystem functioning and provision of ecosystem services under Armenia's aridifying climate. Protection of forests from disturbances by taking efficient proactive measures is critical for maintaining forest functioning and forest resilience under climate change.

Transfer of suitable technologies and the establishment of forest fire early response teams have yielded significant short-term improvements in managing the wildfire problem

Suitable equipment and technical competencies of forest managers to apply advanced techniques to suppress fires in the mountainous terrain have been lacking in the country. The establishment of forest fire early response teams by providing equipment and tools suitable for the suppression of surface fires in the mountain forests to three forest management units in the Syunik Province governing a forest land area of approximately 89 000 hectares has had immediate positive

impacts on the wildfire management capacities in the region. Since the establishment of the early response teams in 2011, the equipment has been used successfully in several instances to prevent the spread of grassland fires to neighbouring forest areas. The tangible and straightforward activity with immediately visible results has enjoyed wide support among the project's partners and stakeholders, and the proven value of this activity transferring suitable technologies to Armenia has spurred replication at the national level by national authorities.

Formalisation of the results is key to long-term improvements in wildfire management

Building on the process initiated under the project to improve co-operation and coordination of all relevant stakeholders involved in wildfire management, a National Task Force on Wildfire Management was established by the decree of the Minister of Emergency Situations. The main task of the Task Force is to develop a short- and medium-term Action Plan for the improvement of prevention, pre-suppression and suppression of wildfires in Armenia. The Task Force is instrumental for ensuring longer-term development of wildfire management in Armenia, securing adequate resources for carrying out required processes and up-scaling of project activities to the national level. Inclusion of climate change considerations into the guiding document of forest management plan development has the same importance for mainstreaming climate change risk into forest management at the national level. The guidelines for incorporating climate change risks into forest management planning process are developed under the project.

The need for improved capacity to respond to disasters such as forest fires under changing climate conditions as well as the need to adapt to climate change is recognised by the project stakeholders – the resulting ownership is very important for successful project implementation

The rapid response of the wildfire danger level to the aridifying climate conditions makes climate change induced impacts in forests felt immediately compared to some other impacts with slower onset. Forest managers give reports of already drying conditions in the forests causing more forest fires and fire fighters have had to deal with significantly worsening grassland fire situation over the recent years. In this setting, the stakeholders have not identified just the need for improved capacities to respond to the increasing disturbances under climate change, but also the need for enhanced co-operation between different authorities. This national ownership has greatly paved way for the activities carried out under the project and has supported their successful implementation by creating an opportune environment for the adoption of new approaches and practices.

Partnerships are essential

The strong national ownership of forest managers and fire fighters of improving wildfire management has been pivotal for the formation of good co-operation between key stakeholders and the project. The establishment of these partnerships, on the other hand, has been elemental for the effective and efficient implementation of project activities. The project has successfully formed good relations with the main local stakeholders, but has also succeeded in creating synergistic relationships with other international organisations and initiatives sharing parallel targets in improving wildfire and forest management in Armenia. Partnering with other organisations has resulted in enhanced outcomes and effectiveness of the project.

Wide stakeholder consultation contributes to a good working environment, broad project support and identification of a comprehensive approach to address the wildfire issue

The involvement of a wide range of stakeholders and a variety of sectors, including representatives from the public and the private sector as well as the third sector and the civil society, in the wildfire management component of the project has contributed to enhanced communication between different parties, establishment of co-operation between national stakeholders and identification of measures to comprehensively address issues contributing to the wildfire problem. Importantly, this has strengthened the support for the project activities and has successfully brought the urgent issues of wildfire management to the national agenda. Key stakeholders, such as the regional forest enterprises and the protected area management authorities, have been involved in the project from the planning stages on, which has contributed significantly to individual and institutional capacity building and to the creation of support for the revision of current practices.

Additionally, this has enabled the utilisation of local traditional knowledge to the fullest extent to identify adaptation options in forest management including for instance local tree varieties resilient to drought.

Increasing public awareness on the causes of wildfires as well as the impacts of fires in natural ecosystems is highly important for improving wildfire prevention and more generally for increasing understanding of the importance of the protection of forests

Overwhelming majority of wildfires is caused by humans in Armenia. Raising public awareness on the issues related to forest and grassland fires, their impacts on natural ecosystems and especially on the causes of wildfires is critical for the prevention of wildfires and protection of vulnerable forests under climate change. Public awareness campaigns, including for example trainings and events for community members, mass media campaigns as well as installation of fire warning signs in recreational areas and distribution of posters on wildfire issues to schools and communities, have been carried out under the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project. However, wider and more continuous public awareness campaigns and establishment of an appropriate warning system about fire danger are required to guide behaviour in regards to the use of fires. More generally, public awareness raising is critical for the promotion of attitudes and action to protect the environment and increase understanding of the importance of healthy natural ecosystems for the provision of ecosystem services supporting livelihoods of rural dwellers and the wider society as well as the adaptation of rural population to climate change.





Introduction

This publication was developed to capture the lessons learned under the UNDP supported “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project and especially its wildfire management component. The project, which is funded by Global Environment Facility under the Strategic Priority for Adaptation funding window, began its activities in 2009 and is coming to its completion in mid-2013.

Against the backdrop of increasing risk of climate change induced impacts in the unique mountain forest ecosystems of Armenia and especially the intensifying forest fire problem under the aridifying climate conditions, this publication presents the approaches chosen by the project to build the capacities of relevant stakeholders to address the forest fire risk from the national to the local level. The activities have included for example the establishment of wildfire early response teams, revision of the legal and regulatory framework related to wildfire management, contribution towards the development of a National Wildfire Action Plan as well as work with rural, forest adjacent communities. Additionally, the project has worked to improve forest management planning and practice to enhance, among others, forest resilience and resistance to increasing disturbances under changing climate conditions. By exploring the success factors of the wildfire component and sharing the challenges and barriers the project has encountered in the implementation of the wildfire management activities, the publication aims to advocate improved wildfire prevention and control to enhance the resilience of forest ecosystems under climate change. Importantly, this aims to ensure the provision of ecosystem services by healthy forests to enable ecosystem-based adaptation to climate change in rural communities.

As one of the 26 projects funded by GEF’s Strategic Priority for Adaptation pilot programme, the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project has global relevance in piloting and demonstrating practical adaptation measures to increase the adaptive capacity and reduce the vulnerability to adverse impacts of climate change.

By providing illustrative examples in improved wildfire management, this publication aims to enable replication of the presented activities, which in the Armenian context were found to be especially successful in increasing preparedness in the forest and protected area sectors to include climate change risks into forest management planning and practise.

1. Background

1.1. Unique mountain forests of Armenia

The Republic of Armenia (population 3.2 million) is located in the northeast of the Armenian Highlands, at the border of Caucasus and Western Asia. Armenia shares borders with Georgia in the north, Azerbaijan in the east, Turkey in the west and southwest, and Iran in the south. Armenia is a mountainous country: over 76 percent of the country's territory, which expands only 29 743 square kilometres, is located at altitudes between 1 000 and 2 500 metres above sea level. The highest point of Armenia is the peak of Mount Aragats reaching to 4 090 metres. The lowest point is at 375 metres above sea level near the Iran border at Araks River. The complex mountainous terrain creates highly variable climatic conditions and a mosaic of different vegetation types. The climate varies from arid sub-tropical to cold high mountainous climate and vegetation types represented in the country range from deserts to arid open forests, mountain steppes, forests and alpine meadows.

In contrast to its small territory, Armenia is characterised by rich biodiversity resulting from the intricate landscape and the microclimatic diversity. A significant part of the species present in the country consists of endemic and rare species. The forests of Armenia harbour a large share of this biodiversity. As a part of the Caucasus-Anatolian-Hyrcanian Temperate Forests Ecoregion, which is listed by WWF as a Global 200 Ecoregion, the forests of Armenia have been identified as a global conservation priority¹. The Ecoregion represents some of the most diverse and distinctive temperate forest in Eurasia, where the moderate climate, rugged topography, varied geology and geographic proximity to both Europe and the Near East contribute to the uniqueness and diversity of both plant and animal species¹. Additionally, significant shares of Armenia's territory belong to the Caucasus and the Irano-Anatolian biodiversity hotspots identified by Conservation International². The forests are formed by over 270 tree and shrub species, with the main tree species in Armenia's forests being beech, oak, hornbeam and pine.

In contrast to its small territory, Armenia is characterised by rich biodiversity resulting from the intricate mountainous landscape and the microclimatic diversity. A significant part of the species present in the country consists of endemic and rare species. The forests of Armenia harbour a large share of this biodiversity. Additionally, in the mountainous area, the forests provide many critical ecosystem services, such as soil stabilisation. Deforestation can lead to, among others, increased risk of landslides and erosion.

Forests cover only about 334 000 hectares, or some 11 percent, of Armenia's territory. The forests are located on the steep and fragmented mountain slopes, mainly between 550 and 2 400 metres above sea level. Access to forests located on the steepest slopes is limited. The scarce forests are not evenly distributed in the country. Most of Armenia's forests (62 percent) are in the north-eastern parts of the country. Only some 16 percent of the forest covered areas are found in the central and southern parts of the country and the south-eastern region of the country has approximately 22 percent of Armenia's forests. Approximately 85 percent of Armenia's forests are natural forests, 15 percent artificial forests³.



Box 1. Forests and ecosystem services

Forests provide many critical ecosystem services, which can be categorised as supporting, provisioning, regulating and cultural services. Some ecosystem services provided by forests include:

Supporting	Provisioning	Regulating	Cultural
<i>Nutrient cycling</i>	<i>Food</i>	<i>Carbon sequestration</i>	<i>Aesthetic and spiritual values</i>
<i>Soil formation and quality</i>	<i>Water</i>	<i>Surface water flow</i>	<i>Recreation</i>
<i>Primary production</i>	<i>Wood and fibre</i>	<i>Climate regulation</i>	<i>Educational</i>
<i>Habitats and biodiversity</i>	<i>Biomass fuel</i>	<i>Flood regulation</i>	
	<i>Pharmaceuticals</i>	<i>Erosion regulation</i>	
	<i>Biochemicals</i>	<i>Water purification</i>	
	<i>Genetic resources</i>	<i>Air quality</i>	

Forests provide many critical ecosystem services in the mountainous areas. The mountainous forests play an important role in stabilising soils on the steep slopes. Deforestation can lead to increased risk of landslides and erosion as well as sedimentation of waterways. Forests are also important for water regulation and regulation of local and regional climate. Furthermore, they sequester and store carbon. The importance of preserving Armenia's forest resources is acknowledged in the country's forest policy and strategy, forest program and forest code. According to the Forest Code of the Republic of Armenia adopted in 2005, Armenia's forests are divided into production forests, protective forests (e.g. forests in water protection zones, forests on steep slopes, forests growing in semi-deserts and steppe areas) and forests of special significance (e.g. specially protected areas of nature, municipal forests)⁴. The two latter classes comprise approximately 77 percent of Armenian forest lands³. For example harvesting is limited in the protective and special forests. The main principle of Armenia's National Forest Program approved also in 2005 is to guard forest ecosystems, ensure restoration of degraded forest ecosystems and ensure sustainable use of forest resources³.

The forests in Armenia are managed by the state. About 80 percent of Armenia's forests are managed by "Hayantar" State Non-Commercial Organisation of the Ministry of Agriculture - the republican forest management authority - and its regional branches. The remaining 20 percent fall under specially protected areas managed by respective authorities under the Ministry of Nature Protection. Communities and private persons are able to acquire ownership of newly established forests on community or

private lands. Local people use forest areas, however, in many traditional ways. Traditional forest uses include e.g. collection of herbs, medicinal plants, nuts, berries, fruits and mushrooms, hunting as well as animal grazing and collection of firewood. Villages with no connection to the gas grid typically rely on wood for fuel. Additionally, the increasing gas prices and prevailing poverty make gas or other alternative fuel types inaccessible to many in the rural areas. Approximately 25 percent of households in Armenia use wood as their source of heating. Fuel wood collection and animal grazing are in some cases uncontrolled.



Anthropogenic pressures have led to significant changes in the forest ecosystems of Armenia, which is reflected in the current low forest cover and especially in the lowered forest integrity in the country. Large-scale deforestation and forest degradation were observed during the energy crisis in the 1990's. Insufficient forest management and lack of forest monitoring and forest inventory in the past 20 years have contributed to further forest degradation. Current levels of reforestation are low. Illegal logging still takes place, despite the enhanced state control and



preventing natural regeneration in degraded forest areas. The continued forest degradation is leading to losses of biodiversity and the reduced forest integrity is hampering the resilience of forest ecosystems to recover from and resist further pressures, such as adverse impacts induced by climate change.

Anthropogenic pressures have led to significant changes in the forest ecosystems of Armenia, which is reflected in the current low forest cover and lowered forest integrity in the country. Large-scale deforestation and forest degradation were observed during the energy crisis in the 1990's. Currently forests cover only about 334 000 hectares, or some 11 percent, of Armenia's territory. Continued forest degradation is leading to losses of biodiversity and the reduced forest integrity is hampering the resilience of forest ecosystems to recover from and resist further pressures, such as adverse impacts induced by climate change.

success in curtailing illegal logging levels during the recent years. Unmanaged selective felling of valuable tree species is leading to degradation of the

remaining forest stock and undesirable changes in tree species composition with impacts also on other forest flora and fauna species. Overgrazing in forest areas is



Box 2. Diverse forests in the south-eastern Syunik Province

Armenia's south-eastern part, the Syunik Province, has a notably high level of biodiversity. The ecosystems of the region form a part of the eco-corridor of the Eastern Lesser Caucasus, which is identified as a conservation priority by the Ecoregional Conservation Plan for the Caucasus. The diverse range of habitats in the region support 35 endemic flora species and more than 150 rare or endangered species listed in the Red Book of Armenia. The extremely rare Leopard (*Panthera pardus*), the Bezoar Goat (*Capra aegagrus*) and the Armenian Moufflon (*Ovis orientalis*) are just a few examples of the unique species found in the mountain areas of the Syunik region. Recognising the need to protect the unique biodiversity of this southern province, the Government of the Republic of Armenia has established six specially protected areas in Syunik – including state reserve Shikahogh and national park Arevik, which cover some 25 660 hectares of the region's forested areas – and is in the process of establishing two more protected areas in the region.

The Syunik Province, which is geographically the biggest of Armenia's 11 administrative regions, can be described by large altitudinal variation. Nearly the same altitudinal range describing the entire territory of Armenia is present also in Syunik, where one can lower from the peak of the Mount Kaputdzhukh of the Zangezur mountain chain at 3 906 metres above sea level to the dry sub-tropics of Meghri located by the Iranian border at the altitude of 375 metres above sea level.

The regions diverse forests can be found on the mountains of this picturesque landscape defined by mountain tops, canyons, gorges, caves and rivers. The forests range from juniper open forests to diverse mountain oak-hornbeam forests and are located at altitudes between 500 and 2 500 metres above sea level. Virtually all forests are located on slopes of over 20 degrees, most with northern or southern aspect. Compared to the forests in Armenia's more humid north, the southern forests can be described by lower productivity and lower growing stock volumes.

Local communities in the region rely on the forests for essential ecosystem services, including firewood for heating and non-wood forest products that provide both food and income security. The region's forests are put under anthropogenic pressures by for example overgrazing and other unsustainable practices, road construction and the extensive mining industry in the region. Increasingly the forests are put under pressure by human-induced fires, which are becoming more intense under aridifying climate conditions.



1.2. Armenia's forests and climate change

Box 3. Observed and expected changes in Armenia's climate

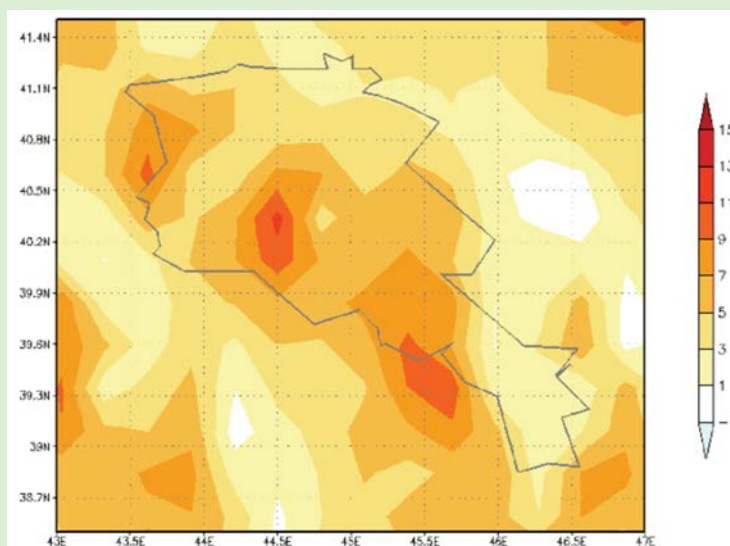
The mountainous relief of Armenia creates a climate that is as highly variable as the country's patchy topography. The average annual temperature in Armenia is 5.5°C, but locally the annual average temperatures range from 14°C in the southern parts of the country to below zero in high mountainous areas. In general, Armenia's climate is characterised by aridity. In over 60 percent of the country's territory annual precipitation is less than 600 mm, and in 20 percent of the territory it is less than 400 mm⁵. In the most arid areas of Armenia, such as the Ararat valley and the Meghri region in the Syunik Province, annual precipitation is only 200-250 mm⁵. The arid climate is a contributor to the on-going erosion processes, and over 80 percent of Armenia's territory is evaluated to be prone to desertification⁶. The country is also prone to climatological natural hazards, such as landslides, flooding and mudflows.

As a mountainous country with arid climatic conditions, Armenia is vulnerable to global climate change. Moreover, climate change is expected to lead to further climate aridification in Armenia. Past observations show that the annual average temperature has increased by 0.85°C since 1929 and the annual precipitation has reduced by 6 percent since 1935 compared to the averages of the baseline period 1961-1990⁷. Between 1994 and 2010 the annual average temperatures were entirely above the baseline temperature. In the recent decades also an increase in the severity and frequency of extreme phenomena – frosts, hails, heavy rainfall and strong winds – has been recorded in Armenia⁷. Since 1990, also more frequent and widespread droughts have been observed in the entire country⁷.

A range of scenarios of future conditions predict a continued increase in the temperature by the end of this century especially in the warm months with less significant changes in the winter months (Fig. 1)⁷. Also precipitation is expected to continue to decrease with a more pronounced trend in the summer months compared to the winter months. It should be noted that the predictions concerning precipitation contain more uncertainty compared to the predictions of temperature. The temperature increase occurring simultaneously with the expected precipitation decrease in the summer season will strengthen climate aridification.

The drying climate has significant impacts on climate-sensitive and climate-dependent sectors and natural ecosystems in Armenia. For example agricultural areas requiring irrigation will likely expand and agricultural crop yields may decline, increasing evaporation can lead to salinization of soils and droughts and hot dry winds will aggravate erosion and desertification processes. Also Armenia's forest ecosystems will face severe risks under the aridifying climate.

Figure 1. Future climatic conditions in Armenia have been simulated using the PRECIS regional model⁷. According to the modelling exercise, a continuous increase in temperature will be observed in Armenia reaching maximum values in the spring and summer months at 5-7°C⁷. The figure represents the annual air temperature changes in 2071-2100 compared to the averages of 1961-1990, according to the PRECIS model under A2 greenhouse gas emission scenario of IPCC⁸.



How changing climate conditions affect forest ecosystems and how vulnerable forests are to climate change depends on, among others:

- The temporal and spatial exposure of forests to different impact factors that are influenced by climate change,
- The sensitivity of the forests to the abiotic and biotic impact variables, which in turn is defined by various site conditions and genetic differences between species and populations, as well as
- The capacity of the forests to adapt to new conditions – or on the capacity of forest managers to plan and implement measures to support forest adaptation under climate change.

Forests are particularly sensitive to changing climate conditions, as the long life-span of trees prevents rapid adaptation in forest ecosystems. A tree might face significantly different climate conditions during its life compared to the time of its establishment, which poses challenges to tree productivity and vitality.

Many climatic factors such as changes in temperature and precipitation or more frequent heat waves and droughts, as well as the rising atmospheric CO₂ concentration itself, will affect tree eco-physiology and tree growth under climate change. Wind storms, wildfires and heavy rains are other abiotic factors, which can become more frequent and intense under changing climate conditions with consequent significant effects on forests. Additionally, biotic factors, such as forest pests, will also be affected by the new conditions. Pest species may benefit from both the new climate as well as the weakened condition of trees under climatic stresses leading to more frequent pest outbreaks and potential spread of pest species to new areas. The complex interplay of the direct and indirect stress factors can make the impacts of climate change on forests both more severe as well as more difficult to predict.

Direct impacts of climate aridification

The most important impact factor under changing climate conditions in the Armenian forest ecosystems is climate aridification – the expected summer time increase in

temperature combined with the simultaneous decrease in precipitation and increasing occurrence of droughts with effects on tree growth, vitality and establishment. Furthermore, climate aridification increases the risk of wildfires as well as benefits many biotic factors, such as leaf eating insect pest species.

The most important impact factor under changing climate conditions in the Armenian forests is expected to be climate aridification – the expected summer time increase in temperature combined with the simultaneous decrease in precipitation affecting tree growth, vitality and establishment. For example seeds and seedlings are highly vulnerable to soil desiccation. Importantly, the drying climate increases the risk of wildfires. Also many biotic factors, such as leaf eating insect pest species, may benefit from the new conditions, while the drying conditions can lead to considerable weakening of trees making them more susceptible to biotic risks. Extreme events, such as droughts and heat waves, will have more drastic consequences on forests compared to the more gradual changes in temperature and

An elevated temperature itself can result in increased tree growth. However, it will also lead to increasing evapotranspiration, which combined with the decreasing precipitation can result in water stress. Temperatures rising too high above optimal conditions can also lead to heat stress or heat injury and inhibited photosynthesis. Under changing climate conditions in Armenia, water is expected to become a major limiting factor of tree growth and seed germination as well as establishment of seedlings. The forest responses to water limitations depend on species composition, life stage of trees and stand structure. For example seeds and seedlings are highly vulnerable to soil desiccation and very dense stands will have increased competition for the scarce resource.

The expected increase of extreme events, such as droughts and heat waves, will have

more drastic consequences on trees and forests compared to the more gradual changes in temperature and precipitation. Additionally, the water and heat stress induced changes in forest ecosystems are not limited to the tree composition, but affect also understory vegetation and soil biota. Furthermore, the changes in forest structure and composition as well as species assemblages can have wider impacts also on fauna species.

Other changes in seasonal conditions and climate variability will also affect Armenia's forests. The increasing frequency of frost events can affect seedling survival. On the other hand, an increase in the temperature in the autumn months combined with the expected slight increase in precipitation can lead to improved growth conditions in this season.

As a result of changing climate conditions, suitable ranges of forest tree species will likely shift – in the mountainous landscape, the shift will be upwards on the mountain slopes. At the upper border of the forest belt in Armenia, the increasing temperature combined with sufficient precipitation present at the higher altitudes will make it possible for trees to gradually establish at altitudes currently above the tree line, soil conditions and dispersal ability permitting.

At the lower forest border, conditions will become unfavourable for the establishment and survival of some forest tree species leading to an upwards movement of their suitable ranges. Indeed, past observations already indicate an upwards shift of the lower forest border in Armenia^{7,9}. The changing conditions will have varying effects on different species with varying threshold levels and capabilities to migrate along with the shifting suitable conditions. Thus changes in forest composition are more likely than uniform shifts of the forest belt. Additionally, penetration of deserts, semi-deserts and arid open forests into the lower forest areas can be expected in Armenia. Ultimately, the changes in suitable conditions can lead to significant decline of forest areas at the bottom forest border. Furthermore, the upwards movement of the forest belt might be limited at the upper forest border by grazing activities preventing sufficient regeneration.

Increasing disturbances – secondary threats related to climate change

Climate change is expected to have significant effects on the population dynamics of forest pest species. The response of insect pest species to changing climate conditions is enhanced by their short life cycles, reproductive potential and sensitivity to temperature. Temperature increase combined with precipitation decrease will likely benefit many defoliating insect pest species by increasing their development rate and survival. The same conditions can lead to considerable weakening of trees making them more susceptible to biotic risks. Armenian forests are expected to suffer significant growth losses caused by insect attacks under climate change. Severe and repeated pest infestations can lead to increased tree mortality, which also contributes to the accumulation of drying dead organic matter in forests increasing the risk of wildfires.

The aridifying climate will increase the risk of wildfires by drying vegetation and making the dead organic matter in forests more flammable. In addition to the aforementioned pest outbreaks, fuel availability might also be increased as a result of for example wind storms. The observed wildfire trends in relation to extreme climatic events, such as heat waves and droughts, are discussed in more detail in the following chapter. Recovery of burnt forests might become a significant issue under changing climate conditions.

As described above, seedling survival is hampered by the drying conditions. Drying can be further intensified in a burnt forest stand, where radiation and wind will increase on the forest floor as a result of canopy removal by the fire. Correspondingly, sufficient post-disturbance recovery might not take place after stand replacing fires or the successional trajectory on a burnt site might be altered. As a result a forest stand can be replaced for example by shrubs which are able to invade the site following the fire. Alternatively burnt forests can be replaced by lower quality coppice forests with altered species composition. The post-disturbance development can significantly affect the ecosystem processes and ecosystem services provided by the forests. If the vegetation does not return fast enough,

intensified soil degradation can be observed in burnt forests.

A severe fire itself can lead to undesirable changes in soil conditions, such as reduced ability to absorb water and loss of organic matter and nutrients, leaving the soils more prone to erosion, increasing water runoff and causing sedimentation of waterways especially in the steep terrain. Trees damaged and stressed by a fire can furthermore be attacked by pests. From the burnt site, the insect outbreak can spread also to healthy trees.

The aridifying climate will increase the risk of wildfires by drying vegetation and making the dead organic matter in forests more flammable. Additionally, the amount of available fuel might increase as a result of severe and repeated pest infestations and wind storms. Recovery of burnt forests might become a significant issue under climate change, as seedling survival is hampered by the drying conditions. Correspondingly, sufficient post-disturbance recovery might not take place after stand replacing fires and the loss of the vegetation cover can lead to intensified soil degradation in the burnt forests.

The reduced growth rates, changes in forest composition, increased tree mortality as well as loss of forest areas can hamper the provision of ecosystem services such as carbon sequestration and water regulation. They can also have an impact on allowable cuts in production forests and can increase the need for e.g. salvation cuts. The changing conditions may also affect non-wood forest products, which can have, in addition to the loss of crucial ecosystem services, significant impacts on rural populations. Recreational values of forests might also be affected. The extent of the impacts depends on the adaptive capacity of the forests as well as that of forest managers.



Are the Armenian forests and the forest sector able to adapt to climate change?

Most of Armenia's forests are natural, mixed forests consisting of native tree species. This natural diversity increases the inherent capacity of forests to adapt to climate change. However, the events in the past two decades, which have led to significant deforestation, and especially to forest degradation and forest fragmentation, have severely affected the ability of Armenian forests to remain resilient under and adapt to additional pressures. Despite significant reductions in annual cuts and improvements achieved in controlling illegal logging over the past decade, the forests are still facing continued anthropogenic pressures from unregulated grazing, fire wood collection, smaller scale illegal logging, mining, construction works, air pollution as well as human-induced fires. The latter are caused in a majority of cases by the frequent burning of dry vegetation on agricultural lands, from where the fires spread easily also to neighbouring forests under the arid climate conditions and poor control of the fires causing forest fragmentation and damage in the forest ecosystems. Uncontrolled selective felling is leading to degeneration of forests stands. Climatic conditions combined with the grazing pressure are preventing sufficient natural regeneration in many degraded forest areas. The degradation of the forests is leading to losses of biodiversity while the protection of forest biodiversity is a precondition for *in-situ* forest adaptation to new environmental conditions. Furthermore, the ability of trees to migrate to new suitable sites is impeded by forest fragmentation.

The reduced growth rates, changes in forest composition, increased tree mortality as well as loss of forest areas under climate change can hamper the provision of ecosystem services, such as carbon sequestration, soil stabilisation and water regulation. The changing climate conditions may also affect non-wood forest products, which can have further adverse impacts on rural populations. The extent of the impacts depends on the adaptive capacity of the forests as well as that of forest managers.

The forest sector in Armenia faces some limitations, which affect the ability of forest managers to assist forests to adapt to climate change. Identification of the long-term climate change risks in forests, assessment of the inherent adaptive capacity of forests as well as reassessment of forest management practices and planning of stand specific

adaptation measures require technical capacities, which are limited both at the institutional and the individual levels. Financial resources required to conduct adequate monitoring in forests to identify the onset of changes and the need for interventions are not available to forest managers. Currently, climate change risks are not taken into consideration in the forest management planning process. The need to protect Armenia's forests has been recognised at the national level, but the efforts to improve forest protection have been made more difficult by the global economic crisis, which has affected Armenia significantly and has led to substantial cuts in the state financing of the forest management organisations. Also other structural issues affect the adaptive capacity of the sector. Factors such as the small scale of economic activity in the forestry sector translate for example to limited nursery capacities and limited silvicultural operations in forests, which in turn can affect the capacity of the forest managers to implement adaptation options.

Box 4. Identification of the most vulnerable forest areas in Armenia under climate change

Syunik – and its mountain forests – have been identified as one of the most vulnerable regions of the country to climate change and climate variability in the comprehensive analyses conducted under the National Communications of Armenia to the United Nations Framework Convention on Climate Change^{5,7}. The climate in the Syunik Province is highly variable; however, the region has the highest annual average temperature in Armenia. Furthermore, some of the driest areas of the country are located in the southern parts of the Syunik Province. An analysis of observation records shows that the annual average temperature has increased by 0.7-0.9°C since 1935 in the Syunik Province compared to the 1961-1990 baseline period¹⁰. The increase in the temperature has been more notable in the summer months, whereas in the winter months the changes have been insignificant. Based on climate projections produced by the regional model PRECIS¹⁰, the temperature is expected to continue to increase gradually in Syunik with the highest increases expected in the southern areas of the region, where also most of the forests of the province are located (Fig. 2)¹⁰. Annual precipitation has decreased in the Syunik Province by about 7-8 percent since 1935 compared to the baseline period¹⁰. Additionally, between 1936 and 2007, the number of consecutive dry days (daily precipitation <1 mm) and the number of summer days (daily maximum temperature >25°C) have increased significantly in Syunik⁹. These conditions have resulted in the intensification of drought in the region. Drought conditions are aggravated in the region also by southeasterly winds⁷. Based on an analysis of the meteorological vulnerability in Syunik, the region as a whole was assessed as moderately vulnerable with very high vulnerability in the district of Meghri and relatively high vulnerability in the district of Kapan¹⁰. The vulnerability was estimated based on the maximum and minimum temperatures, daily maximum precipitation and wind velocity¹⁰.

Significant impacts induced by climate change are expected especially in those forest ecosystems in Syunik, which currently experience the driest climate conditions and which are most exposed to further climate aridification. The some 38 percent of the province's forests, which are located on south facing mountain slopes and are naturally experiencing the warmest conditions, are under greatest exposure^{11,12}. The Syunik Province has already witnessed severe forest fires during the past decade, as is described in more detail in the following chapter. The forests in the most southern parts of the region in the district of Meghri and in the Kapan district in the central part of Syunik have seen some of the most devastating wildfires of the past decade in Armenia. The forests of the Syunik Province have also been extensively affected by forest pests, namely leaf-eating moths, such as Gypsy moth, Brown-tail moth and Common Lackey moth. The forests in the Meghri district have been subject to most extended pest damage. Under climate change, the Syunik Province may also become vulnerable to invasive species migrating from the arid conditions of the neighbouring countries.

Foresters and villagers in the Syunik Province give accounts of aridifying weather conditions in the forest areas, including increasing occurrences of droughts and forest fires⁹. One concern from their perspective is the impact of climate change on the traditional products they collect from the forests.

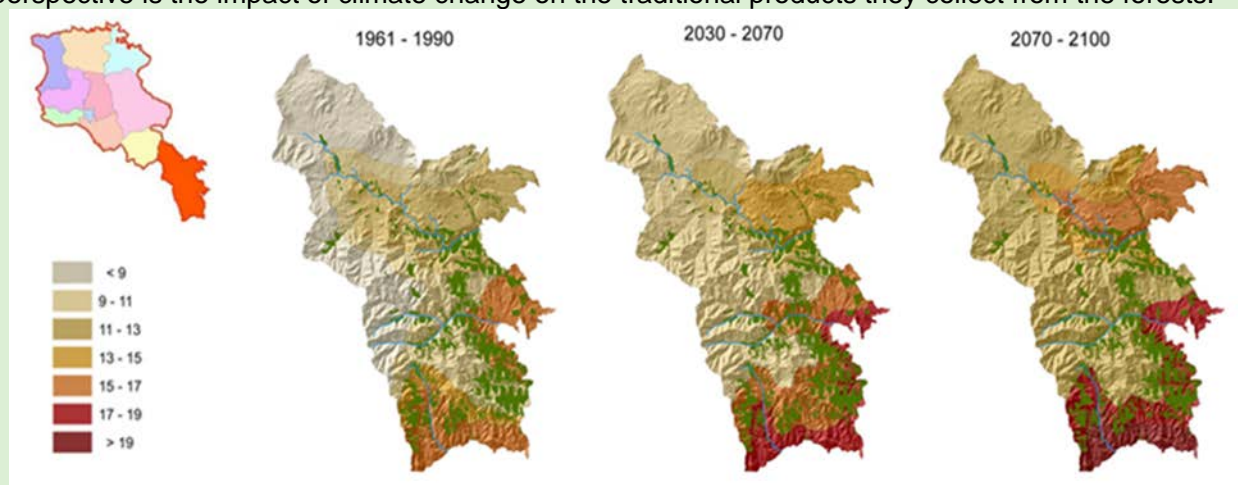


Figure 2. Observed and predicted average air temperatures for warm-half years in the Syunik Province¹⁰. The forests in the Syunik Province are marked by the green areas in the maps.

1.3. Building the resilience of mountain forests to climate change with the support of UNDP

Box 5. Ecosystem based adaptation

The adverse impacts induced by climate change in forests – loss of forest cover, loss of biodiversity, reduced forest vitality and productivity and so on – are reflected also on local communities, who rely on the many ecosystem services provided by forests: provision of clean water, soil preservation and formation, climate regulation as well as income and food support through provision of fruits, nuts, berries, traditional herbs, mushrooms, medicinal plants and so forth. Importantly, forests buffer local communities from the effects of climatic extremes, such as heavy rains. The loss of forests can lead to increasing occurrence of floods, landslides and mudflows with severe impacts on local communities. Correspondingly, in rural areas the preservation of the ecosystem services provided by forests is highly important for the resilience of the local population to climate change. The use of biodiversity and ecosystem services as a part of the strategies aiming to help people to adapt to climate change can be termed ecosystem-based adaptation – or in the case of forests, forest based adaptation. Preserving and restoring forest resilience and reducing the vulnerability of forests to climate change thus supports also the adaptation of people to the effects of climate change. Additionally, the preservation of healthy forests and the ecosystem services, such as carbon sequestration and storage of carbon, will also help mitigate climate change.

Building the resilience of mountain forests to climate change requires forest management that supports the inherent adaptive capacity of forests. The capacity of the forest management sector to implement planned adaptation options in Armenia has been limited, as described above, by certain systemic, institutional and financial constraints. The UNDP supported, GEF funded project “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” has since its beginning in 2009 addressed the key national and sectorial barriers for climate change adaptation in the country’s forests and the forest management sector. The project has operated at multiple levels (i) to integrate climate change risks into the critical decision-making points of forest conservation and management at national and sectorial level; (ii) to develop institutional capacities for planned adaptation by improving climate risk monitoring, data management as well as knowledge and skill-set for scenario-based decisions making and forest management planning under uncertain future conditions and a range of scenarios of change; and (iii) to demonstrate no- and low-regret adaptation options that build the resilience of forests to climate change while supporting sustainable forest management in the country, designed and implemented by the local stakeholders at the sub-national level. The project has thus focused on strengthening the enabling environment for mainstreaming climate change risks in forest and protected area management planning, developing associated technical capacities, as well as on piloting on-the-ground adaptation measures on target sites.

The long-term development goal of the project is to assist Armenia in beginning a process by which strategies to moderate, cope with and take advantage of the consequences of climate change are enhanced, developed and implemented. By building the resilience of the forests to climate change and protecting the ecosystem services provided by the forests, the project aims to support the adaptation of people to climate change.

The efforts of the project are targeted toward addressing the main expected climate change impacts in Armenia’s forests, including the increasing risk of forest fires, the declining sanitary conditions in forests as well as the declining tree survival and success in tree

establishment resulting in forest degradation and forest fragmentation. The project is partnering with a wide range of stakeholders to implement the chosen multipronged approach, including the Ministry of Agriculture, the Ministry of Nature Protection, and the Ministry of Emergency Situations along with their forestry and protected area management organisations, and rescue and meteorological services on the national and regional levels as well as the province administration and local authorities. With expected results relevant for a wider region, the project’s primary target is the vulnerable Syunik Province in south-eastern Armenia.

¹ WWF Caucasus-Anatolian-Hyrcanian Temperate Forests. Available at: http://wwf.panda.org/about_our_earth/ecoregions/caucasus_temperate_forests.cfm.

² Conservation International. 2012. Biodiversity hotspots in Europe and Central Asia. Available at: http://www.conservation.org/where/europe_central_asia/pages/priorities.aspx.

³ National Forest Program of the Republic of Armenia. Annex to the Government of RA Decision N 1232-N from 21 July 2005.

⁴ Forest Code of the Republic of Armenia. Adopted on 24 October, 2005.

⁵ First National Communication of the Republic of Armenia under the United Nations Framework Convention on Climate Change. 1998. Ministry of Nature Protection of the Republic of Armenia. 81 p.

⁶ National Action Programme to Combat Desertification in Armenia. 2002. Ministry of Nature Protection of the Republic of Armenia. 185 p.

⁷ Second National Communication of the Republic of Armenia under the United Nations Framework Convention on Climate Change. 2010. Ministry of Nature Protection of the Republic of Armenia. 132 p.

⁸ IPCC, 2007. Climate Change 2007: Synthesis Report. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

⁹ Project Document. Adaptation to climate change impacts in mountain forest ecosystems of Armenia. GEF Medium-Size Project. Government of Armenia, United Nations Development Programme. 80 p.

¹⁰ Hovsepyan, A. 2012. Adaptation to climate change in the mountain forest ecosystems of Armenia. Expert study under the UNDP-GEF-00051202 project.

¹¹ Gevorgyan, A. 2007. Vulnerability and adaptation of the forest sector of Republic of Armenia to climate change. Expert report under the UNDP-GEF-00035196 project “Enabling Activities for the Preparation of Armenia’s Second National Communication to the UNFCCC”.

¹² Study of the conditions of Syunik Marz forests related to climate change. Expert report under the UNDP-GEF-00051202 project.

2. Identifying the problems – Burning need for improved wildfire management under the aridifying climate

2.1. Wildfire trends

Many regions of the world have seen an increasing occurrence of wildfires in the past decades. Also in Armenia severe forest fires and numerous grassland fires have caused extensive damage in recent years. In many cases globally as well as regionally, changing climate conditions have been a significant contributor to the increasing occurrence of wildfires and extreme weather conditions have often prevailed during devastating fire events. Climatic factors are, however, not the only reason for the increasing fire frequency and intensity. Humans are contributing to wildfires by creating fire-prone conditions in natural ecosystems, importantly by igniting fires as well as by failing to implement efficient and effective wildfire management to control anthropogenic factors causing fires, react to the changing climate and the increasing fire risk as well as to prevent large-scale damages. A closer look at the relationship of wildfires and climate change, impacts of land-use change on wildfire occurrence, root causes of fire ignition as well as the organisation of wildfire management is useful for the identification of the underlying problems behind the recent fire trends.

Wildfires and climate change

The occurrence and characteristics of wildfires are very dependent on weather and climate factors. Weather elements such as temperature, precipitation, humidity and wind speed affect significantly the occurrence, frequency and intensity of fires, the spread of fires as well as the type of fires. Dry conditions created by high temperatures, limited precipitation and low humidity result in increased flammability of vegetation. The availability and continuity of dry fuel, persisting dry weather conditions and for example wind speed affect the intensity of a fire as well as fire spread. Fuel loading and the availability of dry organic matter ranging from surface vegetation, litter and dead wood to the understory trees and shrubs and ultimately to tree crowns affect the type, intensity and severity of a fire. A surface fire burning vegetation at the ground level will

have a lesser impact compared to a fire climbing all the way up to the tree canopy. In addition to the variable climate conditions, the characteristics of fire in the mountainous landscape are affected also by for example topography. Slopes with southern aspect are naturally hotter and drier compared to slopes with northern aspect. This pre-heating effect causes more intense fires on southern slopes. Furthermore, also slope steepness has a great impact on fire spread; the steeper the slope, the stronger the upwards convection of heat from a fire and the faster the spread of the fire uphill. Additionally, the chemical properties of the available fuel play a part in the characteristics of a fire. For example the presence of volatile substances such as oils, resins and wax in the fuel greatly affects the rate of combustion and leads to varying levels of fire danger in forests with different species compositions.

The occurrence and characteristics of wildfires are very dependent on weather and climate factors. Weather elements such as temperature, precipitation, humidity and wind speed affect significantly the occurrence, frequency and intensity of fires, the spread of fires as well as the type of fires. Due to this close connection of the climatic factors and wildfires, fire regimes respond rapidly to climate change and climate variability. Under changing climate conditions, the altered fire regimes can become a major factor affecting natural ecosystems.

Due to the close connection of the climatic and weather factors and wildfires, fire regimes respond rapidly to climate change and climate variability. Changing climate can lead to lengthened fire seasons in regions where the climate is becoming warmer and drier and for example snowmelt takes place earlier in the spring. The increasing occurrence of climatic extremes, such as droughts and heat waves, can significantly increase the fire frequency in fire prone areas and result in occurrence of fires in areas where wildfires do not usually occur. The increasing occurrence of extreme fire weather days, i.e. days with low humidity, high temperature and high wind speed, can result in severe and extended wildfires.

Climate change can also result in an increase in thunderstorms and lightning, which can trigger fires. Furthermore, as was described in the previous chapter, climate change can cause increased tree mortality in forests either due to direct effects on tree health and vigour or through secondary impacts, such as forest pests or storms. The accumulation of dead matter in forests as a result of these processes can further contribute to the risk of wildfires. On the other hand, also increased growth rates of vegetation induced by rising temperatures in areas with sufficient precipitation can affect the wildfire risk due to climate variability where periods of increased growth are followed by extreme droughts and heat waves drying the accumulated vegetation.

Under changing climate conditions, the rapidly altered fire regimes can become a major factor affecting natural ecosystems especially in the short term. In regions where wildfires become more frequent and the natural fire regime is altered considerably, also the composition of woodlands can be changed significantly.

Global wildfire trends

An important factor contributing to the occurrence of forest fires is the on-going change in land-use in many parts of the world. In many regions fuel levels and the fire risk have increased as a result of the abandonment of traditional land-use practices and forest uses, such as grazing. This has led to changes in landscape structures with shrub lands encroaching into former agricultural lands and understory vegetation increasing in forests. Careless or unsustainable forest management practices can also affect the fire risk. Accumulation of fuel can be high in over-dense stand. Intensive logging or land-clearing resulting in the removal of the canopy can alter microclimatic conditions and lead to drying of vegetation. Also logging residues left in the forest after thinning or harvesting can become fuel for a forest fire. In some regions, fire prevention and suppression strategies have efficiently excluded fires from forests where they have previously occurred naturally. The resulting high levels of continuous fuel cause a high risk of intense fires.

Severe wildfire seasons have been observed around the world under warming and drying climate conditions. For example in the Mediterranean basin extreme fire seasons have occurred in the recent years during extreme weather events. The heat wave of 2003 affected especially the fire situation in Portugal and France, where the burnt areas exceeded clearly the annual averages. The area burnt in the whole Mediterranean region in 2003 was 742,500 hectares, whereas the 1980-2010 annual average for the region was 471,300 hectares¹. Extreme fire seasons caused by prolonged hot periods and droughts have been experienced in the past decade also for example in Portugal in 2005² and in Greece in 2007³. In addition to the weather conditions, also on-going changes in land-use practices have contributed to the wildfires in the region.

Furthermore, globally the number of large wildfires, or groupings of several fires across large geographical areas, has been increasing notably in all regions of the world⁴. Large wildfires have been recorded during heat waves accompanied by low precipitation and strong winds⁴. Devastating fire seasons occurred for example in 2003 in California, 2009 in Australia and 2010 in Russia and Israel. These fires have led to unprecedented damages, economic losses and even losses of human lives. As an example, the 2010 wildfire season in Russia was the most severe since 1972 and the worst on record in European Russia⁵. The over 32,000 fires burning nationwide occurred during a severe drought, record-high temperatures and strong winds leaving 2.3 million hectares burnt. The smoke from the fires combined with the prolonged heat wave caused also severe health impacts in Moscow and other urban areas⁵.

Impacts of wildfires

The adverse health impacts are one of the many severe consequences of wildfires. The smoke from fires affects air quality and visibility. Due to incomplete burning, the combustion gases include also for example carbon monoxide, which is a poisonous gas. Furthermore, forest fires are a significant source of fine particles, which can cause respiratory and cardio-vascular illnesses. Also significant amounts of carbon can be

released during wildfires. The released CO₂ as well as other greenhouse gases contribute to climate change, which in many cases is behind the increase of fires thus creating a negative feed-back mechanism.



Wildfires are a significant disturbance in forest ecosystems, where they influence the composition and structure of vegetation and shape the landscape mosaic. In forest ecosystems, where fires return frequently, the vegetation is adapted to fires and the regeneration and reproductive capacity of the forests may depend on the occurrence of fire. Contrarily, forest ecosystems, where fire is not an intrinsic factor, are more sensitive to wildfires. Increased fire occurrence in sensitive forests can lead to loss of species and biodiversity. Recovery of a burnt forest stand may also become an issue as trees might not be able to regenerate sufficiently under continued dry conditions. Thus, forest stands can be replaced by fast-colonising shrubs or grasslands and the forest lands can become fragmented. Forest rehabilitation through artificial regeneration may become demanding under the unfavourable climate conditions as well as due to altered microclimatic and soil conditions following a fire. Fires affect soils in forests and grasslands negatively by removing organic matter and nutrients, deteriorating soil structure, causing erosion and leaching as well as by harming the soil microbial pools. The opening of the canopy after a fire can enhance wind erosion and cause further drying of the forest floor. Additionally, the area to be regenerated might increase as the damage caused by wildfires increases.

Economic losses of wildfires can incur through for example the loss of wood, timber and other forest products, lowered forest health and increased susceptibility to secondary disturbances, loss of croplands

and soil productivity as well as through damage caused to infrastructure and property, such as buildings, bridges and communication and power lines. The environmental impacts of wildfires, like altered water cycles and strengthened erosion processes, can have long-lasting impacts on local communities. Further damage can be caused by increased landslides and mudflows on deforested slopes.

2.2. Wildfire situation in Armenia

Also Armenia has seen extreme wildfire seasons during the last decade. Both forest and grassland fires have been not just numerous but also devastating in regards to the total area burnt by fires. Climate change is altering the fire situation and is creating conditions also in Armenia for increased frequency of both forest and grassland fires. What is more is that under the aridifying climate conditions also the severity of especially forest fires has increased, while forest regeneration and recovery are significantly more difficult. Climate extremes play an important part in the increased fire occurrence. An increase in the number of wildfires has been observed in Armenia over the past decade following prevailing drought conditions and continued hot temperatures.

Both forest and grassland fires saw a pronounced increase in the number of incidents and total burnt area in 2010 and 2011 (Figures 3 & 4). Additionally, 2001 and 2006 were also severe forest fire years. Also the area burned by grassland fires was high in 2006. Against the more average years between 2001 and 2011 (period of available official records for forest fires), when approximately seven forest fires were ignited annually, in both 2010 and 2011 over 50 forest fire cases were observed⁶. Markedly, the total area burnt by forest fires annually in 2001, 2006, 2010 and 2011 grew from some ten hectares to several hundreds of hectares compared to the rest of the period between 2001 and 2011⁷. By July 2012, already 43 forest fires had been reported in Armenia burning approximately 190 hectares of forestlands⁷. This makes also 2012 one of the most severe fire years since 2001.

Official records of grassland fire cases are available for the period 2004-2011. In both 2010 and 2011 there was nearly a five-fold increase in the number of grassland fires in

Armenia compared to the average of the previous six years. The number of grassland fires jumped from some hundreds to around 2 700 cases in both 2010 and 2011 (Fig. 4)⁸. In 2006 grassland fires burned a total area of 17 000 hectares and in 2010 nearly 25 000 hectares⁸. In 2011, despite the

high number of grassland fires, the burnt area was reduced to 9 700 hectares, however being still high compared to the previous years. In 2012 the number of grassland fires has remained high and by October 2012 over 1 300 grassland fires had been reported burning a total area of nearly 3 900 hectares⁸.

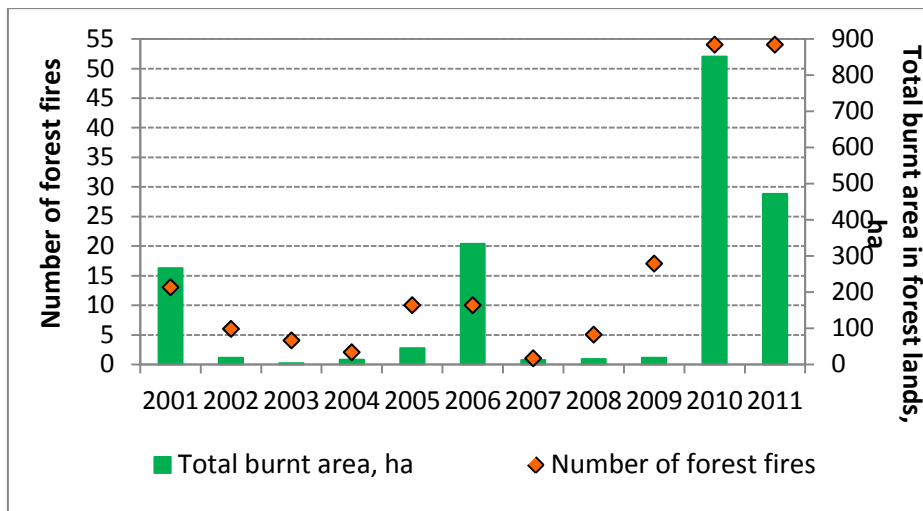


Figure 3. Based on available data from Hayantar, the number of forest fires has increased in the recent years in Armenia⁷.

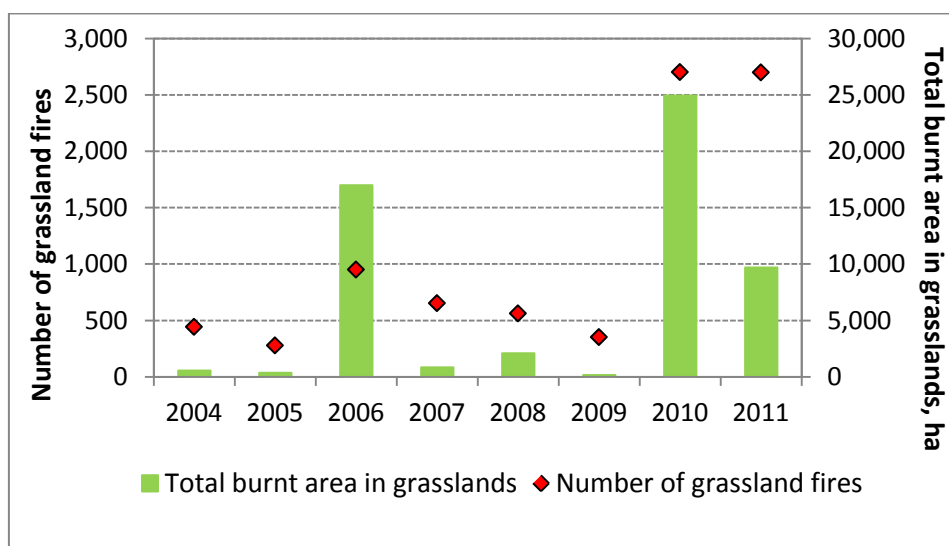


Figure 4. A marked increase in the number of grassland fires was observed in 2010 and 2011 in Armenia⁸. The figures are reported by the national Rescue Service.

Armenia has seen several extreme wildfire seasons during the last decade. Both forest and grassland fires have been not just numerous but also devastating in regards to the total area burnt by the fires. Climate change is altering the fire situation and is creating conditions in Armenia for the increased frequency of wildfires. Increases in the number of wildfires have been observed in Armenia over the past decade following prevailing drought conditions and continued hot temperatures.

The Syunik Province in south-eastern Armenia has observed some of the most severe forest fires in the country over the past decade. In the region the damage caused by single forest fire incidents in terms of area burnt has been nearly three times higher compared to the entire country. The loss of forests in the arid region has devastating environmental consequences.

Nationally most of the forest fire incidents between 2001 and 2011 occurred in the more forested, northern provinces of Armenia. However, the south-eastern Syunik Province has observed some of the most severe forest fires in the same period. In fact, in the region the damage caused by single forest fire incidents in terms of area burnt has been nearly three times higher compared to the entire country. In the recent record, the most devastating year in Syunik was 2006 when four fire incidents burned over 320 hectares of forest lands in the region. Also extended outbreaks of leaf-eating pest species have been observed in Syunik. The consequent drying of trees and increase in dead wood matter in the forests following the pest outbreaks have contributed to forest fires in the region. The most notable case took place in the Arevik National Park in the Meghri region, where approximately 80 hectares of forests, which had in the previous years suffered from pest outbreaks, were burnt in 2001. Altogether, nearly 430 hectares of forest lands were burnt in Syunik between 2001 and 2011, or over 20 percent of the forest lands burnt in the same period in the entire country. The loss of forests in the arid

region has devastating environmental consequences.

Changes in land management have contributed to the availability of flammable organic material also in Armenia. For example the number of cattle and other grazing animals has dropped in recent decades and the grazing patterns have changed and are now concentrated on smaller areas than before. In forest ecosystems, lack of funding has prevented implementation of sufficient wildfire management measures. Additionally, monitoring of forest phytosanitary conditions and control of pests and diseases is inadequate, which further contributes to the increase of fire risk in the forests. Besides the climatic conditions, the insufficient organisation of wildfire management is an important factor contributing to the wildfire situation in Armenia. However, at the root of the problem lie the factors contributing to the actual ignition of wildfires.

Root causes of wildfires in Armenia

Climate change is contributing to the flammability of vegetation in Armenia and is creating settings for both the occurrence of more wildfires as well as for more intense fires. The observations of foresters and forest rangers tell of drying forest conditions as well as resultant increase in the number of forest fires⁹. Additionally, reports of foresters reveal an increase in the occurrence of lightning ignited fires as a result of more frequent thunderstorms and the availability of flammable, dry vegetation¹⁰. Despite the central part played by climate and weather in the creation of the fire environment and in increasing the fire danger, the most important causes for the ignition of wildfires in Armenia, however, are of anthropogenic origin. More specifically, wildfires are ignited as a result of burning of agricultural waste, stubble fields as well as fallow and pasture lands and negligent use of fires in recreational areas. Also for example carelessly discarded cigarette stubs can cause damage under the dry conditions. According to available statistical data, between 2007 and 2011, 60 percent of forest fires in Armenia were identified to have been ignited by humans (Fig. 5)⁷. An overwhelming majority of these cases were caused by agricultural land burning. In the rest of the cases (40 percent) the cause remained unknown, likely including

also human induced fires. The threat of the human ignited fires on agricultural lands escaping to forests and surrounding grasslands and causing extensive damage is significantly increased under the conditions of greater aridity under climate change.

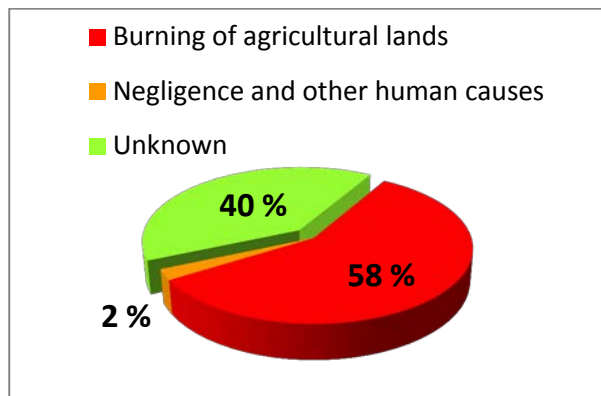


Figure 5. Between 2007 and 2011, majority of forest fires in Armenia were caused by humans. The major cause was burning of organic matter on agricultural lands⁷.

Pasture, stubble field and agricultural waste burning remain the prevailing practice on agricultural lands in Armenia. This traditional practice is perceived useful especially in terms of improving soil fertility and clearance of agricultural lands of dry vegetation as well as of weeds, diseases and pests. However, its benefits have been challenged by many scientific studies as the burning can also affect soil fertility negatively by changing its chemical and physical characteristics¹¹. Burning of stubble or grasslands can alter soil pH value and affect soil microbial pools. Despite increasing the amounts of phosphorus in the soil, volatile nutrients can be lost as a result of the burning. The loss of

soil organic matter can lead to reduced soil water holding capacity and soil moisture penetration capacity as well as increased soil compaction, which will further reduce soil productivity. Repeated burning of stubble fields or pastures in the long term can have permanent negative impacts on the soil quality and eventually on crop yield from burned lands¹¹. The onset of the negative impacts of burning might be slow in soils with high initial fertility levels, but in the long term, offsetting the loss of organic nitrogen, organic carbon, organic matter and respectively soil productivity may require significant efforts.

Additionally, uncontrolled fires escaping from the fields are not one of the main causes of wildfires only in Armenia, but also globally. According to the Global Forest Resources Assessment 2005, majority of forest fires globally stem from uncontrolled agricultural burning for land management in forest adjacent areas and areas outside of the forest itself¹².

Because of the harmfulness of agricultural land burning, the practice is banned by law in many countries. The European Union is an example of this; stubble burning is prohibited in EU countries according to EC Regulation, unless it is permitted for plant health or other reasons in specific situations in individual countries.

Awareness of the negative impacts of agricultural waste burning is low among rural population in Armenia and stubble burning remains a widely used practice as a result of prevailing attitudes and beliefs. The results of a survey conducted in rural communities in the Syunik Province are a good indication, as is shown in the following section.



Box 6. Perceptions of the rural population on forest and grassland fires in the Syunik Province

The UNDP supported project “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” conducted a survey among a select number of forest adjacent rural communities in the Syunik Province to gain understanding of the perceptions of community members in forest neighbouring villages on forest and grassland fires. The survey concentrated on the perceptions of rural population on the trends, causes and effects of forest and grassland fires, on the impacts of human activities on forests and other natural resources as well as on the reasoning and motivation behind prevailing management practices on agricultural lands. Additionally the survey aimed to explore the dependence of forest adjacent communities on forest resources. The survey was conducted to reveal possible underlying reasons for wildfires and to assist the project in targeting its outreach activities. The data was collected through a multiple choice questionnaire and interviews of 137 rural community members each of whom represented one household in 9 villages in the Syunik Province. About 70 percent of the respondents practiced animal husbandry and 97 percent cultivated lands.

The results revealed that forests have an important role in the lives of rural dwellers. 77 percent of the respondents use forests to obtain wood, 74 percent collect other plants and non-wood forest products and 67 percent of the respondents use the forests for recreation. Additionally some of the respondents use the forests for grazing and haymaking. As much as 80 percent of the respondents stated that wood is the only source of fuel in their household.

About a half of the interviewed rural community members burn stubble after harvest. This was not the only practice though; the respondents stated that they also use the stubble as fodder or leave it on the fields. Stated reasons for stubble burning included soil fertilisation and cleaning of the area. Some also stated that they did not know what else to do with the stubble than to burn it.

The respondents identified rightly humans as the main cause for the ignition of forest fires. 61 percent of the respondents, however, named inappropriately extinguished or uncontrolled campfires as a major cause of forest fires. Contrarily, stubble burning (15 %) was identified as a cause of forest fires only slightly more often than carelessness (13 %) and lightning (10 %) (Fig. 6). The results indicate that despite good understanding of the human impact on the occurrence of forest fires, awareness of the causes is limited. Half of the respondents stated that they would participate in the suppression of wildfires. Through the formation of voluntary fire fighting units as well as provision of adequate fire fighting equipment and appropriate training, this willingness of community members to take action could be utilised to address wildfires in a timely manner.

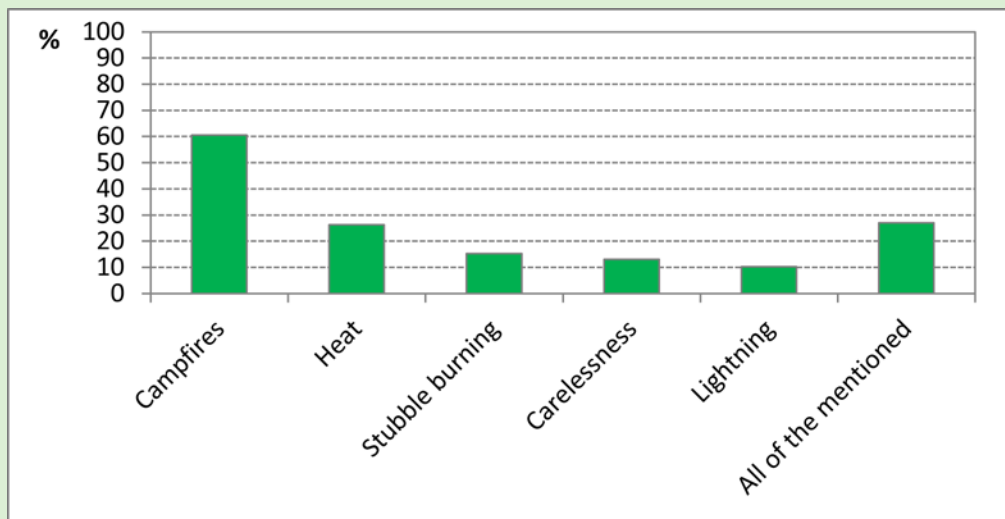


Figure 6. The respondents to the community survey in the Syunik Province identified humans as the main cause for the ignition of forest fires. Awareness of the significant impact of burning of agricultural lands on forest fire ignition was, however, limited.

2.3. Shortcomings of wildfire management in Armenia

Effective wildfire management includes not just suppression of fires, but also measures to prevent wildfires. This proactive approach of fire prevention and pre-suppression is necessary for the minimisation of fire damage in forest ecosystems and protection of forest resources. Proactive fire management should include:

- Measures to increase public awareness of the risks and causes of fires and of the fire danger level during the fire season in order to guide human behaviour,
- Sufficient legal regulation and law enforcement to manage the anthropogenic causes of fires, as well as
- Appropriate early fire detection systems and early response capacities in the forests.

Also other preparatory measures need to be undertaken in the forest ecosystems. These include, for example:

- Construction of fire breaks,
- Fuel mapping and fuel reduction,
- Mapping of roads and water points, as well as
- Maintenance and preservation of healthy and resilient forest conditions.

In addition to preventive measures, sufficient reactive capacities including trained staff as well as equipment and techniques suitable and effective in the local context need to be secured to further limit fire damage in forests.

In Armenia, in accordance with the existing legal framework, the responsibility for organising forest fire management is principally on the regional branches of the state forest organisation Hayantar under the Ministry of Agriculture. Forest fire management in specially protected areas is the responsibility of the corresponding authorities under the Ministry of Nature Protection. For the organisation of early warning, analysis of fire weather conditions and prediction of fire risk, forest managers cooperate with the State Hydrometeorological and Monitoring Service of the Ministry of Emergency Situations. Forest monitoring and fire early detection are assigned to forest

Wildfire management is faced with a multitude of challenges at the systemic, institutional and individual levels in Armenia. The adverse impacts of the failure to implement effective wildfire management will become intensified as the fire problem is becoming more severe under climate change and the drying conditions.

rangers. In case a fire breaks out, the head of the regional forest enterprise manages the fire suppression activities. If the fire size and intensity exceed levels manageable by the regional forest enterprise, fire suppression is organised with the assistance of the regional detachments of the Rescue Service of the Ministry of Emergency Situations and local municipality authorities. Once the Rescue Service is involved in the fire fighting, it takes over the management of fire suppression. The local authorities are in charge of organising the involvement of the local population in the fire fighting. In most severe fire cases, the Defence Forces will become involved in the fire fighting.

Grassland fires occurring in community lands are suppressed by the regional detachments of the Rescue Service. Monitoring in these areas should be organised by the community authorities.

In reality, wildfire management is faced with a multitude of challenges in Armenia, as has been identified by assessments of international and national experts under the UNDP project. Furthermore, the adverse impacts of the failure to implement effective wildfire management will become intensified as the fire problem is becoming more severe under climate change and the drying conditions. Currently climate change risks are not incorporated at the systemic level into policies and strategies concerning natural resource management. Systemic prevention of wildfires is weak and regulation of the anthropogenic causes of forest fires has been insufficient. For example, burning of agricultural lands has been unregulated and sanctions or criminal proceedings are imposed in few fire incidents. Additionally, public awareness of forest fire issues is low and awareness raising campaigns are sporadic at best. Issues such as wildfires or

protection of natural ecosystems have not been incorporated into the national curricula of educational institutions. Furthermore, at the systemic level effective fire suppression is hindered in practice by the lack of a clear command chain and explicitly defined roles and responsibilities between the different authorities involved in wildfire management.

A key short-coming in fire suppression in the country is the lack of equipment and techniques suitable for fighting wildfires in the mountainous terrain. The inaccessibility of a large share of the forest areas located on steep slopes limits the use of heavy fire engines. Additionally, aerial fire fighting equipment is lacking in the region. Off-road vehicles able to access the mountain forests and equipped with appropriate water tanks and pumps as well as other tools suitable for fighting fires in the complicated terrain have not been available to the foresters and rescuers. The lack of effective rapid response capacities and the use of makeshift tools, such as plastic bottles and tree branches, have made unnecessary spread and damage of fires possible.

The lack of capacities to organise sufficient forest fire early warning systems make wildfire management reactive rather than proactive. Sophisticated early warning systems are not utilised in Armenia and co-operation between the Hydrometeorological and Monitoring Service and forest managers should be intensified and more targeted. The system for fire early detection is not well structured and relies on the ability of forest rangers to patrol the forest areas without adequate watch towers and with limited access to remote forest areas in the mountainous terrain.

The limited ability of forest rangers to reach forest areas in a timely manner prevents them also from monitoring, controlling and advising forest users, be they people coming to the forest to collect fruits, berries, plants or fire wood, to graze their animals and especially for recreation, which often involves the use of open fires. Furthermore, forest health monitoring is non-systematic and maps of the forest areas, including of forest roads and water points, are outdated. Annual operative planning of the implementation of fire pre-suppression in forests is not carried out.

One of the key short-comings in fire suppression in Armenia is the lack of suitable equipment and techniques for fighting wildfires in the mountainous terrain. The inaccessibility of a large share of the forest areas located on steep slopes limits the use of fire engines. Additionally, aerial fire fighting equipment is lacking in the region. Off-road vehicles able to access the mountain forests and equipped with appropriate water tanks and pumps as well as other tools suitable for fighting fires in the complicated terrain have not been available to the foresters. Additionally the technical competencies of forest managers to apply advanced techniques to suppress fires in the mountainous forests have been insufficient. The lack of effective rapid response capacities and the use of makeshift tools, such as plastic bottles and tree branches, have made unnecessary spread and damage of fires possible.

The individual capacities of foresters to apply advanced suppression techniques to effectively fight fires in the mountain forests has been limited due to lack of training and availability of suitable equipment. There is also a lack of capacities to assess impacts of climate change in forest ecosystems and to plan measures to respond to potential changes and adjust forest management correspondingly. Rescuers from the Rescue Service have limited training in the suppression of forest fires.

Local community members, who have an obligation to participate in wildfire fighting, are not efficiently organised, which restricts their preparedness to assist in fire suppression. Furthermore, they are not properly trained nor equipped. Voluntary fire fighting troops have not been formed in Armenia. The local authorities, furthermore, do not appropriately carry out monitoring of grassland fires in community lands. Often foresters are the first to observe and respond to grassland fires in community lands adjacent to forests.

Lack of funding is a key factor limiting sufficient organisation of wildfire management. The financial situation of the forest enterprises has become more difficult in the recent years following the global economic crisis, which has had significant impacts on Armenia. As a result of limited financing, the forest enterprises have both limited funds to implement fire prevention and pre-suppression as well as limited amount of personnel to mobilise for fire suppression. The restricted resources make it increasingly important to improve and intensify the co-operation between different authorities to secure efficiency of wildfire management in the country.

The analysis of the key shortcomings of wildfire management in Armenia has been used as the basis for identifying critical approaches to improve the national capacities to prepare for the increasing wildfire risk under climate change. Specific measures have been identified based on international best practice especially from the Mediterranean and Balkan regions. Several approaches have been adapted to the local context and have been demonstrated in the Syunik Province under the UNDP supported “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project.

¹ Forest Fires in Europe - 2003 fire campaign. 2004. S.P.I.04.124 EN, European Communities 2004, Joint Research Centre. 52 p.

² Forest Fires in Europe 2005. 2006. EUR 22312, European Communities 2006, Joint Research Centre.54p.

³ Forest Fires in Europe 2007. 2008. EUR 23492 EN - 2008, European Commission, Joint Research Centre.82p.

⁴ Williams, J., Albright, D., Hoffmann, A. A., Eritsov, A., Moore, P. F., de Morais, J. C. M., Leonard, M., San Miguel-Ayanz, J., Xanthopoulos, G. &van Lierop, P. Findings and implications from a coarse-scale global assessment of recent selected mega-fires. 5th International wildland fire conference, Sun City, South Africa 9-13 May 2011. 19 p.

⁵ Forest Fires in Europe 2010. 2011. EUR 24910 EN - 2011, European Commission, Joint Research Centre.98p.

⁶ National Statistical Service of the Republic of Armenia. 2010.

⁷ Hayantar. 2012.

⁸ Rescue Service of the Ministry of Emergency Situations of RA. 2012.

⁹ Project Document. Adaptation to climate change impacts in mountain forest ecosystems of Armenia. GEF Medium-Size Project. Government of Armenia, United Nations Development Programme. 80 p.

¹⁰ Goldammer, J. G. 2011. Introduction of the ENVSEV Project “Enhancing national capacity on fire management and wildfire disaster risk reduction in the South Caucasus”. Proceedings of the conference “Forecast, prevention and suppression of forest and grassland fires”. Yerevan, Armenia, 14 September 2011. Pp. 62-69.

¹¹ Nikolov, N. 2011. Current European policies and experience on burning of the stubble fields and organic residues in agriculture and forestry sectors. Expert report under the UNDP-GEF-00051202 project. Available at: http://www.nature-ic.am/en/PR_FA_Reports.

¹² Global Forest Resources Assessment 2005. 2006. FAO Forestry Paper 147. 320 p.



“Adaptation to Climate Change Impacts in Mountain Forest Ecosystems of Armenia” UNDP/GEF/00051202

3. Delivering results – Improving the wildfire management system to prevent and control fires

To address the multifaceted wildfire problem and the identified shortcomings in the organisation of wildfire management at all relevant levels, the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project has chosen and integrated, multi-pronged approach for its activities and demonstration pilot projects. The project’s activities are aimed at improving the wildfire management system at all levels ranging from the level of communities including community leaders and forest users, to the institutional level including forest and protected area managers and the Rescue Service as well as to the systemic level including the legal framework and institutional co-operation and coordination. At the same time, the project is working to improve forest management so as to incorporate climate change risks into forest management planning and to increase the resilience of forest ecosystems to both direct impacts of changing climate conditions as well as secondary threats related to climate change, such as forest fires.

The next sections present the different activities taken to:

- Build the early-response capacities of forest managers,
- Strengthen institutional co-operation,
- Address the root causes of fires, and
- Incorporate climate change risks into forest management planning and practice.

3.1. Building early-response capacities of forest managers

The assessment of the shortcomings of wildfire management in Armenia revealed the lack of suitable equipment as one of the key issues in the organisation of timely and effective response to fires. Correspondingly, also the technical competencies of forest managers to apply advanced techniques to suppress fires in the mountainous terrain have been insufficient. To address these issues and to demonstrate international best practises adapted to the local conditions, the

project equipped and trained three forest fire early response teams in the vulnerable Syunik Province.

The early response teams were formed by providing a set of equipment suitable for the initial suppression of forest and grassland fires for the forest enterprises of Syunik (informally referred to as Goris to avoid confusion with province and district level) and Kapan as well as the authority of the Arevik national park, which govern a combined forest land area of approximately 89 000 hectares. In addition to the forest lands, also especially forest adjacent community lands were brought under the improved wildfire management together with other close by forest areas, such as the Shikahogh State Reserve covering an additional 9 000 hectares of forests.

The equipment provided to the forest management units was identified based on the initial needs assessment as well as international experience and international experts’ assessment. Qualitative requirements for the equipment, in addition to the suitability to the local conditions, included durability, versatility and for example ability to extinguish surface fires without the use of water.

To address the short-comings in the institutional and individual reactive capacities to forest fires, the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project equipped and trained three forest fire early response teams in the vulnerable Syunik Province. The three forest management units, which received the equipment, govern a combined forest area of approximately 89 000 hectares in the Syunik region. In addition to the forest lands, also especially forest adjacent community lands were brought under the improved wildfire management together with other close by forest areas. Since the provision in 2011, the equipment has reportedly been used to successfully prevent grassland fires from spreading into the forest areas.

The forest management units were provided with hand tools and other equipment, such as, in total, 20 fire swatters and 18 backpack pumps suitable for smothering and extinguishing surface fires as well as 9 brush hooks and 15 combi-tools designed to effectively remove surface and ladder fuels, 3 quick-assemble and 6 collapsible water tanks and 3 weather metres aiding with the evaluation of fire weather conditions and wind speed. The forest management units were also provided 30 full sets of protective fire fighting uniforms improving issues related to the health and safety of fire fighters. The ability of foresters to reach forest fires rapidly was improved by the donation of 3 off-road vehicles. The donated vehicles were, furthermore, equipped with slip-on units, which consist of 450 litre water tanks and engine operated pumps, and are able to deliver water to fire sites where natural water sources are not available and to suppress more intense fires than the provided hand tools.



Each of the three forest management units received also training delivered by an international forest fire expert on the use of each specific tool. Later on, representatives from the forest management units participated also in a national fire management training course for forest fire fighters covering advanced suppression methods and utilised the provided equipment in a practical command staff field exercise. Both the training course and the field drill were part of a series of wildfire events, organised jointly by the UNDP, OSCE, the

Environment and Security Initiative and the national Rescue Service (see chapter 3.2. for a more detailed description of the events).



To complement the provision of the early response equipment, the project provided also horses to the forest management units in the Syunik Province. The need to include also the provision of horses to the forest enterprises under the project rose from discussions with various stakeholders at different levels. Particularly the local forest managers highlighted the inaccessibility of the forests as a major short-coming of fire detection and fire fighting. While acquisition of horses under the constrained budgets of the forest management units has not been possible, the lack of appropriate means of transportation in the mountainous terrain to conduct fire detection and organise response to fires would have significantly weakened also the effectiveness of the provision of the equipment and the delivery of the expected results of the established early response teams. The forest enterprises of Goris and Kapan requested to be provided with horses, whereas the authority of the Arevik national

park decided against the horses assessing that they do not have adequate resources to take care of them. The provision of 10 horses to both of the two forest enterprises made a significant contribution to the capacity of forest rangers to monitor and control the forest areas. In the mountainous terrain, the horses make it possible for the forest rangers to reach remote forest areas that they were not previously able to monitor regularly. The enhanced monitoring improves detection of forest fires and importantly enables timely response. Among the benefits of this particular activity, as reported by the foresters, is also their new ability to control people using the forests (see below “Forest managers’ experiences of the fire early response equipment”). The foresters reported that with the mobility provided by the horses, they are now able to check for example camp fires and can advise campers to control and extinguish the fires properly. The improved patrolling contributes also to forest health monitoring and has an overall positive impact on the ability of the forest enterprises to carry out tasks assigned to them, including e.g. prevention and control of illegal logging and poaching.

Simultaneously to the activities of the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project, WWF Armenia contributed to the strengthening of the capacities of forest monitoring and forest fire early response through construction of two watching points in Arevik national park in Syunik, as pictured below.

The provided equipment has been received well by the foresters. As the equipment was delivered to the foresters in late summer in

2011, at the time of writing this publication it is difficult yet to analyse long-term benefits of the activity. However, since the provision of the equipment, they have been reportedly used to suppress grassland fires in community lands adjacent to forests in a timely manner and the equipment has been successfully used to prevent grassland fires from spreading to forest areas (see below “Responding to fires – case examples from Kapan and Goris”). By July 2012, no forest fires had been observed in the Syunik Province.



An interesting, adaptive application of the provided equipment is their use by foresters in the maintenance of planted forest regeneration stands. Watering has become a prerequisite for the survival of seedlings in many forest regeneration stands in the most arid regions of Armenia. On reforestation sites located on the steep slopes and in the absence of nearby water sources, the watering task is demanding as well as time and resource consuming. Resourcefully, the forest managers in Syunik have utilised the provided water tanks and water pumps combined with additional hoses to irrigate seedlings up to 200 metres uphill on 30-35 degree mountain slopes.



A good indicator of the success of the provision of the early response equipment is the already carried out replication of the acquisition of some of the equipment by national authorities. The Rescue Service of the Ministry of Emergency Situations, following the demonstration of the use and efficiency of the backpack pumps provided by the UNDP project, purchased and distributed 100 similar portable backpack pumps to the fire detachments of Syunik, Tavush, Lori and Aragatsotn Provinces.



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is critically important also in this area. Most importantly provision of similar equipment to forest management units in other regions of Armenia has to be secured. To this end Hayantar is currently seeking additional funds to acquire early response equipment at the national level. As a positive possibility, the parties involved in forest fire fighting have also discussed the option of reproducing some of the hand tools locally.

The beneficiaries and other stakeholders have been seemingly satisfied with the “Adaptation to climate change impacts to climate change in mountain forest ecosystems of Armenia” project’s activities aimed at building wildfire early response capacities of forest managers. Immediate results have been obtained in the enhanced response capacity to wildfires as well as the improved early warning and detection of fires. Factors contributing to the successful implementation and positive reception of the activities include inter alia:

- *Great need identified and expressed by forest managers for the acquisition of suitable equipment to suppress fires in the mountainous terrain. These capacities have been previously entirely lacking in the country.*
- *The tangibility and concreteness of the activities. The benefits are felt immediately by beneficiaries and are demonstrated clearly to other stakeholders.*
- *The relatively small initial investment associated especially with some of the simple, yet effective hand tools and related techniques with tangible short- and long-term benefits. This combined with the proven value of this activity transferring suitable technologies to Armenia promotes replication at the national level.*



Box 7. Forest managers' experiences of the fire early response equipment

The “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project conducted a survey among the users of the forest fire equipment provided by the project to three forest management units to collect their experiences about the early response equipment as well as to collect information about the use and maintenance of the equipment and of the provided horses. Answers to a questionnaire were collected altogether from 13 staff members of the forest enterprises of Syunik (Goris) and Kapan as well as the Arevik national park. The interviewees ranged from the directors of the forest enterprises/national park to foresters and forest rangers. All of the interviewees provided relatively similar answers, which indicated that general conclusion could be drawn despite the small number of answers.

The questionnaire revealed overall satisfaction with the introduced early response equipment. It was stated that all of the provided tools were easy to use and well designed for their specific purposes. Many of the interviewed foresters also stated that the backpack pumps were the most useful out of the provided equipment. Also the fire swatters were found to be especially useful. Many respondents also highlighted the improved capacity to deliver water to a fire site with the slip-on units and the collapsible water tanks removing the previously significant problem of unavailability of water at many sites. Also the diversity of the equipment was highlighted; the foresters were satisfied with their improved ability to organise complex response to fires. Importantly, according to the statements of the foresters, the efficiency of wildfire fighting has been greatly improved with the provision of the equipment.

The interviewees indicated that the organised trainings on the use of the equipment and specific suppression techniques suitable for mountainous regions were also useful and that the forestry units had organised internal events later on to train and disseminate the information to staff members who were not present at the initial trainings.

The only shortcoming observed in the provided equipment and reported by most of the interviewees concerned a specific plastic part (a screw) of the backpack pumps. The easily replaceable part was changed to a metallic version in all of the forest management units to improve the durability of the backpack pumps.

Several of the statements of the foresters in regards to the provided horses showed a specific sense of contentment and gratitude, as the horses enable the foresters to fulfil the forest monitoring and fire detection tasks assigned to them. Many stated that the horses are irreplaceable in the regular monitoring of the entire forest areas, which without the horses has been impossible. According to the reports, the horses are used for general forest monitoring, monitoring of forest health as well as fire detection. Some of the interviewees stated that they have been better able to control violations of forest use, including illegal logging and unpermitted hunting. Additionally, the foresters have been able to control and advice people making open fires when they detect smoke from the forests. The enhanced control and recording of forest use enables also legal actions in case of illegalities or for example ignition of forest fires.

In examples provided by the foresters about wildfire cases, it is described how the forest rangers have been able to detect the fires and reach the sites quickly with the horses. With the early response equipment, many fires have been extinguished before they have been able to grow larger and spread. Thus, the foresters have been able to limit the damage caused by wildfires to a minimum.



“The horse is my companion. With the help of the horse I am able to monitor daily the forest area, which I am responsible for, and carrying out my duties does not wear me out like it used to.”

Forest ranger from Kapan

Box 8. Responding to fires – case examples from Kapan and Goris

Two good examples of improved and efficient fire suppression with the assistance of the provided forest fire early response equipment have taken place in the areas of Kapan and Goris of the Syunik region. In September 2012, a forest ranger monitoring his forest area on horseback noticed on the lands of the Geghi community a grassland fire threatening to spread to the nearby forest area managed by the Kapan forest enterprise. The forest ranger raised the alarm about the fire and shortly other foresters from the Kapan forest enterprise arrived to the fire site together with fire fighters from the Kajaran Fire and Rescue Detachment. Thanks to the efforts of the 15-strong group using the early response equipment, the fire was limited to an area of about a hectare and it was prevented from spreading into the forest area. An employee of the forest enterprise stated that *“The fire was quickly suppressed mostly thanks to the availability of the backpack pumps and fire swatters”*. Also the fire fighters participating in the fire suppression used the early response equipment provided to the Kapan forest enterprise as the equipment was the most efficient way to suppress the grassland fire. The cause of the fire was likely the burning of dry grasslands by local residents.

In August 2011, the foresters of the Goris forest enterprise quickly launched a response effort after a forest ranger had observed a grassland fire threatening a telecommunications tower located on community land in the Goris district. The foresters equipped with the early response tools were able to prevent the fire, which burned altogether 7 hectares of grassland, from affecting the tower thus preventing also significant monetary damages from incurring.

The two examples showcase how the provided early response equipment enable quick and efficient organisation of fire suppression, which has had benefits for the protection of forests in Syunik but also more widely for communities and other actors in the region. The mobile operator company who owns the telecommunications tower has expressed their great appreciation to the foresters of the Goris Forest Enterprise for their rapid response to the fire.

3.2. Strengthening institutional co-operation

The problem description above identifies the different institutions that need to be involved in proactive wildfire management as well as in the organisation of effective reactive capacities. These include not just the authorities who are directly involved in fire suppression, but also institutions such as the national weather service as well as educational and scientific institutions, who need to participate in the prevention of wildfires. Furthermore, the short-comings of wildfire management in Armenia at the systemic and institutional levels are also described above. In addition to the limited capacities of individual institutions, a significant weakness is the lack of formalised and especially operative coordination of the different institutions participating in wildfire management. Also the limited co-operation between the different institutions impairs efficient wildfire management. In addition to this, the roles of specific organisations in wildfire management should be clarified and

strengthened. The roles, responsibilities and responses of different organisations have not been guided by a national strategy or a formalised action plan. Thus, in addition to building the institutional capacities particularly for early reactive response to wildfires as described above, the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project has placed great emphasis on clarifying and formalising the institutional roles and responsibilities at the systemic level as well as on strengthening coordination and co-operation between institutions in order to improve wildfire management in Armenia.

In order to clarify and strengthen institutional co-operation and enable organisation of improved wildfire management, the project advocated and supported, together with local and international partners, the establishment of an interagency National Task Force on Wildfire Management. The establishment of the Task Force was formally proposed by the national Rescue Service during a national conference and roundtable on wildfire

In order to clarify and strengthen institutional co-operation and enable organisation of improved wildfire management at the national level in Armenia the "Adaptation to climate change impacts in mountain forest ecosystems of Armenia" project advocated and supported, together with local and international partners, the establishment of an interagency National Task Force on Wildfire Management. The Task Force and its mandate were established by the decree of the Minister of Emergency Situations in February 2012. The main expected outcome of the Task Force is the preparation of a short- and medium-term Action Plan for the improvement of prevention, pre-suppression and suppression of wildfires in Armenia.

management organised jointly by the Rescue Service, UNDP and the Organisation for Security and Co-operation in Europe in September 2011. The initiative received wide support across agencies and respectively the Task Force and its mandate were established by the decree of the Minister of Emergency Situations in February 2012. The Task Force consists of representatives of the Ministries of Emergency Situations, Nature Protection, Agriculture, Defence, Territorial Administration, Transport and Communication, Health, Science and Education and Energy and Natural Resources, as well as UNDP and OSCE. The Rescue Service of the Ministry of Emergency Situations acts as the convening party of the Task Force and the UNDP project provides technical support for the Task Force.

The main expected outcome of the Task Force is the preparation of an Action Plan for the short and medium term for the improvement of prevention, pre-suppression and suppression of wildfires. The draft Action Plan, which is under discussion in the Task Force and will be submitted to the Government of Armenia for consideration and approval by the end of December 2012, includes:

- Revision of the legal and policy framework related to wildfire management,
- Establishment of the legal and institutional system to ensure compliance and enforcement of the related laws, including effective command chain to address forest fires as well as measures to enhance the responsive capacity to fires through acquisition of suitable machinery and equipment and organisation of regular trainings for wildfire fighters,
- Institutional setting for the establishment of voluntary fire fighting brigades in communities, and
- Measures to improve public awareness on the risks of wildfires through revision of secondary and higher education curricula, training of community leaders and members as well as through wildfire campaigns,

Importantly, the Action Plan and the work done under the Task Force will contribute towards the development of a National Policy on Wildfire Management and its implementation strategy, which are planned to be formalised with the support of the OSCE-led project on wildfire management under the Environment and Security Initiative.

Achieving the targets set by the UNDP project in regards to strengthened institutional coordination has been made easier by the strong national ownership of the wildfire issue showed by key institutions, such as the Rescue Service of the Ministry of Emergency Situations. Additionally, co-operation established by the UNDP project and other international organisations and initiatives with shared targets to improve wildfire management in Armenia and the larger South-Caucasus region has enabled not just successful implementation of parallel activities but also the finding of synergies and obtaining enhanced results.

The co-operation of international parties, namely UNDP, OSCE, the Environment and Security Initiative and the Global Fire Monitoring Centre, resulted in the organisation of a series of wildfire management events forming a comprehensive and concentrated approach to improve wildfire management in Armenia.

Achieving the targets set by the project in regards to strengthened institutional coordination has been made easier by the strong national ownership of the wildfire issue showed by key authorities, such as the Rescue Service of the Ministry of Emergency Situations. Additionally, co-operation established by the UNDP project and other international organisations and initiatives with shared targets to improve wildfire management in Armenia and the larger South-Caucasus region has enabled not just successful implementation of parallel activities but also the finding of synergies and obtaining enhanced results.



The events, which were organised in September 2011 in partnership with the Rescue Service, consisted of a National Training for forest fire fighters and decision makers based on international best practice and advanced suppression techniques, a Practical Command Staff Field Exercise simulating an escalating wildfire situation including human injuries, a Conference on “Forecast, Prevention and Suppression of Forest and Grassland Fires” as well as a National Roundtable creating a platform for enhanced interagency discourse, which lead formally to the decision to advocate the establishment of the Task Force on Wildfire

Management to continue the positive development achieved with the organisation of the events. The training course and the field exercise were organised in the Syunik Province. Altogether the events brought together over 300 participants from different ministries, the Rescue Service, the Defence Forces, Police, forest enterprises and protected area management authorities, regional administrations, the Red Cross and other representatives of the civil society. The set of events together with their follow-up activities especially under the Task Force have made a significant effort towards improving wildfire management in Armenia. The events and their results are reflected in the Proceedings of the wildfire Conference published by the project¹.



The successful implementation of the activities aiming to enhance the capacities of individual institutions and especially the coordination and co-operation between institutions are important for achieving the long-term development goal of the project as well as sustainability of the project results. Factors strongly contributing to the

Successfully, the amendment was adopted by the National Assembly in September 2011 as part of the Law of the Republic of Armenia on Atmospheric Air Protection. The current law bans the burning of stubble, plant residues and dry vegetation areas as well as vegetation of pastures and meadow lands in agricultural areas, forest and forest neighbouring areas as well as Specially Protected Areas of Nature. Measures to secure the compliance and regulation of the ban are being discussed under the National Task Force on Wildfire Management.

The legal campaign has been supported by activities at the local level aiming to address potential misconceptions and raise the awareness in rural communities on the risks of agricultural land burning related both to the ignition of wildfires as well as to soil productivity. The project developed an informational poster on the negative impacts of agricultural land burning and distributed



1 400 copies of the poster across the country to community municipalities, educational institutions ranging from secondary schools to higher education institutions, local NGOs as well as military units.

During the last year of the project's implementation also a booklet on the forest and grassland fire situation in Armenia, the causes of wildfires as well as preventive actions will be distributed to community

leaders in the Syunik Province. Importantly, the booklet disseminates information to community leaders on the recently adopted legal ban on the burning of vegetation in agricultural and forest areas. Furthermore, it clarifies the role of community leaders and community members in the forest fire fighting command chain and provides information on the recent development on the establishment of volunteer fire fighting brigades in Armenia.



Another significant cause of wildfires is the negligent use of open fires for example in recreational areas. The project has chosen to target young people in rural communities with its public outreach activities aimed at advocating behavioural change in regards to the use of fires and protection of forest resources. The project has organised several educational events at schools in the Syunik Province, where children ranging from primary to secondary school students have discussed wildfire issue as well as wider issues related to the protection of the vulnerable forest ecosystems.

Also biology and geography teachers from the schools in the Syunik Province have participated in trainings organised by the project where issues and educational materials related to forest protection have been presented to improve the capacity of the teachers and encourage them to include these issues into their lessons.

Additionally, a wider audience in the rural communities has been targeted by airing a documentary and a short social advertisement on wildfires on local television channels. To further increase the media coverage of forest and climate change issues, the project organised a specific seminar and a writing competition on the topics for Armenian media representatives. The participants of the event represented both regional media from the Syunik Province as well as national media outlets.

The project has chosen to target especially young people in rural communities with its public outreach activities aimed at advocating behavioural change in regards to the use of fire and protection of forest resources.

Another important part of the project's activities aiming to prevent forest fires and address the main causes of wildfires has been the installation of 35 fire warning signs in popular recreational areas in the Syunik Province. Traditional and typical summer time recreational activities in Armenia often entail use of open fires to prepare barbecued food. The signboards promote taking adequate precaution when using fires and contain also information about whom to inform in case a fire breaks out. The simple but relatively visible activity has been received well by the local authorities, and the Ministry of Agriculture replicated the activity by installing 170 similar forest fire warning signs across the country in other provinces than Syunik.

In order to widely address anthropogenic pressures on forests and especially to extend the public outreach campaign on forest fire prevention to all relevant sectors, the project has also targeted institutional capacities out-side of the immediate parties involved in wildfire management. An important sector with potentially increasing impacts on the forests and other natural ecosystems of Armenia is tourism. Armenia's varied nature provides great opportunities for tourism development, but significantly growing numbers of visitors in the forest areas can also lead to increasing pressure on the forests as well as increasing risk of forest fires if not controlled appropriately.



Furthermore, the increasing number of tourists can lead to also otherwise increasing pressure on the environment, which is already facing pressure from other sectors competing for the same resources and from adverse impacts under changing climate conditions. To increase awareness among the actors in the tourism sector on climate change and forest fire issues, to promote attitudes to prevent the risk of forest fires imposed by tourism activities as well as to enhance the capacity of decision makers and tour operators alike to incorporate climate change risks into development strategies of the sector, the project convened authorities, institutions and organisations involved in the sector together with tour agencies to a seminar on sustainable tourism development under climate change in Armenia.

3.4. Incorporating climate change risks into forest management

Parallel to the activities aimed at enhancing institutional capacities to manage wildfires and increasing public awareness of the risk of forest and grassland fires, the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project has worked with foresters in order to ensure resilience of forests to the direct and indirect impacts related to climate change through enhanced forest management planning and practice and improved forest health monitoring. If the previously presented activities under the forest fire component have aimed to reduce the risk of fire ignition due to anthropogenic factors and to build capacities to effectively suppress and limit fires, the project activities which are looked at next have aimed to reduce forest susceptibility to the abiotic and biotic disturbances and enhance forest ecosystem resistance under climate change. Securing forest resilience, inherent adaptive capacity and sufficient recovery after disturbances under changing climate conditions have also been important targets of the project and its on the ground forest rehabilitation work. Furthermore, the project has initiated the process of increasing the capacities of forest managers to conduct rigorous assessments of the potential climate change impacts in different forest types under a range of scenarios of climate change in order to identify feasible and flexible adaptation measures to mitigate these impacts and help forests adapt to the changing conditions. The overall aim of both the on the ground forest rehabilitation activities as well as the capacity building activities under this project component has been to review current forest management planning and silvicultural practices from the point of view of sustainability under changing climate conditions and to begin the process of incorporating climate change considerations and adaptation strategies into the forest management sector.

Piloting adaptation options on the ground

An important approach in achieving the targets defined above has been the piloting and demonstration of adaptation options on the ground. The project has established four forest rehabilitation pilot projects in the Syunik Province, covering altogether 56.8 hectares of forest land located in different

types of forests in the districts of Goris, Kapan and Meghri (see boxes below).

During the implementation of the pilot projects, which have been designed based on assumptions derived from technical studies on enhancing forest resilience and inherent adaptive capacity to changing climatic conditions, the project has gathered practical knowledge on adaptation options in forest rehabilitation enabling the identification of feasible, flexible and cost-effective adaptation measures at the forest regeneration stage in Armenia. Furthermore, despite the extent of the changes in the climate realised in the future, the demonstrated adaptation options support sustainable multi-purpose forest management and can be considered no-regret or low-regret adaptation options.

Three of the pilot projects have been implemented by the regional forest enterprises of Hayantar and one has been implemented by the management authority of the Arevik National Park. The co-operation with local forest managers has aimed to enhance the capacities within the forest management units to plan for climate change adaptation through revision of the current forest management practices and silvicultural operations over the course of the implementation of the pilot projects and thus to remove individual and institutional barriers for adaptation. Additionally, community members have been directly involved in the reforestation and maintenance work on the forest rehabilitation sites, which has provided them employment but has also aimed to increase their understanding of the need for forest protection.

The pilot project sites represent the types of forest regeneration areas expected to increase under climate change and are located in vulnerable areas in the Syunik Province (see above “Identification of the most vulnerable forest areas in Armenia under climate change” in chapter 1.2). The target forest areas have been disturbed by forest fires, severe and continued pest outbreaks, forest fragmentation and a combination of these factors, and have been further affected by extreme climatic conditions including extended hot periods and droughts as well as by overgrazing and soil erosion. Sufficient natural regeneration

An important approach in achieving the project targets related to securing forest resilience, forest inherent adaptive capacity and sufficient forest recovery after disturbances such as forest fires under changing climate conditions has been the piloting and demonstration of adaptation options in forest management on the ground. The project has established four forest rehabilitation pilot projects in the vulnerable Syunik Province, covering altogether 56.8 hectares of forest land. The target forest areas have been disturbed by forest fires, severe and continued pest outbreaks, forest fragmentation and a combination of these factors, and have been further affected by extreme climatic conditions including extended hot periods and droughts as well as by overgrazing and soil erosion. Three of the pilot projects have been implemented by the regional forest enterprises of Hayantar and one has been implemented by the management authority of the Arevik National Park. The co-operation with local forest managers has aimed to

enhance the capacities within the forest management units to plan for climate change adaptation through revision of current forest management practices and silvicultural operations and thus to remove individual and institutional barriers to adaptation.

has not been observed on the sites due to climatic and anthropogenic factors. In addition to piloting strategies to enhance resilience and adaptive capacity on these vulnerable sites, it has been the target of the project also to identify forest regeneration strategies including the timing of regeneration and site preparation techniques as well as necessary silvicultural operations and interventions during the initial years after forest regeneration, such as irrigation, removing of competition from grasses and agro-technical maintenance, that enable successful reforestation on degraded sites under climate change and climate variability.

With the project coming to its end, agreements on the continuation of tending and management of the reforested sites have been reached with Hayantar, Arevik National Park as well as the Syunik Diocese of the Armenian Apostolic Church.



Box 9. Rejoining a forest area in Goris

The forest rehabilitation pilot site located in Goris is an area where several anthropogenic pressures, including fire, have led to deforestation and where climatic conditions together with overgrazing have prevented natural regeneration following the removal of the forest cover. Respectively, the area, which is surrounded by oak-dominated forests, has been deforested for some decades. This has led to significant soil erosion in many parts of the 15-hectare site. The target of the pilot project located on this relatively demanding site is to rejoin the forest area to improve forest connectivity and integrity necessary for the migration of tree species following potential shifts in their suitable ranges.



In addition to increasing forest connectivity, the site has been planted with mixed species to rehabilitate the inherent adaptive capacity of the area. It is expected that healthy forests with high levels of diversity between and within functional groups are more resilient to changes in the environment. Using local genotypes of native tree species, the site has been planted with seedlings of oak, ash-tree, maple, elm and wild apple. Soil preparation and planting work began on the site in the fall of 2009.

The reforestation site has been tended regularly over the project implementation period. Maintenance activities carried out on the site have included e.g. grass-mowing, weeding and tillage. Under the extremely dry weather conditions observed in the past summers in the area, watering of the seedlings has been a precondition to enable seedling establishment on the poor soil. The survival of the planted seedlings on the reforestation sites is also monitored regularly. In accordance with the monitoring results, infilling has been carried out on the site in order to ensure wanted results of the reforestation. In the most degraded parts of the site, obtaining an adequate tree density to rehabilitate forest ecosystem services has been relatively challenging and resource intensive. In other parts of the site, satisfactory results have been achieved with less effort. As with also the other three forest rehabilitation pilots under the project the regeneration site has been fenced to prevent further damage from grazing.



Box 10. Rehabilitating a valuable juniper open forest in Kapan

The pilot project located in Kapan applies perhaps the most unique approach out of the four forest rehabilitation pilots under the project. The 20-hectare pilot project aims to rehabilitate a part of burnt juniper open woodland on a steep mountain slope. The fire that destroyed the area burned altogether 90 hectares of the juniper forest in 2006. Due to biotic factors, natural regeneration of junipers is very low in Armenia and as the species lack economic value, they have not been prioritised in artificial forest regeneration either. Respectively, regeneration of juniper forests has not been carried out in Armenia in the past three to four decades.



However, junipers can survive on poor, rocky soils and are very important for soil protection and generation, biodiversity preservation, water regulation and even soil carbon management. In this particular case the reforested juniper stand would also prevent soil and debris flow into a river located downhill from the site. Using natural and nursery stock, the project is testing regeneration strategies to prevent further degradation of this valuable ecosystem and to rehabilitate the provision of the critical ecosystem services under climate change.

Starting from the spring of 2010, the site has been planted with seedlings of two native juniper species as well as on a smaller, more fertile part of the site with oak. As before, tending, including grass-mowing, tillage and watering, has been carried out on the pilot site. In accordance with the survival rate monitoring results, also infilling has been carried out on the site. The pilot project has provided the local forest managers knowledge in the rehabilitation of juniper stands and has been able to obtain satisfactory results in establishing a seedling stand on the rocky site, provided that maintenance on the site including e.g. grass clearing is continued to support the growth of the seedlings. A challenge in the implementation of this unusual pilot project has been the availability of good quality juniper seedlings.



Box 11. Ensuring post-disturbance recovery in Meghri

One of the project's forest rehabilitation pilots is located in the newly established Arevik National Park in the Meghri region. The Arevik pilot is an important demonstration project summing up both indirect and direct climate change threats on forests. The oak-dominated forest area initially dried up following an extended pest outbreak creating, together with exceptionally dry and hot weather, conditions for devastating fires. Eventually a carelessly handled fire escaped from a nearby recreational area burning some 80 hectares of the forest. Sufficient post-disturbance regeneration has not been observed on the site due to unfavourable climatic conditions and grazing, and without intervention the forest in the important wildlife area would have likely been left fragmented and degraded. The project has rehabilitated a 20-hectare burnt area taking into consideration the special status of the forest as a part of the National Park and the existing legal requirements for the management of protected areas.



The pilot project has aimed to create a mixed stand with increased inherent adaptive capacity. Simultaneously it has aimed to connect the fragmented forest area, which is a habitat of many protected species. Additionally, the enhanced diversity is planned to reduce susceptibility of the forest to pests by limiting the availability of host species of the main insect pests in the region, which are expected to further benefit from the changing climate. A certain level of natural regeneration has been observed previously in the burnt forest area and the reforestation work carried out on this site has aimed to support the natural regeneration and enrich the species composition established on the stand. Native species planted in the forest area since the fall of 2010 include ash-tree, hornbeam, maple, beech, wild apple and wild pear. Additionally, coppicing has been promoted on the site. Tending and infilling have been carried out on the site based on regular monitoring. Watering has been very important for the survival of the seedlings also on the Arevik site.



Box 12. Preserving resilient local species and biodiversity in Tatev

The most recently launched forest rehabilitation pilot under the project is located on the premises of the beautiful monastery of Tatev in the Syunik region. This smaller scale 1.8-hectare reforestation pilot aims to preserve forest biodiversity and local genotypes of feral fruit trees to maintain forest resilience under climate change. Seedlings of for example walnut, barberry, mulberry, pear, hackberry, cherry plum, medlar and hazelnut have been planted on the site in the fall of 2011. The implementation of the pilot project was agreed with the Mother See of Holy Echmiadzin and has the support of the Tatev village community. The local village members and the monastery will benefit from the fruits and nuts grown on the site.



Introducing scenario planning as a decision support tool in forest management

The pilot projects implemented on the ground by the project have concentrated on adaptation options at the forest regeneration stage. The forest regeneration stage is not just the most sensitive stage to climate variability thus requiring special attention but provides also an opportunity to directly alter the species composition and increase diversity of tree species and the resilience of a forest stand. However, also other silvicultural operations and e.g. harvesting systems might have to be adapted to new conditions. In order to enable the identification of potential impacts induced by climate change in different forest ecosystems under different scenarios of change and at scales relevant to forest management decision making as well as to assess different adaptation options, the project has initiated the process of introducing scenario planning and use of modelling as decision support tools in the forest sector. Under the project, climate change scenarios have been developed for the Syunik Province (Fig. 7) and additionally, the most significant climatic impact factors, namely temperature, rainfall and wind, in the region have been identified based on analyses of long-term weather conditions (see above “Identification of the most vulnerable forest areas in Armenia under climate change” in chapter 1.2).

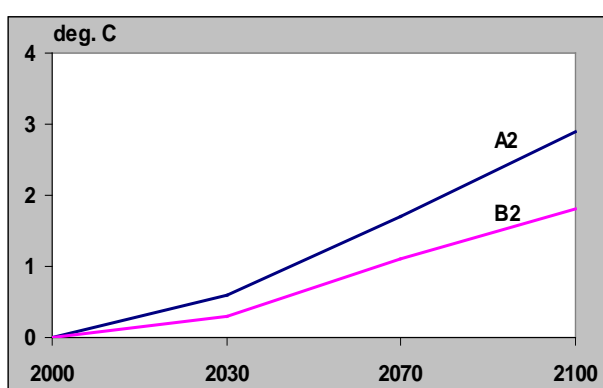


Figure 7. The temperature increase in the Syunik Province is expected to be in the range of 1°C to 3°C. The largest increase of around 5°C will be expected during the summer season. The projections are based on the regional PRECIS model under the A2 and B2 greenhouse gas emission scenarios of IPCC³ compared to the baseline period of 1961-1990.

Furthermore, the use of forest ecosystem modelling to support decision making and forest management planning have been discussed with forest management units, the research community as well as other forest projects implemented and planned to be implemented in Armenia.

Building systematic forest health monitoring

Systematic and regular forest inventory has not been carried out in Armenia's forests in the past two decades. Also capacities to conduct forest health monitoring in a systematic manner are limited. The project has targeted specifically the capacity of forest managers and forest rangers to conduct systematic forest health monitoring so as to identify risks in a timely manner and to allow sufficient time for effective proactive responses. The capacity of forest rangers to conduct regular monitoring in their forest areas was significantly improved by the provision of horses to the forest enterprises of Goris and Kapan, as was described in chapter 3.1. Additionally an important activity under the project has been the development of the first Armenian language manual on the most important forest pest species in Armenia⁴. In addition to describing the most common pests in Armenian forests and nurseries together with their lifecycles and biological characteristics, the manual identifies suitable methods for their monitoring and control and presents also other phytosanitary issues related to forest management and silvicultural operations. Furthermore, the scientific community in Armenia has participated under the project in the identification of leaf-eating pest species which will, based on their biological and climatic requirements and characteristics, likely benefit most from the changing conditions enabling targeted monitoring schemes. They also identified bird and butterfly species which can serve as an indicator of changing forest conditions to enable early warning of the onset of adverse impacts under climate change.

The textbook on forest pests was distributed widely to foresters in the regional forest enterprises and protected areas around the

In order to identify climate change risks in forests in a timely manner and to allow sufficient time for effective proactive responses the project has targeted specifically the capacity of forest and protected area managers and forest rangers to conduct systematic forest health monitoring.

country as well as to scientific institutions. Importantly, the textbook was provided also to higher education institutions, including departments of forestry and agriculture at local universities. In addition to this, the project has worked with the forestry department of the Armenian State Agrarian University in order to incorporate more widely climate change issues as well as modules on sustainable forest management under climate change into the curricula of the students studying to become forest managers. This activity is very important in terms of long-term capacity building in the forest management sector.

Timely and effective control of forest pest species is also increasingly important under aridifying climate conditions. To date the use of environmentally sound pest control methods has been limited in the country and the widespread use of pesticides in the forest ecosystems has affected also forest species communities other than the targeted pests causing adverse impacts to forest biodiversity. To improve forest pest control in Armenia, the project will conduct a pest control demonstration using a biological pest control agent during its last year of implementation.

Guidelines for integrating climate change risks into forest management plans

Forest and protected area management is guided by forest management plans. Currently changing climate conditions and risks posed by climate change are not taken into consideration in forest management planning in Armenia. Based on the gathered experience, the project is developing guidelines on incorporating climate change considerations into the most critical points of forest management plans. The guidelines will comprise for example revised and adjusted

reforestation strategies, diversification of forest stands and revision of recommended silvicultural operations to improve regeneration success under climate variability. Furthermore, the guidelines will include strengthening of forest fire early response preparedness and improved pest monitoring and control. At the landscape level the recommendations will aim to improve forest connectivity to facilitate migration of forest species. The guidelines for integrating climate change risks into forest management plans are planned to be formally included in the national guidelines for the development of the 10-year forest management plans in co-operation with the GIZ "Sustainable Management of Biodiversity, South Caucasus" (SMB) Programme, which is working on updating the Armenian forest management planning system.

Currently changing climate conditions and risks posed by climate change are not taken into consideration in forest management planning in Armenia. Based on the gathered experience and international best practice, the project is developing guidelines for incorporating climate change considerations into the most critical points of forest management plans and the national guiding document of forest management plan development. This is an important step in securing that the impacts of climate change will be taken into consideration at an adequate level in forest management in Armenia.

The "Adaptation to climate change impacts in mountain forests ecosystems of Armenia" project's forest rehabilitation pilots have highlighted the increasing difficulty and the need for more intensive tending required to achieve successful forest regeneration and tree establishment under climate variability in areas affected by disturbances. The forest regeneration stage is most sensitive to changes in the climate due to the sensitivity of seedlings to extreme climate conditions. Watering has been a precondition for the survival of the planted seedlings in the dry summers that have occurred during the project implementation period. Rehabilitation of disturbed areas under climate change will

demand increasing inputs and resources, which may not be available in forest management units. Thus, stand replacing disturbances are and will become an increasingly significant threat to forest biodiversity, forest connectivity as well as forest ecosystem functioning and provision of ecosystem services under Armenia's aridifying climate. The pilot projects have also revealed some institutional barriers, which hinder the adaptive capacity of the forest management sector in addition to the financial constraints. For example, a limiting factor is the capacity of nurseries. Production of high-quality seedlings and breeding of seedlings resilient to extreme climatic conditions are important factors and will be increasingly important for successful forest regeneration under climate change.

Like in the case of the other activities presented previously in this publication, an important factor contributing to the successful implementation of also the forest management activities has been the established good co-operation with the project's main partners, such as Hayantar and its local forest management units. The local forest managers have already observed adverse climate change impacts in the forests and in carrying out their work and agree on the need to review current practices and identify measures to mitigate the negative impacts.

The inclusion of climate change considerations into the national guiding document of forest management plan development is an important step in securing that the impacts of climate change will be taken into consideration at an adequate level in forest management in Armenia. The upcoming renewal of the forest management plans in most parts of Armenia will enable up-scaling of climate change considerations in forest management to the national level in the coming years. The lack of adequate forest inventory data, however, remains a limitation to both improved forest management planning as well as the analysis of potential impacts of climate change in forests.

¹ Proceedings of the Conference "Forecast, Prevention and Suppression of Forest and Grassland Fires". 2011. Available at: http://www.nature-ic.am/en/PR_F_Publications.

² Tourism oriented brochure Armenia – Syunik Forests and Sustainable Tourism. 2010. Available at: http://www.nature-ic.am/en/PR_F_Publications.

³ IPCC, 2007. Climate Change 2007: Synthesis Report. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

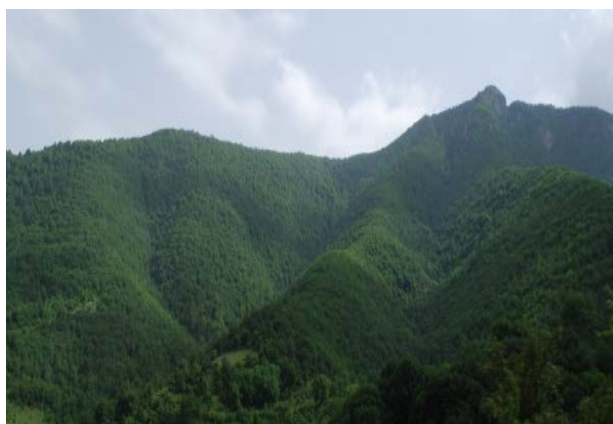
⁴ Nalbandyan, A. 2012. The main pests of Armenian forests and pest control measures. Available at: http://www.nature-ic.am/en/PR_F_Publications.

4. Key lessons from the project's wildfire management component

Disturbances are becoming a significant threat to forest biodiversity, forest ecosystem functioning and forest resilience under Armenia's aridifying climate - controlling forest fires is of great urgency to reduce the vulnerability of forests to climate change

The forest rehabilitation pilot projects of the "Adaptation to climate change impacts in mountain forest ecosystems of Armenia" project have highlighted the increasing difficulty and the more intensive tending required to achieve successful forest regeneration under climate variability in disturbed forest areas located in arid parts of the country. Rehabilitation of disturbed areas under climate change will demand increasing inputs and resources, which may not be available in forest management units. Natural regeneration on disturbed sites in arid areas will likely be insufficient to maintain forest ecosystem functioning at levels similar to those prior to the disturbance. Stand replacing disturbances will thus become a significant threat to forest biodiversity, forest connectivity as well as forest ecosystem functioning and provision of ecosystem services under Armenia's aridifying climate.

Protection of forests from disturbances by taking efficient proactive measures is critical for maintaining forest functioning and forest resilience under climate change. Otherwise maintaining a sufficient forest cover on the demanding sites will become resource intensive, which on a wider scale and under the prevailing economic conditions could lead to lowered rates of reforestation and prioritisation of more productive sites.



Transfer of suitable technologies and the establishment of forest fire early response teams have yielded significant short-term improvements in managing the wildfire problem

The establishment of forest fire early response teams by providing equipment and tools suitable for the suppression of surface fires in the mountainous terrain to three forest management units in the Syunik Province, despite being limited to suppressing smaller scale fires, has had immediate positive impacts on the wildfire management capacities in the region. The tangible and straightforward activity with immediately visible results has enjoyed wide support among the project's partners and stakeholders, and the proven value of the activity transferring suitable technologies to Armenia has spurred replication at the national level by national authorities. The comparative simplicity of the introduced technologies, which however are specifically well suited for the mountainous terrain, and the relatively low initial investment costs associated especially with some of the hand tools have supported the adoption of the approach by local stakeholders. With immediate impacts in the short term, the early response teams create an enabling environment for the development of more comprehensive national responses to wildfires and wildfire management in the longer term.

Furthermore, the provision of horses to the forest management units has built the critical capacities of forest rangers to monitor the forest areas for fires, pests as well as violations in the use of forest resources.

Formalisation of the results is key to long-term improvements in wildfire management

Building on the initiated process of improving co-operation and coordination of all relevant stakeholders involved in wildfire management under the "Adaptation to climate change impacts in mountain forest ecosystems of Armenia" project, a National Task Force on Wildfire Management was established by the decree of the Minister of Emergency Situations and with the endorsement of UNDP, OSCE and the Environment and Security Initiative. The Task Force convenes

technical experts from all relevant government organisations and is led by the national Rescue Service. Its main task is to develop a short-term Action Plan for the improvement of prevention, pre-suppression and suppression of wildfires in Armenia. The Task Force is instrumental for ensuring long-term development of wildfire management in Armenia and up-scaling of project activities to the national level. Furthermore, the formalised Action Plan is important for securing adequate resources for carrying out the longer term processes including revision of the legal framework and establishment of adequate institutional system to ensure law enforcement as well as acquisition of suitable equipment and machinery to build responsive capacities to forest fires. The Action Plan additionally contributes to the long-term public awareness raising through inclusion of the topic into national curricula.

The inclusion of climate change considerations into the guiding document of forest management plan development has the same importance for mainstreaming climate change risk into forest management at the national level.

The successful endorsement of the legal ban on burning of organic matter in forests and agricultural lands is key to beginning the process of changing behaviour related to the use of fire and controlling the main cause of wildfires in Armenia.



The need for improved capacity to respond to disasters such as forest fires under changing climate conditions as well as the need to adapt to climate change is recognised by the project stakeholders

The rapid response of wildfire danger level to the aridifying climate conditions makes climate change induced impacts in forests felt immediately compared to some other impacts with slower onset. Forest managers give

reports of already drying conditions in the forests that they manage causing more forest fires and fire fighters have had to deal with significantly worsening grassland fire situation over the recent years. Additionally, both actors have to deal with the increasing wildfire problem with limited resources. The stakeholders have not identified just the need for improved capacities to respond to the increasing disturbances under climate change, but also the need for enhanced co-operation between different authorities to organise wildfire fighting in an efficient manner. This national ownership has greatly paved way for the activities carried out under the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project and has supported their successful implementation by creating an opportune environment for adoption of new approaches and practices.

The locally made initiative to establish the National Task Force on Wildfire management, which was supported by international organisations, creates a formal platform to develop the organisation of wildfire management in Armenia with the involvement of all relevant stakeholders and importantly with the leadership of local technical experts under the mandate created by the decree of the Minister of Emergency Situations.

Partnerships are essential

The strong national ownership of forest managers and fire fighters of the issue of improving wildfire management has been pivotal for the formation of good co-operation between key stakeholders and the project. The establishment of these partnerships, on the other hand, has been elemental for the effective and efficient implementation of project activities.

The project has successfully formed good relations with the main local stakeholders, but has also created synergistic relationships with other international organisations and initiatives sharing parallel targets in improving wildfire management in Armenia. Partnering with other organisations has resulted in enhanced outcomes and effectiveness of the project.

Cooperation between the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project and GIZ

SMB Programme is contributing to the revision of the current forest management planning guidelines and the inclusion of climate change considerations into the crucial parts of forest management plans securing project results also in the long term.



Wide stakeholder consultation contributes to a good working environment, broad project support and identification of a comprehensive approach to address the wildfire issue

Inclusion of a wide range of stakeholders representing government agencies, ministries, national, regional and local authorities as well as the private sector and the civil society into the activities under the wildfire management component of the project has contributed to enhanced communication between different parties, establishment of co-operation between national stakeholders as well as identification of measures to comprehensively address issues contributing to the wildfire problem. Importantly, this has strengthened the support for the project activities and has successfully brought the urgent issues of wildfire management to the national agenda.

The key stakeholders, such as the regional forest enterprises and the protected area management authorities, have been involved in the project from the planning stages on, which has contributed significantly to individual and institutional capacity building and to the creation of a working environment supporting revision of current practices and adoption of new approaches as well as for example to the utilisation of local traditional knowledge to the fullest extent to identify adaptation options and for instance non-commercial tree species resilient to drought.

Increasing public awareness on the causes of wildfires as well as the impacts of fires in natural ecosystems is highly important for improving wildfire prevention and more generally for increasing understanding of the importance of protection of forests

Overwhelming majority of wildfires is caused by humans in Armenia. Raising public awareness on the issues related to forest and grassland fires, their impacts on natural ecosystems and especially on the causes of wildfires is critical for the prevention of wildfires and protection of vulnerable forests under climate change. Public awareness campaigns have been carried out under the “Adaptation to climate change impacts in mountain forest ecosystems of Armenia” project, but wider and more continuous public awareness campaigns and establishment of an appropriate warning system about fire danger are required to guide a behavioural change in regards to the use of fires. More generally, public awareness raising is critical for the promotion of attitudes and action to protect the environment and increase understanding of the importance of healthy natural ecosystems for the provision of ecosystem services supporting livelihoods of rural dwellers and the adaptation of rural population to climate change.





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