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Appendix 4: Assessment of the Forestry Sector

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DISCLAIMERS

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Abbreviations and Acronyms

a.s.l.	Above sea level
AM	Alternative Management
AR5	Assessment Report 5
ARRANGE	Advanced Multifunctional Forest Management in European Mountain Ranges
BAS	Bulgarian Academy of Sciences
BAU	Business-as-Usual
BCWFI	Branch Chamber of Woodworking and Furniture Industry
BFSA	Bulgarian Food Safety Agency
CBA	Cost-Benefit Analysis
CCA	Climate Change Adaptation
CoM	Council of Ministers
DG CAA	Directorate General “Civil Aviation Administration”
DSS	Decision Support System
EC	European Commission
ECHOES	Expected Climate Change and Options for European Silviculture
EEA	European Environment Agency
EFA	Executive Forest Agency to the Minister of Agriculture and Food
EFFIS	European Forest Fire Information System
EMEPA	Enterprise for Management of Environment Protection Activities
EU ETS	European Union Emissions Trading System
EU	European Union
ExAAA	Executive Agency Automobile Administration
ExAEMDR	Executive Agency for Exploration and Maintenance of the Danube River
ExAMA	Executive Agency Maritime Administration
ExARA	Executive Agency Railway Administration
ExEA	Executive Environment Agency
ExFA	Executive Forest Agency
FA	Forest Act
GHG(s)	Greenhouse Gas
GIS	Geographic Information System
INDCs	Intended Nationally Determined Contributions for reductions in greenhouse gas emissions
LULUCF	Land Use, Land Use Change, and Forestry

MAF	Ministry of Agriculture and Food (until May 2017)
MAFF	Ministry of Agriculture, Food, and Forestry (after May 2017)
MC	Ministry of Culture
MCA	Multicriteria Analysis
MEc	Ministry of Economy
MEn	Ministry of Energy
MEx	Ministry of Exterior
MF	Ministry of Finance
MH	Ministry of Health
MI	Ministry of Interior
MoEW	Ministry of Environment and Water
MOTIVE	Models for Adaptive Forest Management
MRDPW	Ministry of Regional Development and Public Works
MTITC	Ministry of Transport, Information Technology and Communications
NAPCC	National Action Plan on Climate Change
NECCC	National Expert Council on Climate Change
NFI	National Forest Inventory
NGO	Non-Governmental Organization
NIMH	National Institute for Meteorology and Hydrology
NP	Nature Park
NPV	Net Present Value
NSDFSRB	National Strategy for Development of the Forest Sector in the Republic of Bulgaria
NSI	National Statistical Institute
NTEF	National Trust EcoFund
OP	Operational Programme
OT	Operational Target
RCP	Representative Concentration Pathway
RIEW	Regional Inspectorate of Environment and Water
SG	State Gazette
UBF	Union of Bulgarian Foresters
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WGII	Working Group II

Glossary[1]

Climate change refers to a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.
Adaptation is the process of adjustment to actual or expected adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
Mitigation (of climate change) is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).
Vulnerability to climate change is the degree to which any system is susceptible to, and unable to cope with, the negative impacts that climate change imposes upon it. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.
Resilience is the opposite of vulnerability and is defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, capacity for self-organization, and capacity to adapt to stress and change.
Risk is the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as the probability or likelihood of occurrence of hazardous events or trends, multiplied by the impacts if these events or trends occur.

[1] Definitions are based on WGII AR5 (IPCC 2014)

Executive Summary

Bulgarian forests in brief

1. Forested areas in Bulgaria occupy about one third of the country territory, amounting to 4.230 million ha, of which 3.864 million hectares are forests. They are crucial for the supply of various ecosystem services which are key to the quality of life of people and a number of economic activities, such as provisioning of pure drinking water, protection of soils from erosion, climate regulation, timber and non-wood resources, biodiversity protection, and territories for tourism and recreation. Of all sectors, forestry has the highest share of absorption of greenhouse gasses (GHGs) in the Land Use, Land Use Change, and Forestry (LULUCF) assessment for Bulgaria, compensating for about 12 percent of total emissions from 1988 to 2011. Following the Paris 2015 Agreement, that was ratified by Bulgaria, the role of forests for the absorption of GHGs has to increase in the next few decades. In the agreement the forest sector was accorded prominence, through a specific clause (Article 5) dedicated to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks. At present, deforestation is not a problem in Bulgaria. The potential beneficial role of the forest sector is high, because forests are among the most important carbon sinks in the agreement. Governments and forest sector stakeholders should reach an understanding on the role of forests and land-use planning and management in meeting their national long-term climate change mitigation and adaptation goals.

2. The standing wood volume of forests in Bulgaria has almost tripled from the 1960s and now amounts to about 680 million m^3. Bulgarian forests have outstanding biodiversity with the vascular flora alone consisting of 4,102 species. There is a high number of endemic species, which are found only on the Balkan Peninsula and in certain locations in Bulgaria. This sets the country as one of the richest in biodiversity in Europe. To ensure the proper management and protection of this biodiversity and provisioning of various ecosystem services, a large proportion of Bulgarian forests is included in the extensive network of protected areas, which consists of 11 Nature parks, 3 National parks, and 55 strict nature reserves and largely overlaps with the network of NATURA 2000 protected areas, which cover about 34 percent of the territory of the country. The protection of valuable ecosystems has been additionally recognized as a need in article 7 of the Paris Agreement: *"Any assessment of climate change impacts should also take into account vulnerable ecosystems that may have to be protected by 'nationally determined prioritized actions' (Art. 7.9 (c)). Parties should also increase the resilience of 'ecological systems, including through economic diversification and sustainable management of natural resources' Art. 7.9 (e))."*

3. In economic terms, the annual contribution by forestry, logging and furniture production is approximately €500 million (EUROSTAT and European Sector Monitor of Wood Processing and Furniture Industry). About 43,000 people are occupied in the forestry sector and in some rural areas it is the main driver of economic output.

Climate change impacts on the Forestry Sector

4. For Bulgaria, scientific projections indicate that climate change will be associated with increase in temperature, warmer winters and more summer droughts. At the same time, the

number and magnitude of extreme climate events such as prolonged or short-lived periods of intense heat or cold, severe storms, wet snow, and ice accumulation are expected to increase. This will reduce forest health and tree growth, increase attacks from insects and fungi, including invasive species and cause serious losses due to fires and storm-related damages. This could contribute to very high economic losses, degradation of the ability of forests to sequester carbon and affect the quality of life in Bulgaria by reducing the delivery of valued ecosystem services. According to one study (Expected Climate Change and Options for European Silviculture [ECHOES], see ***Annex 4***), wood growth could be reduced by up to 3.5 million m^3 per year. This is equivalent to 42 percent of the annual harvest and would have a devastating effect on the primary production of forest products and the rural economy. Impact of a similar scale could be expected on the forests' ability to protect drinking water supplies, attenuate extreme rainfall and flooding, stabilize vulnerable soils and slopes, facilitate a growing recreation and tourism sector, capture carbon, and support a rich resource of natural biodiversity.

5. Despite the viability and adaptive potential of the Bulgarian forests, there are several groups of vulnerabilities in the context of climate change. These include the following:

- High uncertainties for species-specific responses to modified climate conditions;
- Large areas with coniferous plantations at too low elevations and related to this, the potential for growth decline and various health problems;
- Increased probabilities of large fires and other disturbances such as windthrows, damages from wet snow and ice, attacks from insects;
- Improved conditions for invasive species with high potential for considerable damages to forests; and
- High prevalence of firewood as a timber product that contributes little economic value to the economic sustainability of the sector and its ability to self-fund resilience actions and sequester carbon.

6. These vulnerabilities combined with several other factors, such as (1) lack of in-depth knowledge on the potential effects of climate change on tree species, (2) low state of awareness in society and the lower level of personnel involved in forestry and wood-processing activities, (3) lack of joined-up thinking across sectors, and (4) low level of mechanization in forestry works, may hinder the adaptation of forests to climate change.

Identified adaptation options

7. To adapt the Bulgarian forests to climate change and its potential consequences, to reduce the overall vulnerability of the forestry sector, and to increase its economic viability and resilience, it is recommended that Bulgaria engages in several adaptation measures. These include the following:

1) **Conducting research, education, capacity building, and knowledge extension** to provide a solid foundation for informed decision-making process and adaptive management. Among the necessary main topics of research and needed actions are:
    - Updating the climate change scenario models for the territory of Bulgaria using the most up-to-date versions of climate models;

- Reviewing and updating the existing models of productivity of the most important tree species and those species which may have potential in Bulgaria in a future changed climate;
- Modeling the potential performance of all these species and the forest ecosystems, over the entire territory of the country and under different climate change scenarios and different timescales;
- Continuing the scientific study of genotype variability and suitability for various climate conditions for the most important, endangered, and highly vulnerable tree species;
- Developing spatially explicit risk models for disturbances such as windthrows, fires, insects and damages from diseases;
- Continuous monitoring of forest ecosystems and the effects of climate change, management, adaptation, and mitigation measures;
- Conducting research and planning for the availability of reproductive material on time;
- Assessing the impact of changing wood resources on the processing sector and adaptation strategies to support long-term resilience and value-adding potential;
- Researching additional use of wood and forest products to foster and promote diverse uses of wood and increasing the value-adding potential;
- Disseminating research findings to practitioners and engaging with forest extension service to ensure effective communication; and;
- Taking actions for capacity building in government organizations, forest management structures, private companies, universities, and higher education.

2) **Building resilience in regenerating, expanding, and strengthening forest resources** to increase resilience of forests and meet challenges in recovery operations and higher demand of wood;
   - Strengthening the existing forest resources through enrichment planting;
   - Rehabilitating areas damaged by natural disturbance or die-back and supporting management of protected forests;
   - Maintaining and creating new forest shelter belts in agriculture lands;
   - Creating forest corridors to link existing forest patches in the lowlands; and
   - Initiating new afforestation for short-rotation production of wood for biomass and technological needs.

3) **Maintaining biodiversity and genetic diversity,** thus maximizing the ability of forests to absorb the effects of climate change through a high degree of species and genotype heterogeneity:
   - Preserving available hotspots of biodiversity, old growth patches, and clusters of habitat trees;
   - Promoting management strategies, which insure high species and structural diversity and natural regeneration;

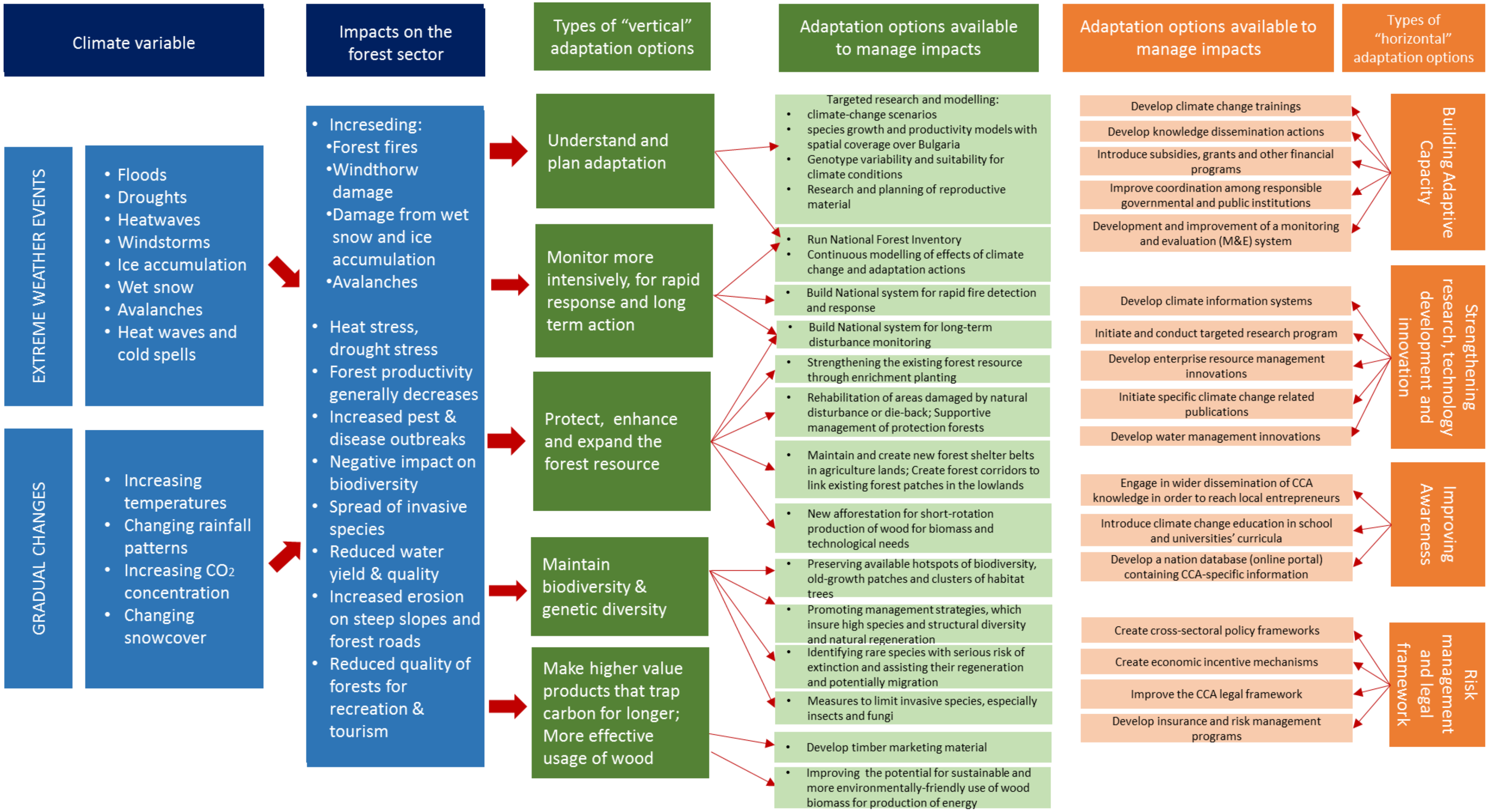
- Limit the spatial clustering of forest patches with lower structural heterogeneity and species richness;
- Identifying rare species with serious risk of extinction and assisting their regeneration and potential migration; and
- Implementing measures to limit the potential of invasive species, especially insects and fungi to enter forest ecosystems.

4) **Building and maintaining systems to cover national rapid forest fire detection, long-term disturbance monitoring, and forest resource monitoring** and in this way minimizing the losses from disturbances and enabling proper management planning and adaptation of forests in areas with the highest risks:
   - Building a national system for rapid fire detection and response;
   - Building national system for long-term disturbance monitoring;
   - Running a National Forest Inventory (NFI); and
   - Integrating existing and novel information systems in modern National Information System for Forest Resources.

5) **Improving the potential for long-term use of higher-valued wood products** and in this way, raising the revenues from wood-processing industries. Implementing these measures and ensuring long-term policy of adaptive management will provide a resilient forest sector, which can handle the various challenges from climate changes better and help forest ecosystems to continue to serve their important role in the Bulgarian society and economy.

6) **Improving the potential for sustainable and more environment-friendly use of wood biomass for production of energy** by decreasing the widespread burning of large quantities of wood in inefficient and polluting household heating facilities. Such measures would provide more efficient use of wood for energy and hence decrease the volume of required wood while at the same time significantly decreasing fine-particle pollution. Afforestation for energy crops and improved supply chains would increase the overall carbon efficiency of this source of energy and displace fossil fuels while preserving the core forest areas.

Figure 1. Simplified Illustration of Impacts of Climate Change and Identified Adaptation Options



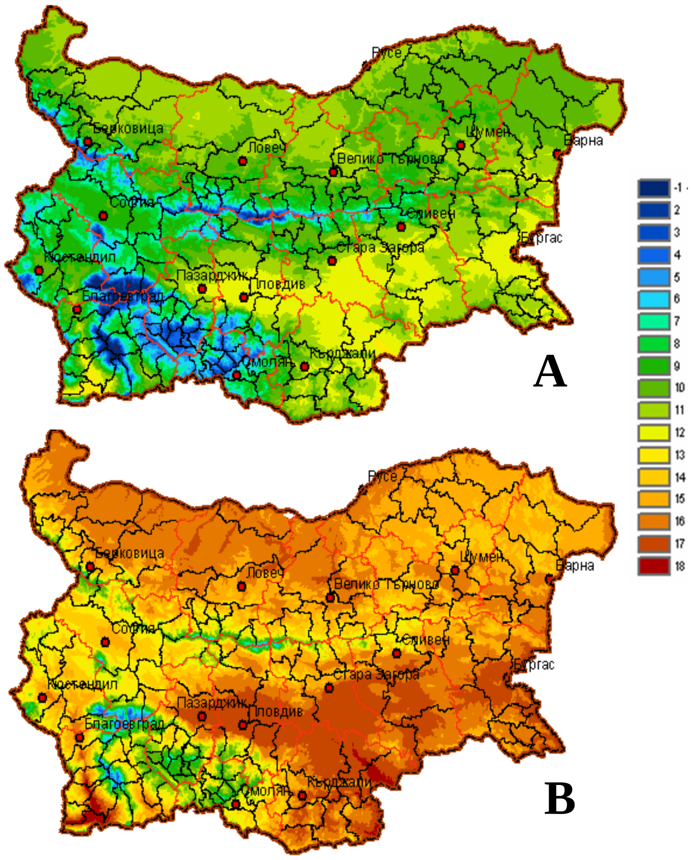
Source: World Bank design.

Introduction – Climate Change in Bulgaria

8. Bulgaria is situated in one of the regions that is particularly vulnerable to climate change (mainly through temperature increase and extreme precipitation) and to the increased frequency of climate change related extreme events, such as droughts and floods. The risks inflicted by climate change related events may lead to loss of human life or cause considerable damage, affecting economic growth and prosperity, both nationally and transboundary.

9. Consensus exists in the scientific community that climate change is likely to increase the frequency and magnitude of extreme weather events. Over the past decades, in Bulgaria this frequency has increased significantly. The most common hydro-meteorological and natural hazards are extreme precipitation and temperatures, storms, floods, wildfires, landslides, and droughts. The number of deaths and victims due to natural hazards is considerable, indicating weather and climate vulnerability. The vulnerability of Bulgaria's population and businesses to the impacts of climate change is accelerated by a relatively high degree of poverty in the most affected areas, the continuing concentration of the country's population in several industrial and urban regions, and various consequences of the transition from a state-controlled economy to a free-market economy. A growing body of evidence suggests that economic losses from climate- and weather-related disasters have also been rising.

Figure 2. Average Year Temperature for 1961–1990 (A); Pessimistic Climate Scenario for Average Year Temperature for 2080 (B)



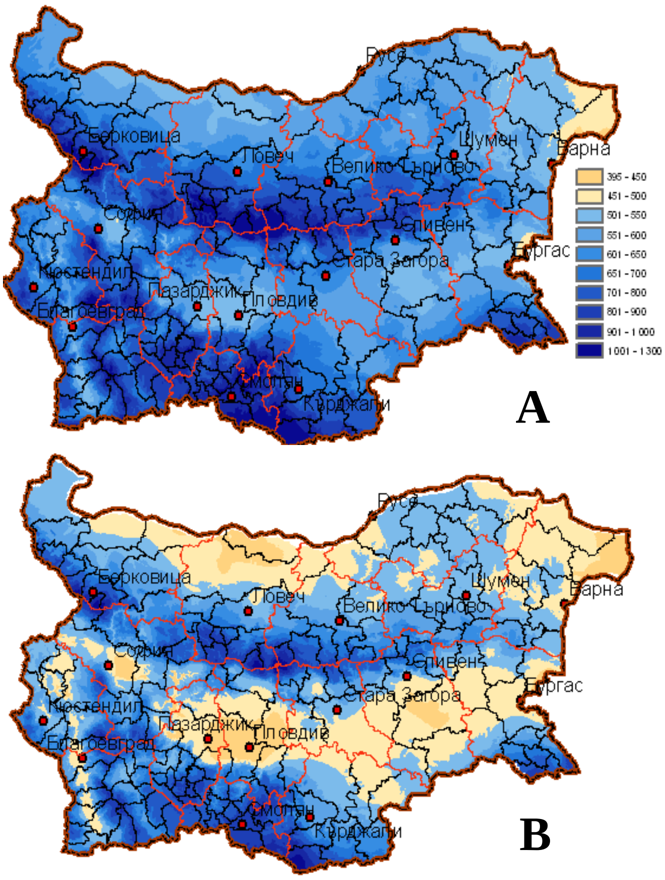
Source: NIMH-BAS.

10. Scientific projections indicate that global temperature will rise between 1.8°C and 4°C by 2100, with the temperature increase in Europe expected to be even higher than the estimated global average.

11. Research conducted by the Department of Meteorology, National Institute of Meteorology and Hydrology at the Bulgarian Academy of Sciences (NIMH-BAS), projects an increase in annual air temperature in Bulgaria of between 0.7°C and 1.8°C by 2020. Even warmer temperatures are expected by 2050 and 2080, with projected increases of between 1.6°C and 3.1°C and between 2.9°C and 4.1°C, respectively. Generally, the temperature increase is expected to be more significant during the summer season (from July to September).

12. In terms of the expected changes in rainfall patterns, a reduction in precipitation is likely, leading to a significant reduction of the total water reserves in the country. In this regard, projections suggest a decrease in precipitation by approximately 10 percent by 2020, 15 percent by 2050, and up to 30–40 percent by 2080. In most climate change scenarios, rainfall during the winter months is likely to increase by the end of the century, but significant decrease in rainfall during the summer months is expected to offset this increase.

Figure 3. Precipitation per Year for 1961–1990 (A); Precipitation per Year for 2080, According to the Pessimistic Scenario (B)



Source: NIMH-BAS.

13. According to the available climate change scenarios for Bulgaria, there is a trend toward increased frequency of extreme events and disasters, as demonstrated in frequent occurrences of heavy rainfalls, heat and cold waves, floods and droughts, hurricane winds, forest fires, and landslides.

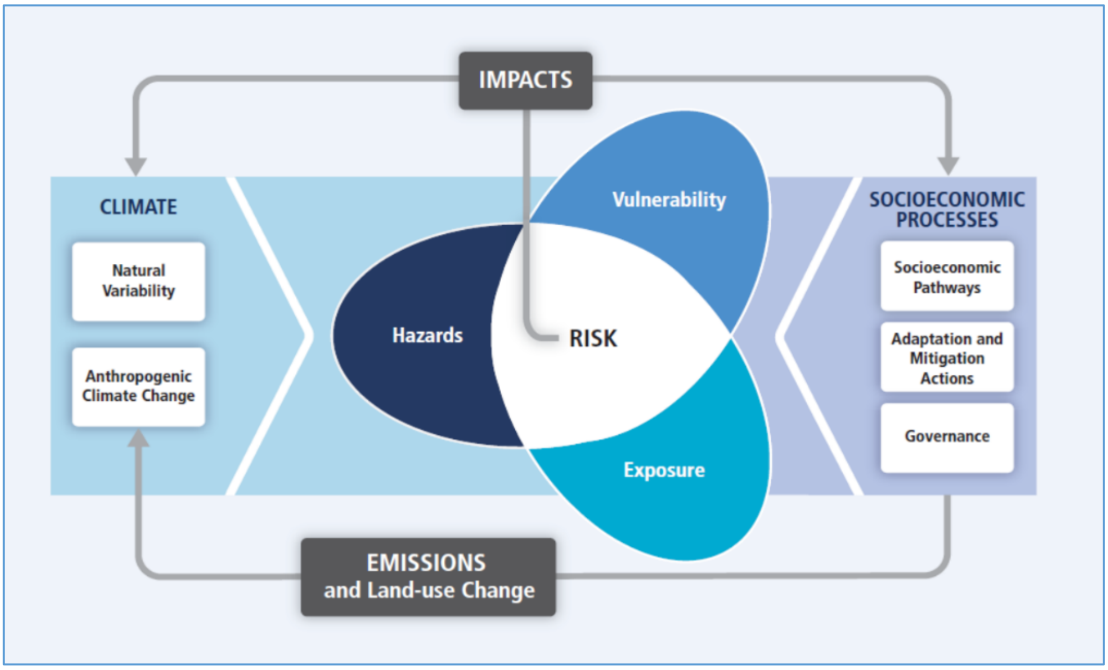
14. Biodiversity, land and aquatic ecosystems, as well as water resources, agriculture, and forestry sectors are expected to be affected by the anticipated changes. These changes would furthermore affect society and its citizens as well as the economy as a whole.

15. Climate change impacts do not affect all people and territories equally due to different levels of exposure, existing vulnerabilities, and adaptive capacities. The risk is greater for the segments of the society and businesses that are less prepared and more vulnerable.

16. This report aims to inform on the vulnerabilities in the Bulgarian forestry sector and at the identification of adequate climate change adaptation (CCA) options. The report is part of a set of nine sectoral assessment reports considered under the climate adaptation support program for Bulgaria, which will form the baseline for the National Climate Change Adaptation Strategy (NCCAS) and Action Plan. The report follows the general logic and structure as proposed for all sectors and is divided into three parts: (1) part one of the report (chapter 1) focuses on the climate change risks and vulnerabilities' assessment; (2) part two comprises a gap analysis of the policy, legal and institutional context (chapter 2); and (3) part three focuses on the identification and prioritization of adaptation options (Chapter 3). This sector assessment was carried out during March–November 2017 as a combination of quantitative and above all, qualitative analysis. Several workshops have been organized as part of an ongoing consultation process, bringing in the wealth of expertise of various stakeholders.

17. The report uses the terms and definitions of risk, vulnerability and adaptation options as introduced by WGII AR5 (IPCC 2014). The risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure. Changes in both the climate system (on the left side in ***Figure 4***) and socioeconomic processes including adaptation and mitigation (on the right side in ***Figure 4***) are the drivers of hazards, exposure, and vulnerability. This understanding reveals the importance of adaptation options. When the options are properly identified and implemented on time, vulnerability, hazard, and/or exposure will be reduced, and thus the risk will be mitigated.

Figure 4. General concept of WGII AR5



Source: IPCC 2014.

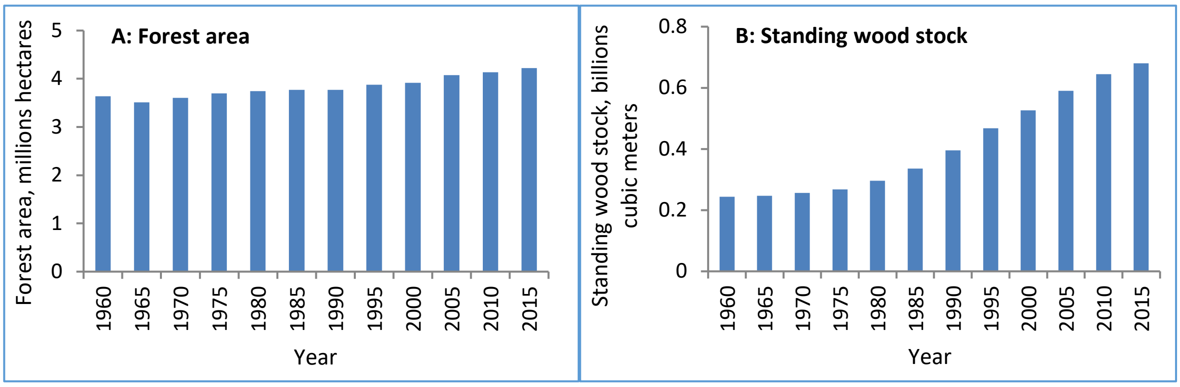
Chapter 1. Risk and Vulnerability Assessment

1.1. Sector Characteristics and Trends

18. Forests are a major sink of carbon dioxide (CO_2) and play a key role in the absorption of carbon through photosynthesis. Tree growth normally exceeds harvest levels and thus represents a net increase in stored carbon. At a national level, the estimation of current and future carbon stocks is essential in the assessment for carbon accounting. Furthermore, forests provide numerous ecosystem services, which are key for the quality of life of people and for sustaining a number of economic activities.

19. Forested areas in Bulgaria occupy roughly one-third of its territory, amounting to 4.230 million ha, of which 3.864 million hectares are forests (data from the Ministry of Agriculture and Food [MAF] 2016) of which 30.5 percent are coniferous and 69.5 percent are deciduous. The total growing stock of forests is estimated at 680 million m^3, of which 44.6 percent are coniferous and 55.4 percent are deciduous. The average national annual increment is 14 million m^3 of wood, which has almost doubled since 1960. The average annual harvest is about 8.4 million m^3. It has increased compared to the period 1960–2000, when it was about 6.5 million m^3. About half of the annual harvest is used as firewood (National Report of Forestry Sector, 2005–2011). Between 2011 and 2014 the percentage of sawn wood produced was between 11 and 15 percent of the total volume harvest, which is well below the average for the European Union (EU) of approximately 23 percent (EUROSTAT). In the 50 years between 1960 and 2015 the forest area increased by 0.5 million ha, but the standing wood volume has almost tripled (***Figure 5***). The territory increase was mostly due to afforestation before the 1990s and natural forest succession on abandoned agriculture lands after the 1990s. The average age of forests is 57 years. According to the Sixth National Communication on Climate Change (2013), in the years between 1988 and 2011, the Land Use, Land Use Change, and Forestry (LULUCF) sector of Bulgaria compensated about 12 percent of the total GHG emissions of Bulgaria. There was a highly varying share mostly due to strong reduction of GHG emissions in the country which dropped from 105 million tons CO_2 equivalent in 1990 to 55 million tons CO_2 equivalent in 2014 (EUROSTAT report). The highest share for the absorption of GHGs was forests, which accounted for 93 to 95 percent under the LULUCF emissions assessment. The total estimated carbon stock of Bulgarian forests is 202 million tons, which together with the accumulation in the soils and forest floor litter amounts to 733 million tons (Raev et al. 2011). Following the Paris 2015 Agreement, that was ratified by Bulgaria, the role of forests for the absorption of GHGs has to increase in the next few decades. In the agreement the forest sector was accorded prominence, through a specific clause (Article 5) dedicated to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks. At present, deforestation is not a problem in Bulgaria. The potential beneficial role of the forest sector is high, because forests are among the most important carbon sinks in the agreement. Governments and forest sector stakeholders should reach an understanding on the role of forests and land-use planning and management in meeting their national long-term climate change mitigation and adaptation goals.

Figure 5. Total forest area of Bulgarian forests (A) and standing wood stock (B) by 2015



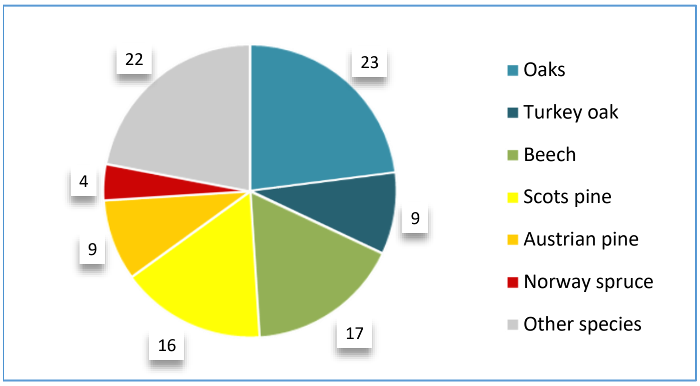
Source: Data from EFA.

20. The total economic aggregate of forestry and logging of Bulgaria is about €197 million (EUROSTAT 2013 data). According to the European Sector Monitor of Wood Processing and Furniture Industry (2009 and update in 2010), the production of furniture in 2010 accumulated to €356 million. About 43,000 people are occupied in the forestry sector, of which about 8,000 are employed in the management structures of the forest administration, 20,000 are employed in enterprises for furniture production, and 15,000 in the wood processing (NSI 2016). However, in certain regions with high forest area, the forestry sector is the most important provider of incomes for the population. The wood processing and furniture sectors of Bulgaria comprised 3,600 enterprises, most of which are microenterprises. By number, large enterprises account for less than 1 percent.

21. The Bulgarian flora and forests have several important characteristics. The great diversity in relief (from sea level up to almost 3,000 m above sea level [a.s.l.]), transitional position between different climate types and vegetation regions, and the fact that the Balkan Peninsula was one of the most important refugia for species in Europe during large glaciations, all contribute to the very high diversity in ecosystems and number of species. The vascular flora of Bulgaria consists of 4,102 species (Assyov et al. 2012), of which more than 10 percent are trees, shrubs, and lianas. There is a high number of endemic species, which are found either only on the Balkan Peninsula or only in certain locations in Bulgaria. This sets the country as one of the richest in biodiversity in Europe. To ensure the proper protection of these species, there is an extensive network of protected areas, of which there are 11 Nature Parks (NPs), 3 national parks, and 55 strict nature reserves. In addition, there is an extensive network of NATURA 2000 protected areas, which cover about 34 percent of the territory of the country. More than 55 percent of the forest areas are included in these protected areas, which set specific requirements for their management directed toward protection of the natural environmental conditions and species composition. The protection of valuable ecosystems has been additionally recognized as a need in article 7 of the Paris Agreement: *"Any assessment of climate change impacts should also take into account vulnerable ecosystems that may have to be protected by 'nationally determined prioritized actions' (Art. 7.9 (c)). Parties should also increase the resilience of 'ecological systems, including through economic diversification and sustainable management of natural resources' Art. 7.9 (e))."*

22. The largest forest area is occupied by species from the *Fagaceae* family (52 percent of the forest area), followed by *Pinaceae* (27 percent), *Betulaceae* (10 percent), *Fabaceae* (4 percent), and others. The *Fagaceae* family is represented by oaks, beech and chestnut (***Figure 6***). The oaks are the most important species for the lower-altitude areas of the country and dominate the lowlands, hills, and the lower-altitude slopes of the mountains up to about 800 m a.s.l. There are eight naturally presented species of oaks in Bulgaria (depending on botanical classifications, the number may rise up to 21). For practical reasons, the Turkey oak (*Quercus cerris*) is often categorized separately due to lower wood quality. Beech species (*Fagus sylvatica* and *Fagus orientalis*) occupy 17 percent of the total forest area and dominate many mountain slopes between 900 m and 1,500 m a.s.l. *Fagus orientalis* is represented in the Strandzha Mountain and small areas in the eastern most part of Stara Planina, while *Fagus sylvatica* dominate the whole range of Stara Planina, Sredna Gora, Osogovo, Vitosha, Belasitsa Mountains and mix with coniferous species (mostly fir) in the Rila, Pirin, and Rhodope Mountains. The family *Pinaceae* is represented in the country by five pine species, one spruce species, and one fir species. The pines are Scots pine (*Pinus sylvestris*), occupying 47 percent of the area of the natural coniferous forests, Austrian pine (*Pinus nigra*) occupying 8 percent of the natural coniferous forest, Bosnian pine (*Pinus heldreichii*) (limited distribution), Macedonian pine (*Pinus peuce*) occupying 2 percent of the natural coniferous forests, and Mountain dwarf pine (*Pinus mugo*) forming large bushes above the tree line mostly in Pirin and Rila national parks. Norway spruce (*Picea abies*) occupies 22 percent of the natural coniferous forest, fir (*Abies alba*) occupies 5 percent and mixed beech-conifer forests occupy 12 percent, where mostly the mixture is between beech, fir, and spruce. These coniferous forests dominate the mountain slopes and are the main species in the high mountains in southern Bulgaria (Rhodopes, Rila, Pirin, and Vitosha) (Panayotov et al., 2016b).

Figure 6. Percentage of area occupied by the main tree species in Bulgaria

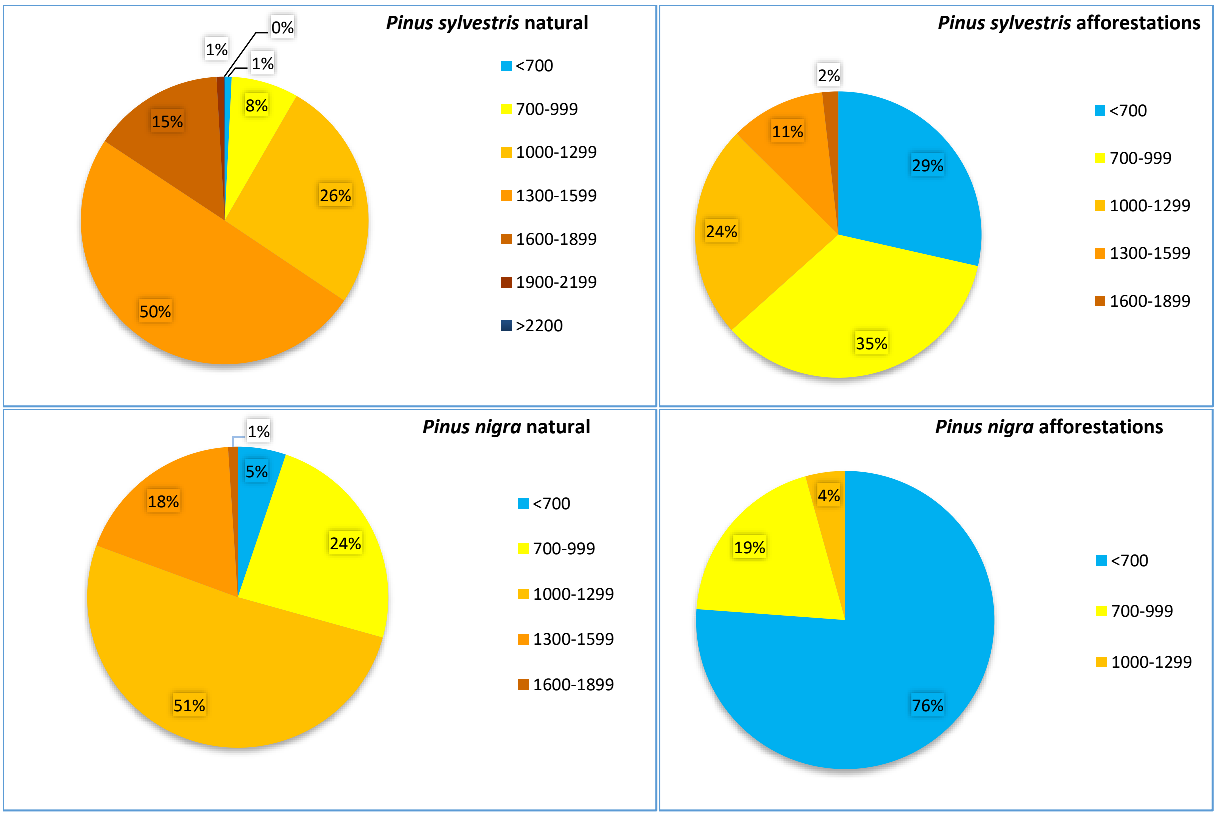


Source: Data from EFA.

23. Besides the natural distribution of pines, there are large areas of plantations (above 1.5 million hectares), which were created mostly during the middle of the 20th century for erosion control and restoration of degraded forest areas. They are mostly Scots pine (48 percent) and Austrian pine (41 percent). About 30 percent of these plantations from Scots pine were established at altitudes below the natural distribution of the species in Bulgaria (***Figure 7***). Another 35 percent are between 700 m and 1,000 m a.s.l., where only 8 percent of the natural forests of the species are found. The altitude distribution of Austrian pine plantations is similar with 76 percent of their territory below 700 m a.s.l., where only 5 percent of the natural forests of this species are found. The reasons for this were several: (1) these species are relatively easy to plant and grow well on a variety of soils, including those prone to erosion; (2) coniferous species reduce fine-particle sedimentation all year round, which is important for the land areas

next to water dams; and (3) these two species produce valuable timber with a variety of possible uses in the wood-processing industry and construction works. However, in recent decades there has been an increase in drought stress due to higher observed temperatures and occasional long precipitation-free periods in summer and autumn. This has contributed to reduced growth and deterioration in the health status of many plantations, especially of Scots pine at lower altitudes.

Figure 7. Distribution in altitude belts (m a.s.l.) of natural forests and afforestation of Scots pine (Pinus sylvestris) and Austrian pine (Pinus nigra) in Bulgaria



Source: Panayotov et al. 2016b.

24. The future development of the forestry sector is largely dependent on several simultaneous processes, the general policy of the governments for the forests role and management, climate change effects, land use and land-use change effects, and timber processing industry and market evolvement. Policy is reflected in various legal acts (see Chapter 2) and especially in the **National Strategy for Development of the Forest Sector in the Republic Bulgaria (NSDFSRB) 2013–2020 and** provide the basis for the solid role of the forest and continuous growth of the importance of the Bulgarian forests for the national economy and environment. The main priorities of this strategy are: (1) sustaining vital, productive and multifunctional forest ecosystems, contributing to the mitigation of the effects of the climate changes; (2) protection, restoration, and maintenance of the biological and landscape diversity in the forest territories; (3) increasing the vitality and competitiveness of the forest sector; and (4) usage of the forest sector potential for the development of the green economy. The 20 operational targets (OTs) of this strategy are based on the expectation of increase in the forest area, growing stock and carbon storage, improvement of management strategies, protection of genetic diversity and biodiversity, and general increase of forest resilience to the various biotic and abiotic challenges

for the forests. The overall forest area is expected to increase slightly, mostly due to plantations in eroded lands and abandoned agriculture lands. While the forest area cannot grow substantially due to land-use restrictions (that is significant conversion of agriculture land to forestry is not expected), the growing stock and hence, carbon accumulation is expected to increase in the next decades mostly due to growth of the currently young forests. The expected increase in the total growing stock is to 743.5 million m^3 in 2020 and 812 million m^3 in 2030, which is about 20 percent of total increase compared to 2015.[2] The amount of stored carbon in trees is expected to increase to 264 million tons of carbon in 2020 and 288 million tons of carbon in 2030. The main risks for the overall forest state, growing stock, and ability to serve various ecosystem services are related to the potential negative effects of climate change, which are listed in sub-chapter 1.3. There is high uncertainty linked to some of these effects and their magnitude.

1.2. Past and Present Weather Events and Their Consequences and Response Actions in the Forestry Sector in Bulgaria

1.2.1. General changes in climate and weather extremes

25. Climate records in Bulgaria, which date from the end of the 19th century show trends of increase of temperatures in the last decades. This is particularly well-expressed in the mountain regions, where for 2000 to 2015, 7 of the 10 warmest summer periods (June-August) and 4 of the 10 warmest winters (December-March) were recorded for the whole continuity of the mountain records.[3] In the period 2010–2015, the highest average monthly temperatures as well as several absolute maximum temperatures were also observed. At the same time some of the driest seasons and years have occurred both in the lowlands and the mountains. The droughts they caused were comparable or more severe than the renowned droughts of 1902–1913, 1928, 1942–1953, 1982–1994 and 1988. These observations were considered as signs of ongoing climate change by several researchers (Raev et al. 2003, Alexandrov et al. 2004, Brown and Petkova 2007, Grunewald et al. 2009, Nojarov 2012) and considered as the first signs of the predicted future climate for the region, which is expected to be marked by higher summer temperatures, frequent summer droughts, and warmer autumns and winters.[4] Phenological observations provide an additional indicator of changing climate and these show 7 to 15 days earlier onset of development phases in the last decades compared to previous periods.[5] While such an effect generally increases the growing season and, therefore, the potential net growth, it also poses higher risk for damages from late frosts. This was frequently observed in the last decade not only in flowering fruit trees, but also in important forest species such as beech. The most recent examples were in 2016 and 2017, when earlier leaf development due to warmer winters caused frost damage when cold spells occurred in May.

26. It is important to note that despite the general trend of higher temperatures in recent decades, long cold periods have periodically occurred during winter. Typical examples are the January–February period of 2012 and January of 2017, when there were long periods with temperatures below -10˚C and persistent snow cover even in regions with mild winters. January

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[2] Sixth National Communication on Climate Change, 2013.
[3] Musala station, 1933 to present.
[4] National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy, 2014.
[5] Third National Action Plan on Climate Change (NAPCC), 2012.

2017 was the coldest in the last 53 years for Sofia. During such cold periods, which sometimes occur in otherwise warm winters (for example 2016), temperatures below -20˚C were recorded in many places in Bulgaria and -25˚C were registered in several locations. Although higher than the absolute record of -38˚C (Tran 1947) such cold events remind that the climate of Bulgaria is characterized by high seasonal temperature amplitudes.

1.2.2. Increased frequency and severity of drought

27. Droughts are usually described as the most typical impact that can be expected due to climate change in southern Europe, including the territory of Bulgaria (IPCC 2013). The potential adverse impact of droughts on Bulgarian forests has been studied in several occasions in the past, when higher mortality was observed. Among the examples are insect outbreaks and associated mortality in Scots pine forests after the extensive droughts of 1928 (Russkoff 1928) and 1945–1947 (Zashev 1950); the first wave of mass mortality in pine plantations at the end of the 1980s and beginning of the 1990s, which according to Raev, Knight, and Stevena (20113), and Raev et al. (2011) was related to a long drought in the 1980s; and the recently observed health problems in many plantations, mostly from Scots pine at lower altitudes (Naydenov 2016), which is also often initiated by dry years.

1.2.3. Increased pest and diseases outbreaks

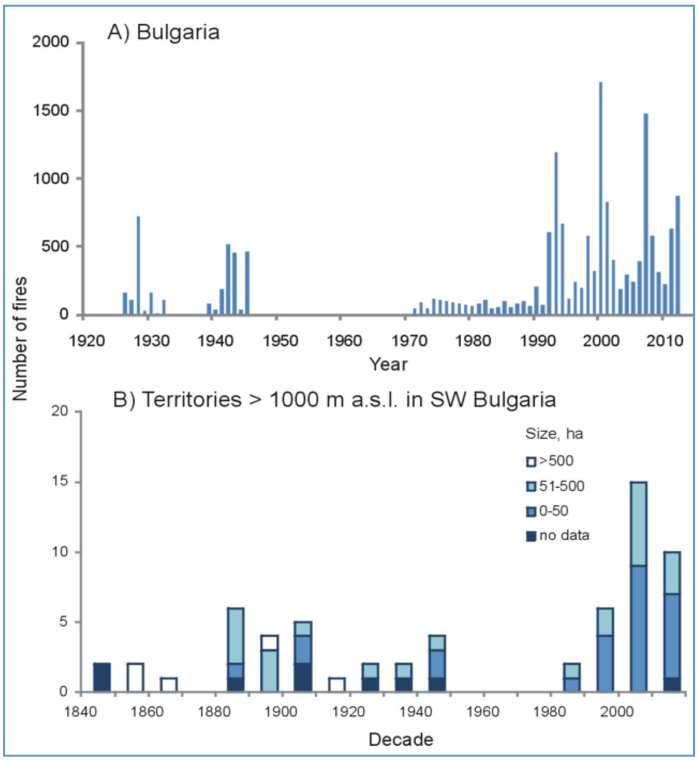
28. Recent reports for the health status of Bulgarian forests show a wave of mortality where the direct cause were insect outbreaks, but often they were preceded by general health deterioration after drought years. The most strongly affected were Scots pine plantations at lower elevations (for example below 700 m a.s.l.) where mostly *Ips acuminatus* and *Ips sexdentatus* outbreaks resulted in wood losses of 225,000 m^3 on an area of 15,000 hectares in 2015 and 2016 (Naydenov 2016). More drought-resistant *Pinus nigra* plantations also experienced higher stress at lower altitudes in the last decades, mostly due to periodic outbreaks of the pine processionary moth (*Thaumetopoea pityocampa*) and the group of pine sawflies (*Diprionidae*), mostly *Neodpirion sertifer* and *Diprion pini*. The deciduous species, mostly oaks were affected by attacks from *Lymantria dispar* L. This caused defoliation, loss of increment and physiological stress, often contributing to death (Mirchev, Georgiev, and Matova 2011). These attacks, which are ongoing, have prompted several actions from the EFA and in 2016 several instructions were issued to increase the intensity of sanitary salvage logging in plantations with low health status. Another example of very high losses from insect outbreaks is the *Ips typographus* outbreak in Vitosha NP, which started after windthrows in 2001, and within a 10-year period affected more than 300 hectares of mature natural and planted Norway spruce forests. This outbreak was facilitated by several unusually warm and dry summers, which allowed the bark beetles to have several consecutive generations in one season and thus affect a much larger territory. Although such outbreaks are controlled by several factors, including tree species composition, forest age and structure, appropriate and timely silvicultural activities, and storm damages, warmer summers increase the potential of insects to affect wider territories, including at higher altitudes (Panayotov et al. 2017). In addition to the damages caused by insects, coniferous forests are especially affected by the spread of fungi. The highest negative effects are caused by *Heterobasidion annosum*, which increased its impact after the drought of the 1980s. Recently, mortality problems in low-altitude pine plantations, established outside

their natural distribution area, were also attributed to attacks by several fungi, namely *Sphaeropsis sapinea, Gremmeniella abietina and Cenangium ferruginosum.*[6]

1.2.4. Forest fires

29. Probably the most important effect of continuous dry and warm periods is the increase of fire risk. The fire statistics of the EFA revealed almost 14,000 forest fires for 1970–2014, with a dramatic increase after 1990. The number of fires that occurred annually in forests peaked at more than 1,000 in several years with dry summers in the last decades (n=1,150 with 10,147 hectares burnt area in 1993; n=1,700 with 58,000 hectares burnt area in 2000 and n=1,400 with 43,000 hectares burnt area in 2007) causing huge economic losses. A recent analysis of historical data (Panayotov et al. 2017) revealed that, although most forest fires were located in the lowlands, in the mountain coniferous forests, there were also extensive fires with burnt territories of more than 500 hectares (up to 10,000 ha) and many of them also occurred in dry years (***Figure 8***).

Figure 8. Forest fires in Bulgaria for the whole territory of the country (A) and only for mountain regions in Southern Bulgaria (B)



Source: Panayotov et al. 2017.

Note: Prior to the 1970s the country-level statistics are available only for two isolated periods. The highest fires frequencies for Bulgaria are in known dry summers.

1.2.5. Damage through wet snow accumulation

30. Wet snow events occur periodically in Bulgaria and damage high wood stocks in forests. The largest recorded was in the winter of 2015, when an exceptional snowfall event (more than 1 m of new wet snow in one night, March 7–8, 2015) caused extensive damages (about 1 million m^3) mostly in the Rhodope Mountains at elevations between 800 m and 1,300 m a.s.l. The majority of the forests affected by that event were dense Scots pine afforestation. Other large recorded events occurred in the Mesta region of the Western Rhodopes in 1987 (affecting *Picea abies* and *Pinus sylvestris* forests, 70,000 m^3) and 1988 (affecting *Picea abies* and *Pinus sylvestris* forests, 120,000 m^3); the Razlog area in the Pirin Mountains in 1988 (affecting *Fagus sylvatica* and *Pinus sylvestris* forests, 15,000 m^3); and the Simitli area in the Pirin Mountains in 1988 (affecting *Fagus sylvatica* and *Pinus sylvestris* forests, 15,000 m^3). Following snow events, more than 100,000 m^3 of wood was logged in the 1930s in the western most parts of the

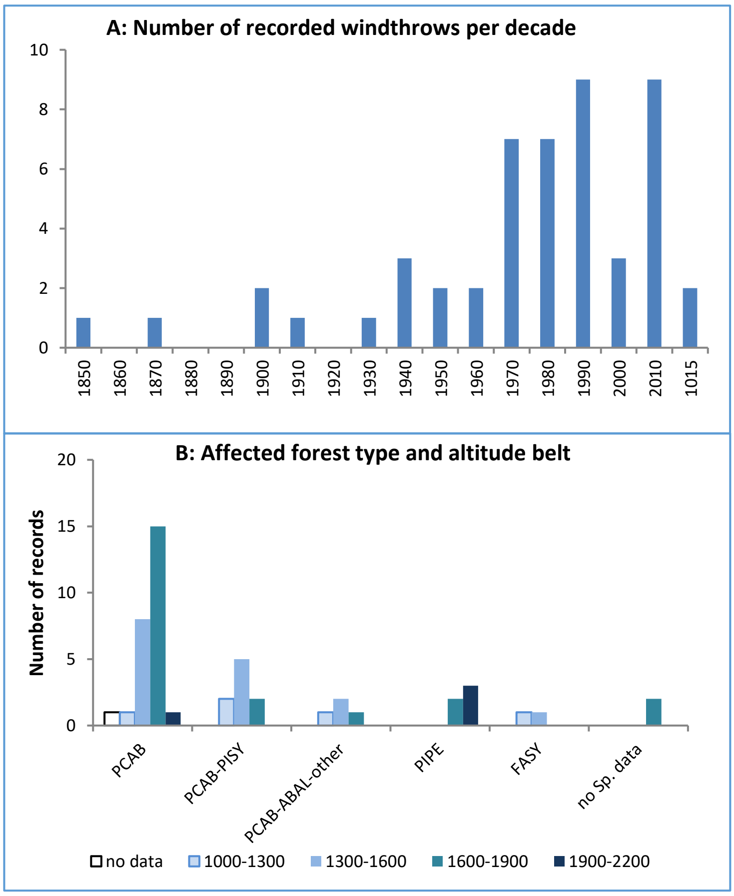
[6] N. Zafirov, personal communication

Rhodope Mountains (Penev 1948, Panayotov et al. 2017). The available data shows that most vulnerable from the severe damages from wet snow are dense pine plantations and young natural forests below 1,500 m a.s.l.

1.2.6. Increased frequency and severity of storms

31. Storms with strong winds cause endemic and catastrophic windthrows mostly in coniferous forests usually dominated by *Picea abies* (Norway spruce). This is the second-most frequent natural disturbance in the Bulgarian mountain forests after fires. The data analysis by Panayotov et al. in 2017 showed that there were at least 59 windthrows which caused the collapse of all trees on territories of more than 1 hectares for the last century. Windthrows mostly affected Norway spruce forests, Norway spruce-Scots pine mixed forests, and, to a lower extent, Macedonian pine and beech forests (***Figure 9***). The same analysis revealed that other coniferous species besides Norway spruce were also affected in severe storms (***Figure 9***). The largest recorded windthrow (known as the 'Beglika windthrow') occurred in May 1961 when 3,000 hectares of Norway spruce and mixed Norway spruce-Scots pine forests were blown down in several patches in the Western Rhodopes. The next two largest windthrows occurred in the Pirin Mountains–a 600 hectares windthrow in 1978 and a 535 hectares windthrow in 1971. Several events larger than 300 hectares affected mixed Norway spruce-Scots pine forests in the Beslet region in the Western Rhodopes (in 1984 windthrows affected 350 ha; in 1983 they affected greater than 400 ha; in 1997 they affected 350 ha) (Panayotov et al. 2017). There is a trend of increase in the number of events after the 1960s (***Figure 9***), which is in line with the European-wide trend for this kind of disturbance (Seidl et al. 2014). Most of the windthrows were at areas between 1,300 and 1,900 m a.s.l.. Windthrows and bark beetle outbreaks, which frequently follow windthrows, are among the highest risks for coniferous forests in Europe and are expected to be a major management problem in the future (Seidl et al. 2014, Kulakowski et al. 2017).

Figure 9. Recorded windthrows with size above 1ha in Bulgaria per decade (A) and Forest type and altitude belt (B)



Source: Data from Panayotov et al. 2017.

Used abbreviations: PCAB – Norway spruce (Picea abies); PISY – Scots pine (Pinus sylvestris), ABAL – Silver fir (Abies alba); PIPE – Macedonian pine (Pinus peuce); FASY – Beech (Fagus sylvatica); No sp. data – no specific data on the dominant species.

1.2.7. Damage through ice accumulation on trees

32. Ice accumulation on trees is a frequent event for the eastern part of Bulgaria and is usually associated with winter storms coming from the Black Sea. These events cause breakages of branches and occasionally of whole trees (mostly lime and oak species) thus reducing wood quality and sometimes requiring salvage logging. Several events were also recorded for the mountain regions causing damage to common hornbeam and beech forests. The largest recorded damage event in recent decades occurred in 2015 (about 5,000 hectares of damaged forest area mostly in northwestern Bulgaria) and 2007 (2,180 hectares of damaged forest area). For the 2015 event, the estimated losses were over 240,000 m^3 wood and costs for recovery more than BGN 15 million.

1.2.8. Floods

33. Floods usually cause damage in the lowlands of Bulgaria but are often linked positively to forests because of their very high importance for erosion control and the regulation of water runoff on steep slopes (Raev 2005). This is one of the most important ecosystem services of the Bulgarian forests and dominated the management goals during the 20th century, when large-scale afforestation took place on steep and eroded slopes and decreased the number of flood events. About 250,000 hectares of the Bulgarian forests serve special water-protection functions and another 220,000 hectares have as a primary goal the protection from soil erosion. According to the climate records, the number of events with overnight rainfall above 100 mm, which are the main reason for floods, increased by 30 percent during 1991–2007 compared to 1961–1990. In recent decades, the most damaging events of this kind were the floods along the Black Sea coast in the summer of 2014 and the floods in the summer of 2005, when continuous heavy rains caused numerous floods in many regions of Bulgaria. This underlines erosion control and regulation of water runoff as one of the most important future ecosystem services that must be provided by Bulgarian forests in the 21st century and beyond.

1.3. Sector Related Climate Change Risks and Vulnerabilities

34. Climate change is a potential driver of significant changes in the forests of Bulgaria and while their interactions and combined effects are complex, the main **vulnerabilities** are outlined in the following paragraphs:

1) Species-specific physiological responses to modified temperature and precipitation regime and inability to respond to changing climatic conditions.

35. Plants are immobile organisms and are particularly vulnerable to changes in temperature and moisture conditions which are outside the usual range. Some species may lack the plasticity and adaptability to cope with new climate conditions and thus become locally or globally extinct or suffer serious growth and health problems. This is a major challenge in a country with a high number of endemic species and rich biodiversity protected by modern standards and legal obligations (such as the Biodiversity Act [BDA]) and the Forestry Act [FA]). It is likely that much of the efforts in forest management in Bulgaria in future will be related to maintaining rare habitats and species besides serving other ecosystem services. Such efforts will require thorough understanding of the species capabilities to cope with various climate conditions, which sets an urgent need for further research because many local plant species were not well studied in terms of their adaptability and capability to cope with harsher climate conditions. In

addition, the responses of trees to environmental conditions differ in the course of their life, which may have serious consequences. An example is lower drought resistance of saplings and young trees compared to older trees which may compromise regeneration and lead to general decrease in the presence of a species in a given region despite the ability of older trees to cope with harder climate conditions. A general decrease in production of woody material will decrease carbon sequestration, reducing the ability of Bulgaria to offset its carbon emissions from other sectors and ultimately, leading to a vicious circle of increased climate change. A productive forest sector supplying the raw material for long-lived wood products will bolster the economic case for forestry and afforestation while storing the captured CO_2 over the long term.

36. Most vulnerable from this aspect are:

i. Rare species with already limited distribution, especially when migration options are not possible. Examples are treeline species (for example, *Pinus heldreichii, Pinus peuce, Acer heldreichii*), the habitat of which will be pressurized between other tree species migrating from lower altitude and an inability to migrate upward due to terrain and climatic constraints. Another example in this category includes species with small habitat in an isolated location which are relict from an earlier climate, such as endemic globally unique populations of *Quercus protoroburoides* and *Quercus mestensis*, isolated localities of rare *Salix* and *Daphne* species in mountains, *Aesculus hippocastanum*, *Cercis siliquastrum*, *Castanea sativa*, *Abies borisii-regii*, *Juniperus excelsa* and numerous shrub species described in the Red Book of Bulgaria, Vol.3, 2015, category F; and

ii. Species with higher demand for moisture, especially in lowlands (for example, *Alnus* species, *Quercus robur* and *Quercus hartwissiana*, *Fraxinus oxycarpa*, *Ulmus minor, Salix* sp. and *Populs* sp. (local species, and so on).

2) Uncertainties for the interaction between species such as competition for resources, which is one of the main drivers of forest dynamics and composition in conditions of modified climate.

37. There is high probability that some species may lose their growth advantage compared to other species which in turn may seriously modify forest composition and, in the long-term, productivity and other related ecosystem services served by the specific forests.

3) Effects of natural disturbances on forests.

38. This is potentially the most important factor for forests given the fact that natural disturbances often lead to dramatic changes in forest structure and environment, which may quickly lead to other responses due to the abovementioned points (i) and (ii). Examples are fires, windthrows, and bark-beetle outbreaks, which cause mass mortality and after which the species with a better adapted regeneration strategy for the new climate conditions may take advantage of the lack of competition and replace the formerly dominant species. While in natural conditions such temporal dynamics in forest composition and structure are often a part of the overall forest dynamics, new climatic conditions may lead to completely different species compositions and, therefore, ecosystems over a relatively short time period. In addition to the general environmental impact, natural disturbances often cause huge losses due to loss of wood,

high cost of recovery measures, or the need to sell salvaged wood at very low prices. The losses in wood stock alone could be demonstrated with examples from past events with high severity as for example the 1961 windthrow in the Rhodopes (less than 1 million m^3 of high-quality wood stock), the wet snow damages from 2015 in the Rhodopes (less than 1 million m^3), and the large fires with potential for complete losses of wood. The financial losses from fires in 2016 alone, which was relatively low when compared to other years, were more than BGN 6 million without considering further necessary expenses for forest recovery (EFA data).

39. Most vulnerable from this aspect are:

i. Coniferous plantations at low altitude, especially bordering with agriculture land or urban settlements. These plantations, mostly from Austrian pine and Scots pine are the most affected by fires in the last decades which resulted in modeling high total risk of fires for the lowlands and it can be expected that this risk will further increase with heat waves and drought periods;

ii. Norway spruce forests with uniform structure and age below 160 years, which are highly vulnerable to windthrows and consequent bark beetle outbreaks (Panayotov, Kulakowski, et al. 2016). These are the majority of Norway spruce forests in the Bulgarian mountains. Even subalpine forests, which were considered to be of lower risk to be affected by bark beetles due to temperature limitations (that is, the insects were constrained by low summer temperatures at higher altitudes) are expected to be at risk with the increase of temperatures; and

iii. Young planted forests of Scots pine and Austrian pine in the zone with occasional wet snow events (800 m to 1,500 m a.s.l.). About 70 percent of the Scots pine plantations are in this zone. Almost 50 percent of these plantations are of age below 40 when they are still very dense but tall; and are thus highly vulnerable to wet snow damage.

4) Impact of invasion or increase of the distribution of non-native species.

40. There are a number of European and worldwide examples for mass mortality among certain tree species caused by the invasion of non-native species, mostly fungi and insects. Impressive examples in this respect are the Dutch elm disease, caused by the distribution of the invasive fungi species *Ophiostoma ulmi* introduced by chance from Asia and the chestnut blight, caused by the fungi *Cryphonectria parasitica*. The Dutch elm disease caused the mortality of many elm trees (more than 90 percent of the elm trees in France, 25 million trees in the United Kingdom). In Bulgaria, it also caused high mortality during the drought in the 1980s and early 1990s. The process is still active. The chestnut blight was caused by the first introduction of the fungi species from Asia first to North America, where it almost destroyed the local Chestnut population killing more than 4 billion trees. The disease was then transferred to Europe, where it gradually spread and caused high mortality, including in the local population in Bulgaria, where it is still a major problem (see the Annexes).

41. Though these species presently occupy warmer climate zones future climate changes may provide better opportunity for them to migrate. In addition, non-native plant species which are better adapted for new climatic conditions may increase their distribution and thus hinder local species. This is potentially a very high risk for habitats which are rare and in marginal locations.

42. It is hard to define which forests are the most vulnerable as non-native species are easy to

be introduced and consequences are often unpredictable. However, certain insects and fungi, which are already creating serious problems in other European countries, but have still not been introduced to Bulgaria, could be classified as most risky.

5) Large areas of coniferous plantations outside the natural range of distribution of the species.

43. This vulnerability is an effect of the large-scale afforestation in the 20th century, when more than 1.5 million hectares of areas were planted mostly with *Pinus sylvestris* and *Pinus nigra* (see sub-chapter 1.1.). While the plantations often served their primary goal to help in the control of erosion processes, in the last decades, there were numerous mortality waves, which were attributed to the combined negative effects of drought, ageing, and lack of possibilities for regular thinning. The observations of authorities and scientific data point out that the plantations became extremely vulnerable after reaching ages above 40 years. Then, they were often affected by insect outbreaks (see sub-chapter 1.2.) frequently following drought waves, damages from wet snow and ice, fires and mortality without clear reason, but often happening after dry years (Naydenov 2016). The most affected and hence vulnerable were plantations below 700 m a.s.l., which is outside the natural range of *Pinus sylvestris* and mostly outside the range of *Pinus nigra* (see sub-chapter 1.1.)

6) A key vulnerability is the lack of adequate scientific information to support an adaptation strategy.

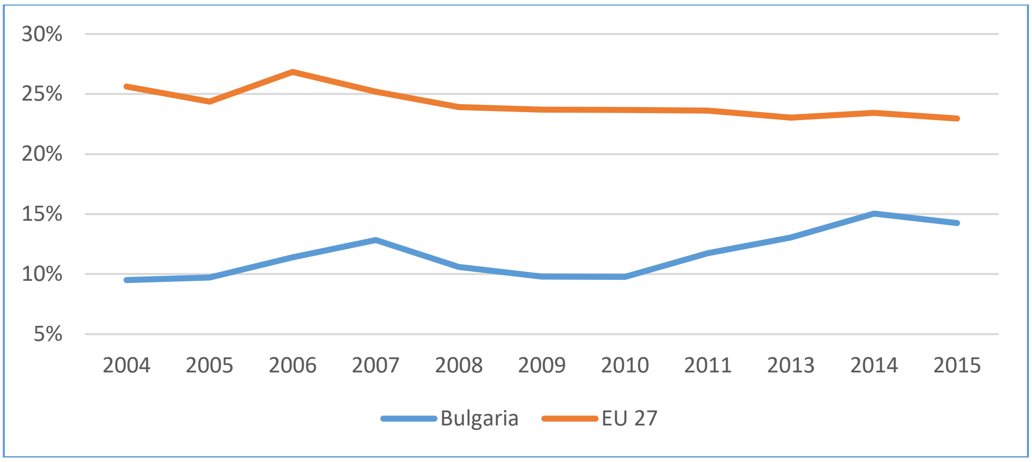
44. For many of the potential effects of climate change there is lack of adequate scientific knowledge due to the complexity of involved factors. Certain topics were addressed locally or on a EU-scale by research activities, but data is scarce for rare or locally important species. Bulgaria also still lacks detailed country-level modeling for the potential effects of climate change on the growth of the most important tree species and forest types. Although a scientific, rather than strictly biotic or abiotic vulnerability, it is important to recognize this sectoral vulnerability as a real threat to effective CCA.

7) High prevalence of low value, short-lived forest products.

45. Increasingly across Europe, lifecycle analysis is used to determine the length of time for which carbon may be locked in long-lived wood products. As forests are replaced and subsequently harvested, this storage mechanism can become a significant and cumulative carbon sink. Where wood products are short lived, such as pulp or firewood, the carbon benefits are a lot lower. This represents a lost opportunity to improve carbon sequestration.

46. These short-lived products are also usually of least monetary value. There exists a very high demand for this category of wood product in Bulgaria and large amounts of wood are used for heating purposes in old house-heating facilities which have low effectiveness and contribute to pollution. The improvement of these facilities is urgently needed to reduce the amount of fuelwood required and to reduce pollution. There are examples of modern public or communal facilities combining efficient production of energy from wood and solar energy.

Figure 10. Sawn wood as a percentage of total roundwood production



Source: Eurostat.

47. What may be even more damaging to the sustainability of the industry is the low unit value achievable for this category of timber. Where approximately 50 percent of the annual harvest is sold as firewood, the revenues are not sufficient to meet the costs of silviculture and other activities that are necessary to ensure a highly marketable product at harvest time. Thus, the industry finds itself stuck in a cycle of low-value production and inadequate budgets for necessary works.

48. The expected growth of the bioenergy industry will increase the demand for wood of this type, although prices are unlikely to rise appreciably due to the availability of imports. Where they do rise, this may prove to be an existential threat to smaller wood processing and furniture production industries, thus threatening competition. Production of additional amounts of wood through specifically-designed biomass plantations, particularly on agricultural lands, could mitigate such potential problems. However, legal restrictions (that is, Natura 2000 sites do not allow the use of foreign tree species) and risks of spread of invasive species require careful planning of such activities.

49. A supply chain containing high value saw logs is more vulnerable to the threats of corruption, theft, and illegal logging. For a successful, value-adding, and sustainable forest industry, these must be minimized although with higher product prices the added costs of increased control in the supply chain is easier to justify. In addition, often the interaction model in the chain 'producers-consumers' is not sustainable and the possibility for long-term contracting could improve the mutual interest for adaptive forest management with aims of producing high-valued wood products.

8) Level of professional education and capacity for innovation in the wood processing and furniture industries

50. Most enterprises in the wood processing and furniture industries reported that critical problems for them were the insufficient level of professional education of their workers and the lack of real capacity for innovation.[7] About half of the enterprises did not have programs for training and additional education of the workers. The share of factories which were ISO 9001

[7] National Report for the Wood Processing and Furniture Industries in the Republic of Bulgaria. INNO Trans Project Report, 2009

certified was also very low. All these factors hinder high-quality production and opening of new markets, which is linked with a lower share of use of wood for longer-lasting items such as furniture or house construction. Such increased demand would trigger a need for higher quality wood, which is related to management strategies with a longer rotation period and, therefore, a higher carbon sequestration potential.

51. All the earlier mentioned factors may have profound effects on the ability of Bulgarian forests to continue fulfilling their many functions on a sustainable basis. Adapting the forest resources and the way they are managed to ensure that these negative effects are minimized and whatever limited benefits that may arise from climate change are maximized, is challenging. The required actions and the outcome of those actions will be seen over multiple decades, well beyond the timescales of this specific project. There is no centralized geospatial database that stores and shares records of damage due to the above factors. This means that modelling the geographic spread of such damage or investigating causative factors is challenging.

52. Devising the right course of action is largely dependent on available scientific knowledge on the different topics, modeling of different climate and management scenarios, and availability of management capacity and resources. To begin addressing these issues in Bulgaria, a number of activities have been carried out (see ***Annex 4***).

53. The general conclusions of modeling activities on the possible development of forest ecosystems can be summarized as:

- There will be potential strong effects on the distribution of many species in the lowlands with most severe problems for species with high demands for moisture. At the same time, the level of adaptability of many of the local species, which have generally good drought resistance, is not completely studied. There are high chances for further severe health problems exist in coniferous plantations, mostly of Scots pine at lower altitudes. The limited climate modelling exercises undertaken thus far predict a high probability of new climatic conditions emerging in certain regions and great uncertainty over future species composition and interaction between species. This has been outlined by the projection of potential climate changes on vulnerability zones in the country and forest ecosystems in them in the 'Program of Measures to Adapt Forest in the Republic of Bulgaria and Mitigate the Negative Effect of Climate Change on them 2012–2020' and two nongovernmental organizations (NGO)-led projects for a forest enterprise in southwestern Bulgaria (Kresna Forest Enterprise) and the Black Sea region (see ***Annex 4***).
- A general decrease of increment by 1 m^3 per hectare per year, which could amount to annual loss of timber supply of more than 3.5 million m^3 at the country level using a pessimistic scenario that predicted losses mostly due to disturbances, natural mortality, and decrease of increment related to forest ageing (Kostov and Raffailova 2009). Potential high increases in harvesting under intensive-management scenarios are possible mostly using thinning operations (EFISCEN modeling, point 5 in ***Annex 4***). However, careful evaluation of management opportunities should be done to comply with the potential of forests to serve various ecosystem services.
- Decrease of the vitality and productivity of Norway spruce forests in mountain areas and beech forests at their lower altitude distribution range predicted by modelling of

different management scenarios for a representative region in the Rhodope Mountains within the EU ARRANGE project (see ***Annex 4***). The productivity loss may reach up to 300 m^3 per hectare under the pessimistic climate scenarios for Norway spruce forests in the range of 1,000 m to 1,800 m a.s.l., which extrapolated to the country level may be a loss of up to 25 million m^3 of stock by 2100. Scots pine and Austrian pine forests in their natural habitats and beech forests at higher altitudes are expected to be relatively robust and resilient.

- Modified relationships between oak species in mixed oak-dominated forests with potential losses in productivity and distribution for the less-drought resistant Sessile oak and potential changes in the ratio of distribution between the more drought resistant Hungarian oak and Turkey oak due to differences in their regeneration strategies. The potential high effects on productivity of management strategies will probably require flexible adaptive approaches to respond to observed tendencies. This has been outlined by modelling of the different management scenarios in a case study of the EU project MOTIVE for a low-altitude mountain terrain in Sredna Gora Mountains in Bulgaria.
- There is high probability for increase of the risk of windthrows and associated bark beetle outbreaks in mountain coniferous forests, according to the EU-level modeling from the MOTIVE project and fire dangers, especially in the southern parts of Bulgaria according to the PESETA II project.

54. Based on the findings mentioned earlier, several climate-related potential risks and opportunities have been outlined (***Table 1***) and the most vulnerable forest types have been listed (***Table 2***).

Table 1. Climate and climate change – potential direct risk and opportunities for the forestry sector

	Risks	Opportunities
Higher temperature (including heat spells and heat waves)	• Heat stress, increased drought stress	• Increased growth in colder (for example, mountain) locations with enough moisture
	• Improved conditions for currently cold-limited pathogen insects	• Increased opportunities for use of warm-demanding and drought tolerant species in case of lack of cold spells
	• Increased risk of fires	-
	• Higher potential for invasive species	-
Lower temperatures (including cold spells and cold waves)	• Mortality in plant species with lower cold-hardiness	• Mortality in pathogens with lower cold-hardiness
	-	• Decreased spread of warm-demanding invasive species
More precipitation and humidity	• Floods	• Improved growth of tree species in generally drier locations
	• Increased erosion on steep slopes and forest roads	• Recovery of riparian forest types
	• Improved conditions for pathogen fungi	-

	Risks	Opportunities
Droughts	• High drought-stress to trees, especially in drier environments	-
	• Drought stress weakens trees and increases the chances for pathogens	-
	• Increased risk of fires	
Increase of winds and storms	• High damages due to windthrow, wind snapping, and other similar disturbances	• Increased landscape heterogeneity due to damage from windthrow
Shorter snow cover and warmer winters	• Frost damages to small plants in mountains	• Improved conditions for warm-demanding species
	• Decreased water supply	• Earlier start of growing season and longer growth period
	• Higher risk of frost damages due to late frosts and earlier development of plants	-
Wet snow events	• Damages from wet snow mostly to coniferous tree species (*Pinus sylvestris, Pinus nigra*)	-
	• Increased damages from avalanches	-
Ice accumulation	• Severe damages from ice loading to crowns and stems	-

Table 2. Climate change - potentially most vulnerable forest types

Forest Type	Potential problems	Vulnerability
Scots pine *(Pinus sylvestris)* plantations below 800 m a.s.l.	Drought-related health deterioration	Very high
	Insect outbreaks and other diseases	Very high
	Fires	Very high
	Wet snow	Medium
Austrian pine *(Pinus nigra)* plantations below 500 m a.s.l.	Fires	Very high
	Drought-related health deterioration	High
	Insect outbreaks and other diseases	High
	Drought-related growth decrease	Medium
Pinus sylvestris and *Pinus nigra* natural forests and plantations with age below 60 years, high density and at 800 m - 1,400 m a.s.l.	Damages from wet snow	High
	Fires	Medium
Bosnian pine *(Pinus heldreichii)* dominated forests	Drought-related health deterioration	Medium
	Competition from other species	High
Macedonian pine *(Pinus peuce)* dominated forests	Drought-related health deterioration	Medium
Austrian pine forests on rocky locations in the Rhodopes	Competition from other species	High
Norway spruce *(Picea abies)* dominated forests below 1,800 m a.s.l. and ages below 140 years	Drought-related growth decrease	High
	Windthrow and bark beetle outbreaks	High

Forest Type	Potential problems	Vulnerability
Sessile oak *(Quercus petraea (Q. dalechampii)* forests on dry sites, primarily steep sun-exposed terrain	Drought-related health deterioration	High
	Insect outbreaks	High
Riparian forests next to big rivers and the Black Sea	Drought-related growth decline	Medium
	Invasive species	High
Beech *(Fagus sylvatica)* forests at dry sites (karst terrains) and at lower altitude sites (for example, below 900 m a.s.l.)	Drought-related growth decrease	Medium
	Damages from ice accumulation	Medium
Forests and localities of rare species at marginal locations (a reference can be the Red Book of Bulgaria, Vol.3, 2015, types F [shrubs] and G [forests] besides already listed	Potential various growth and health problems related to modified temperature and precipitation regime	High*
	Problems related to increased competition from other species, including invasive species	High*
Chestnut *(Castanea sativa)* forests	Drought-related growth decrease	High
	Insect and fungi pathogen problems	Very high

** Note: The effect and magnitude of response would be specific for different species. Some species may benefit from certain evolvement of conditions, while others may not. High uncertainty and vulnerability often arise from lack of species-specific data and studies on the adaptability options of such species.*

1.4. Conclusions

55. Bulgarian forest ecosystems are very important for the country and well-being of society. They are highly diverse and productive. However, despite the serious efforts already undertaken to prepare for CCA, there are several groups of vulnerabilities of the forestry sector. These include:

1) High uncertainties for species-specific responses to modified climatic conditions;
2) Large areas with coniferous plantations at too low elevations and, therefore, at risk of decline in growth and various health problems;
3) Increased probability of large fires and other disturbances such as windthrows, damages from wet snow and ice, attacks from insects;
4) Potentially improved conditions for invasive species with high chances for considerable damages to the forests;
5) High prevalence of low-value short-lived products from timber.

56. Overcoming these obstacles would require adaptive management using modern and up-to-date information resources, capacity building, and considerable efforts in social education with regard to climate change.

Chapter 2. Baseline – Policy Context

2.1. State of Awareness, Understanding of Future Consequences of Climate Change and Knowledge Gaps in the Forest Sector

57. At the political level, there appears to be high awareness of potential future consequences of climate change which is reflected in a number of official acts, programs, and strategies in Bulgaria (see sub-chapter 2.4.). They comply with the European political framework on the topic (see sub-chapter 2.3.).

58. The forest sector of Bulgaria is highly diverse in terms of the involved actors. The management of the forest enterprises and their subdivisions is done by specialists with a bachelor's degree in forestry. According to the FA, the directors of these divisions can be persons only with a master's degree in Forestry. At the same time, the level of education of many people involved in the actual implementation of the work in the forests is often not high.

59. The specialists in the management of forestry enterprises and higher level of management of the forestry sector in Bulgaria are aware that climate changes are a likely contributing factor to many of the growth and health problems in forests and that future climate changes may cause further problems. Besides the official documents issued by the EFA and the Ministry of Environment and Water (MoEW) (see sub-chapter 2.4.), there are additional instructions and decrees aiming to respond to various urgent problems, increase the resilience of forests, and ensure the protection of biodiversity in forests, which is directly related to the general adaptation of forest to future climate changes.[8] This helps raise the awareness of the professional staff involved. At the same time, there is high uncertainty, which is a general problem for many sectors in Bulgaria as to what 'climate change' exactly means and what might be the possible consequences for the forestry sector. Many people perceive that 'climate change' is simply an increase in temperature. This leads to the misunderstanding of the possible consequences for forests and required adaptation and mitigation measures. There is a widely-held view that the best measure is to simply start planting species typical for regions with warmer climate, such as the Mediterranean. However, the problems related to climate change are far more diverse (see sub-chapters 1.2 and 1.3) and most staff are not aware of this.

60. As already noted, much of the personnel working in forests at an operational level, especially in contractor companies, have a lower educational level. In this group, the general knowledge on the complexity of forest ecosystems is low and they are not aware of the climate change issues and potential future problems. This could be a major hindrance to the actual implementation of many measures. The wood processing and furniture industries also recognize the lower level of education of many of the personnel.

61. While there is a small group of professionals and NGOs communicating on the topic of climate change, there is still a general lack of understanding of the potential effects on forests and the social and economic outputs from forestry. Most people take the various services of forests for granted or assume they are only dependent on the appropriate management intervention. There is a general lack of awareness on potential deterioration of certain ecosystem services in forests. There is an urgent need for preparing the society for the fact that some losses

[8] www.iag.bg

might be inevitable and that maintaining some of the most important ecosystems services is going to be very costly. This also includes the wood-processing sector, which to a large degree looks on the forests as only a guaranteed resource of timber and has expectations that the quality, availability, and price of timber is dependent mostly on political and management decisions and not just natural factors.

Knowledge gaps in the sector

62. There are a number of knowledge gaps in the forestry sector which are some of the potential consequences of climate change. The following paragraphs present a short list of the most important gaps:

A GENERAL LACK OF KNOWLEDGE OF THE POSSIBLE CONSEQUENCES OF CLIMATE CHANGE ON THE MOST IMPORTANT TREE SPECIES, FOREST TYPES AND PRIORITY TREE SPECIES AND HABITATS FOR PROTECTION

63. As noted, Bulgaria has a very high diversity of plant species. Many of them are at the margins of their distribution. This could be a potential problem, but also an opportunity. On one hand, species at marginal locations could be considered as highly vulnerable, but at the same time, they might have the genetic potential to cope with harsher climate conditions. This could only be understood by in-depth research of the capabilities of species and provenances to cope with stress-related to expected future climatic conditions. While such work is advanced for some of the most important tree species at the European level, it has not been done or there are just occasional experiments at the local level for species which are most typical of the region.

LACK OF ADEQUATE MODELING AT THE COUNTRY LEVEL OF POTENTIAL AND EXPECTED CHANGES IN THE PRODUCTIVITY AND FOREST DYNAMICS OF THE MOST IMPORTANT SPECIES

64. Such data and information are the basis for taking adequate management decisions and experimental work on the potential effects of different management strategies on the current forest resource. However, as noted in sub-chapter 1.3, there are few examples of adequate modeling work covering small parts of the range of certain species and forest types in Bulgaria. While basic conclusions could be extrapolated, the high diversity of environmental conditions and species richness in the country require much better understanding of the possible effects on a wider range.

LACK OF ADEQUATE KNOWLEDGE AND MODELING AT THE COUNTRY AND DISTRICT LEVELS OF THE POTENTIAL BIOTIC AND ABIOTIC DISTURBANCES AND THEIR EFFECTS ON FORESTS

65. Because disturbances are expected to be one of the major factors for forest development in future, there is an urgent need for such work and knowledge. It should be an integral part of planning and decision making. While now there are a number of activities, especially for prevention, early detection, and fighting fires, much of them are taken mostly on the basis of expert knowledge and experience. This could be an adequate approach, but only if the full range of possible disturbances, their magnitude, and effects is well-known and studied. For Bulgaria, much of this information is scarce or lacking. For example, a recent study in the endemic coniferous forests in the subalpine belt of Pirin (*Pinus heldreichii* and *Pinus peuce* forest)

demonstrated that infrequent fires are part of their natural dynamics (Panayotov, Kulakowski et al. 2016, Panayotov et al. 2017) and this has to be considered and additionally studied to guide the appropriate decisions for their effective protection. Similarly, there is a wealth of information showing that infrequent fires are an integral part of the natural dynamics in Austrian pine (*Pinus nigra*) in southern European forests and their complete exclusion is not always the best possible management option, especially in conditions of general warming and drying. The studies on the natural dynamics of spruce forests in Bulgaria contributed to the understanding that windthrows of various size and magnitude are a major part of them and this requires integration of this knowledge in the management strategies (Panayotov et al. 2011, 2015, and 2017). There is a general lack of such knowledge for some of the most important forests such as the ones dominated by beech and oak.

66. Overcoming the abovementioned gaps require strategic activities for initiation and support of scientific programs that have to directly serve the needs of the forestry sector at a much wider level than currently being done. In addition, creation of a common database on the already available knowledge and meta-analysis of the data on various topics could be extremely valuable. Such knowledge should be incorporated in future planning, decision making, and additional education of practitioners in the forest sector. It should also serve for better education and raising the awareness of society.

2.2. Experience with CCA in the Forest Sector in Other (EU) Countries

Introduction

67. A comprehensive analysis was carried out at the European level by the 'Expected Climate Change and Options for EU Silviculture' (ECHOES) project, funded by the EU-funded ‘Cooperation in Science and Technology’ program resulting in specific country reports[9] emphasizing the fact that developing adaptation measures is an urgent task, including response to both risk and opportunities created by climate change and addressing all stages of forestry operations (Kolstrom et al. 2011).

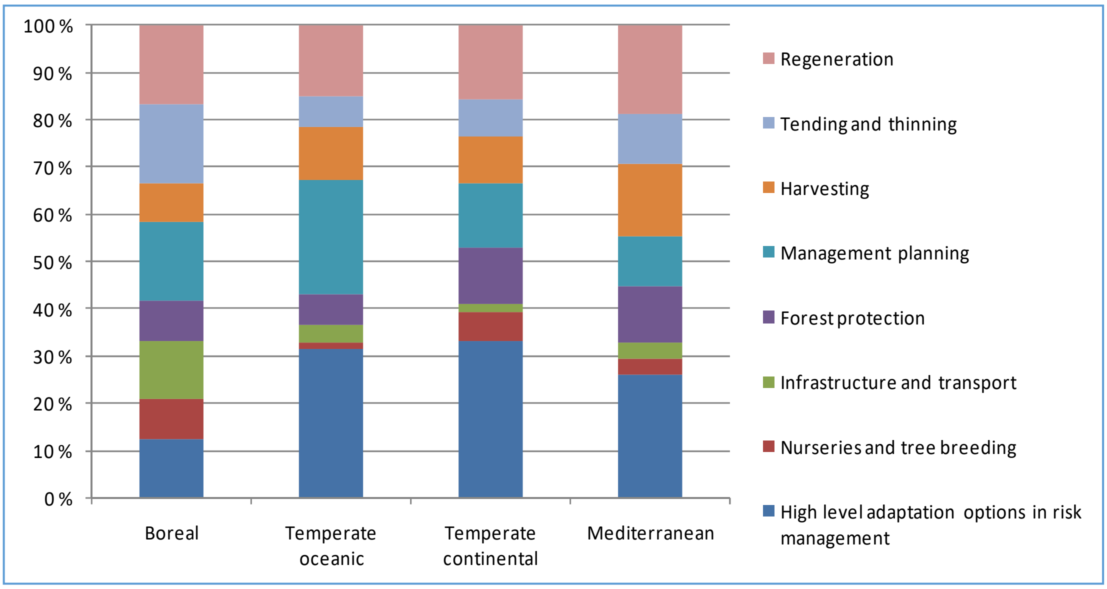
68. Although the need for immediate implementation of adaptation measures is well-recognized in many European countries, the elaboration, implementation and monitoring of such measures faces numerous challenges. Therefore, dissemination of ‘lessons learned’ and achievements in suitable adaptation measures is of great importance.

Box 1. Reported adaptation measures in different European regions

The ECHOES data indicate that adaptation is ongoing all over Europe (see ***Figure 11***). Species and provenances that are more tolerant to future conditions and extreme events are tested. Tree species diversity is considered in both the regeneration and thinning and tending phases of forest management to enhance the capacity of forests to cope with various potential problems. In temperate and Mediterranean countries, investments in fire prevention policies and fire prevention infrastructure have been initiated. Dealing with high-level adaptation options in risk management are common in all regions except the Boreal region (Kolstrom et al. 2011).

[9] http://echoes.gip-ecofor.org/index.php?sujet=cr *(04.27.2017)

Figure 11. Types of measures applied in different bioclimatic regions based on ECHOES data



Source: Kolstrom et al. 2011.

2.2.1. Research and policy interactions

69. In almost all countries in Europe, the process of elaborating CCA policies and measures relies heavily on scientific research. In almost all cases, the lack of information on the possible impact of the CC as well as the possible measures to be undertaken caused policy makers to turn to the scientific community for evidence upon which to base their actions. As a result, in many European countries the conclusions of scientific research are reflected in the adopted CCA strategies and in the practical guidelines being applied by forest landowners, managers, and practitioners to make forestry operations both legal and sustainable.

Box 2. Science - policy interactions during CCA adaptation strategy elaboration in Finland

Existing research knowledge on climate change in Finland in different sectors was a very important contributory factor in the development of CCA strategies. The first attempt, done before the formation of the adaptation strategy working group in the government was the creation of the Finnish Environmental Cluster Research Programme coordinated by the Ministry of Environment, in charge with implementing FINADAPT – a crosscutting project aimed at assessing the adaptive capacity of Finnish environment and society under a changing climate. As a result, a set of socioeconomic scenarios were produced for the CCA strategy and a preliminary assessment was made of the order of magnitude of the costs and benefits of climate change for Finland (Marttila et al. 2005). Other studies could use the conclusions of the strategy report as material for stakeholder discussions, which also offered some opportunities for a critique of the strategy. The relationship between mitigation and adaptation is touched upon in the strategy and was taken up as a land management and planning issue in various studies. Finally, all studies were able to reflect on the major gaps in knowledge that currently impede the development and implementation of adaptation strategies in different sectors and regions (Swart et al. 2009).

The adopted CCA strategy included key recommendations regarding the establishment of a five-year Finnish Climate Change Adaptation Research Programme (called ISTO) aimed at filling knowledge gaps and providing relevant knowledge on adaptation for policymakers (Swart et al. 2009).

Box 3. Forests and climate change - United Kingdom Forestry Standards Guidelines

United Kingdom Forestry Standards Guidelines on forest and climate change have been developed by the U.K. Forestry Commission through an open and consensual process in accordance with governmental guidance and apply to all U.K. forests and woodlands. It incorporates recent advances in the scientific understanding of CCA and mitigation needs and includes national and international initiatives on climate change and the role forests can play in mitigation and adaptation. For instance, one of the measures within the Forests and Climate Change Guidelines, is *where timber production is an important objective, consider a wider range of tree species than has been typical of past planting, and consider the use of planting material from more southern origins* (Forestry Commission 2011). Based on rigorous research, applying this measure has consequences in nursery stock and operational planning. Another example is linked to the long-term use of wood products. The Forest and Climate Change Guidelines states: *where woodlands are managed for timber production, maximize carbon sequestration through efficient management, consistent with the output of durable products* (Forestry Commission 2011).

Source: Forestry Commission 2011.

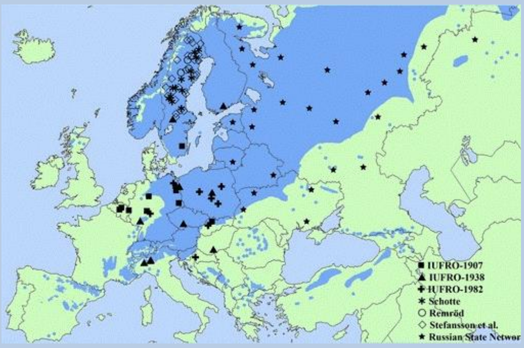
2.2.2. Forest regeneration

70. The predicted climate change effects have triggered the need for manipulation of forest stands composition. This includes a series of possible and recommended measures: raise the level of genetic diversity, tree seeds and seeds transfer certification, innovative technical options to be applied in the regeneration phase, and so on (Kolstrom et al. 2011).

Box 4. Climate preadapted seed transfer for Scots Pine (Pinus sylvestris) in North Europe

A study done over 283 populations of Scots pine (*Pinus sylvestris*) originating from a broad geographic range (long-term experiments) revealed important conclusions regarding the growth and survival in response to climatic transfer distance, the difference in mean annual temperature between the sites and the population origin. Climate transfers equivalent to warming by 1°C – 4°C markedly increased the survival of populations in northern Europe (≥ 62°N, < 2°C MAT) and modestly increased height growth ≥ 57°N but decreased survival at < 62°N and modestly decreased height growth at < 54°N latitude in Europe. Populations which moved from warmer locations were the best performers in the southern part of the range. With climate change warming, adaptive transfers of populations need to be made at increasingly larger distances in the south and across narrower distances in the north.

Figure 12. Location of experimental common-garden provenance sites. Darker color denotes range of Scots pine



Source: Reich and Oleksyn 2008.

Box 5. Species survivorship in changing climatic conditions – the case of Pinus

Studies done in the upper Rhone valley in Switzerland (Richter et al. 2012) evaluated the influence of different climate parameters (that is, summer drought, rain seasonality, start of the growth period) and interspecific competition on germination and early growth of Scots pine (*Pinus sylvestris*) and black pine (*Pinus nigra*). These and similar studies (Richter et al. 2012, Nicotra et al. 2010, Eilmann et al. 2010, Ivanova and Anev 2014, Anev et al., 2016) explore the susceptibility of certain species to climate change and which species may be better suited to a given geographic location; as such they are very valuable when formulating evidence-based CCA strategies.

2.2.3. Tending, thinning and harvesting

71. Adaptation measures that have been studied and applied in Europe are mainly aiming to change the frequency or intensity of these activities but may also include other measures addressing the species composition amelioration.

Box 6. Thinning is improving the recovery of growth in subsequent years after dry periods for Norway spruce (Picea abies)

Analysis of thinning trials established in southeast Germany in 1974 (Kohler et al. 2010) concluded the beneficial effect of thinning on reducing the stress period of individual trees in the subsequent years after dry periods. The results of the study reveal that heavy and frequent thinning in spruce stands might support the promotion of future crop trees with more drought tolerance due to relatively close thinning intervals. The higher resilience of trees in heavily thinned Norway spruce stands against extreme drought is of high relevance because these trees are most likely less susceptible to secondary pests or pathogens.

2.2.4. Forest management planning

72. Included in this category are such examples, which describe measures taken beyond the level of individual stands.

Box 7. Forest growth models and decision support systems to evaluate impacts of climate change and to identify suitable management options

In the context of the recognized impacts of the climate change on forests and the provision of ecosystem services in general, the identification, design, selection and implementation of adaptive measures in forest management require a sound knowledge base as well as tools to support the forest manager in decision making (Lexer and Vacik 2016). Decision support systems (DSS) are considered particularly useful to assist in dealing with ill-structured decision-making problems. Such DSS have been developed in the following countries:

- ***Portugal*** – to support management planning of *eucalyptus* plantations facing climate change (Garcia-Gonzalo et al. 2014). The proposed tool is based on a modular structure to integrate (1) a management information module, (2) a prescription generator module that integrates a process-based model, (3) a decision module, and (4) a solution report module. To demonstrate the usefulness of the DSS, a eucalyptus forest with 1,722 stands (6,138 hectares) in Portugal was considered.
- ***Hungary*** – to identify potential CCA options (Czimber and Galos 2016). The DSS can generate projections, as well as sensitivity and risk assessments, and in this way, it can help to develop adaptation and mitigation strategies.
- ***Germany*** – for climate change impact assessment on forests (Thielle and Nuske 2016). The DSS, tailored to assess climate change impacts on German forests, was implemented as a web application offering information for single stands on-demand as well as interactive maps and processed assessments on a coarser level for entire Germany.

2.2.5. Pest and diseases risk management

73. The preparedness to respond to increased pest and disease risks on the European level is only moderate and there are only a few ongoing measures recorded in the ECHOES database.

Box 8. Temporary planting moratorium in the UK

Red band needle blight is an economically important disease affecting several coniferous trees, especially pines. In much of the world, including Britain, it is caused by the fungus *Dothistroma septosporum*, and many of the studies incriminate climate change as influencing the evolution of the disease (Woods et al., 2016). Since the late 1990s the incidence of the disease has increased dramatically in Britain, particularly on Corsican pine (*Pinus nigra* ssp. *laricio*), and due to the extent and severity of the disease on this species, there is a planting moratorium of it on the Forestry Commission estate.

Figure 13. Foliar damages done by Dothistroma septosporum on Pine

Source: Brown and Webber 2008; https://www.forestry.gov.uk/dothistromaneedleblight (09.05.2017).

2.3. EU CCA Legal Framework and Policies in the Sector

2.3.1. EU Forest Strategy

74. The 2013 EU Forest Strategy builds upon 1998 EU Forestry Strategy and implements the achievements of FOREST EUROPE. It has three pillars of sustainable forest management: Pillar 1. Contributing to major societal objectives; Pillar 2. Improving the knowledge base scopes on forest information and monitoring and research and innovation, and Pillar 3. Coordination and communication and eight priority areas.

75. **Priority Area 3.** Forests in a changing climate change, invites Member States to increase their forests' mitigation potential through increased removals and reduced emissions, including by cascading use of wood, and enhancing their forests' adaptive capacities and resilience, building on the actions proposed in the EU Strategy on Adaptation to Climate Change and the Green Paper on Forest Protection and Information, such as bridging knowledge gaps and mainstreaming adaptation action in forest policies.

76. **Priority Area 4.** Protecting forests and enhancing ecosystem services, requires Member States to:

- Develop a conceptual framework for valuing ecosystem services, promoting their integration in accounting systems at the EU and national levels by 2020. They will build on the mapping and assessment of the state of ecosystems and of their services;
- Maintain and enhance forest cover to ensure soil protection, water quality, and quantity regulation by integrating sustainable forestry practices in the Programme of Measures of River Basin Management Plans under the Water Framework Directive and in the Rural Development Programmes (RDPs);

- Achieve a significant and measurable improvement in the conservation status of forest species and habitats by fully implementing EU nature legislation and ensuring that national forest plans contribute to the adequate management of the NATURA 2000 network by 2020. They should build on the upcoming guide on NATURA 2000 and forests;
- Implement the Strategic Plan for Biodiversity 2011–2020 and reach its Aichi targets adopted in the context of the Convention on Biological Diversity, building on the upcoming common Restoration Prioritization Framework; and
- Strengthen forest genetics conservation (tree species diversity) and diversity within species and within populations.

77. **Priority Area 8.** Forests from a global perspective, is focused on supporting the global efforts to fight illegal logging through the implementation of Regulation 2173/2005[10] on the establishment of a forest law-enforcement, governance and trade-licensing scheme for importing timber into the EU, and the Regulation (EU) No 995/2010 laying down the obligations of operators who place timber and timber products on the market.

2.3.2. Multi Annual Implementation Plan of the EU Forest Strategy

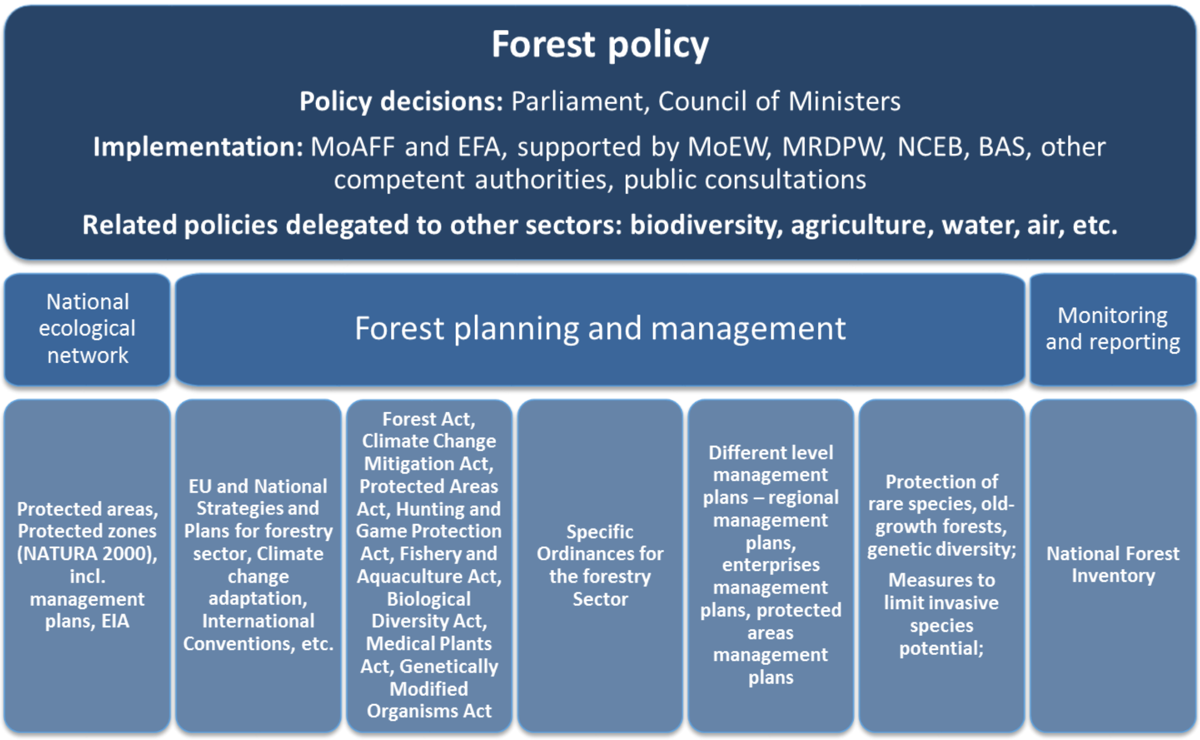
78. The 2015 Multiannual Implementation Plan provides a concrete list of actions to ensure a coherent, coordinated approach to the various policies and initiatives related to the forest sector, with the particular involvement of stakeholders. The plan also includes actions to enhance essential ecosystem services provided by forests, such as floods, landslides and erosion protection, carbon sink, climate stabilizer, habitat for animals and plants, genetic resource, and recreational space, and to provide both experts and the public with comprehensive and harmonized information on EU forests.

[10] Council Regulation (EC) No 2173/2005 of 20 December 2005 on the establishment of a FLEGT *(Forest Law Enforcement, Governance and Trade)* licensing scheme for imports of timber into the European Community

2.4. Bulgarian CCA Legal Framework and Policies in the Forest Sector

79. Having in mind the multifunctional role of the forests, the forest legislative framework to greater extent reflects the requirements of the environment protection legislation, including those related to climate change.

Figure 14. Structure and main actors in implementing the Bulgarian forestry policy



Source: World Bank design.

2.4.1. *National Strategy for Development of the Forest Sector in the Republic of Bulgaria 2013–2020*

80. This is an integrated document for the development of the forest sector until 2020, defining the national priorities, in relevance with the European framework for planning in the sector. The vision, mission, and aims of the NSDFSRB 2013–2020 are defined in the context of strategic vision and main targets for the development of the country, set in the National Programme for Development: Bulgaria 2020. The NSDFSRB was developed after broad analyses on the forest sector and on the implementation of the previous strategic documents, including climate change modeling. It consists of three strategic aims, four priorities and twenty measures.

81. The strategic aims are (1) ensuring sustainable development of the forest sector by achieving optimal balance between the ecological functions of the forests and their long-term ability to support material goods and services; (2) strengthening the role of the forests for supporting the economic growth of the country and more balanced territorial socioeconomic development; and (3) increasing the contribution of the forest sector in the green economy.

82. Priorities of the strategy are (1) sustaining vital, productive and multifunctional forest ecosystems, contributing to the mitigation of the effects of the climatic changes (Measure 1.4 – 'Increasing the resilience of the forest ecosystems to and their ability for climate change

adaptation'); (2) protection, restoration, and maintenance of the biological and landscape diversity in the forest territories; (3) increasing of the vitality and competitiveness of the forest sector; (4) usage of the forest sector potential for the development of the green economy.

2.4.2. Strategic plan for the development of the forest sector for the period 2014–2023

83. The Plan has 20 OTs, corresponding with the NSDFSRB and 102 activities for their achievement. All OT are related to CCA and some of them are as follows:

- OT 1: 'Increasing the forests' area, growing stock and carbon storage in the forest territories'
- OT 2: 'Improvement of the management and utilization of the forests'
- OT 3: 'Increasing the effectiveness of the prevention from forest fires and illegal activities in the forests, and restoration of the damages from them'
- OT 4: 'Increasing the sustainability and ability for adaptation of the forest ecosystems toward the climate changes'
- OT 5: 'Improvement of the system for planning and conducting of activities, connected with the protection of biological and landscape diversity in the forest territories'
- OT 6: Development of the protected areas network, including by extending the implementation of the financial mechanisms for improvement of the forest management in the NATURA 2000 protected zones
- OT 7: Maintenance and development of the system for protection of the forest genetic resources
- OT 8: Improvement and increasing the populations of game and fish species for the protection of the biological diversity and sustainable development of the forest ecosystems
- OT 9: Ensuring a sustainable planning of the activities in the forest territories
- OT 17: Sustainable production and usage of biomass as renewable energy source
- OT 18: Supporting the process of certification of the forest territories
- OT 19: Effective and sustainable usage of the touristic potential of forests and development of recreation activities in them
- OT 20: Establishment of conditions for sustainable and paid usage of ecosystem services, ensured by the forest territories

84. The plan clearly defines budget and funding resources, expected results, deadlines for implementation, performance indicators, and responsible institutions. Its performance is monitored, evaluated, and updated through specially developed rules for monitoring.

2.4.3. Forest Act

85. In addition to its other environment protection provisions, the FA provides that public ecosystem benefits from the forest territories shall be results from the specialized activities of its management. It defines public ecosystem benefits like protection against erosion of soil from avalanches and floods, guaranteeing the quantity and quality of water, maintaining biological diversity, maintaining micro-climate, providing conditions for recreation and tourism,

maintaining the traditional landscape, protection of the natural and cultural heritage, and protection of infrastructure sites and equipment, and slowing down and regulating the impacts from climatic change. The necessity to execute a National Forest Inventory is also specified in this legislation.

2.4.4. Climate Change Mitigation Act

86. The Climate Change Mitigation Act describes and regulates the state policy on the mitigation of climate change and the implementation of the mechanisms for fulfillment of the obligations of Bulgaria related to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP). It describes the functioning of the national systems for green investments and inventory of emissions of greenhouse gases in the atmosphere and the implementation of the European Emissions Trading Scheme (EU ETS) as well as the measures to decrease greenhouse gas emissions from the use of liquid fuels in transport. Since short further obligations arise from the ratified Paris 2015 Agreement.

2.4.5. Ordinance on the Protection of Forest Areas from Erosion and Floods and on the Construction of Fortifications

87. The ordinance regulates the planning and performance of forest territories protection against erosion, flood (rains), and landslides, including the design of the anti-erosion activities and fortifications, types of constructions, including forest protection belts, their building and maintenance. The responsible bodies (EFA, Regional Inspectorates of Environment and Water [RIEWs], SEs) and their coordination and cooperation are also herein identified.

2.4.6. Ordinance № 8 on the Terms and Conditions for Protection of Forest Areas from Fires

88. It establishes terms and conditions for forest fire prevention planning, including prevention/early warning, localization, limitation, and extinguishing of fires. The ordinance determines the responsible bodies (EFA, Ministry of Interior [MI], municipalities, and so on), their coordination, cooperation and control. In 2017, a program for protection of forests from fires was accepted. It aims at preparing better coordination, planning, and response capacity to respond to potential increase of forest fires with climate change.

2.4.7. Ordinance № 12 on the Protection of Forest Areas from Disease, Pests, and Other Damage

89. The ordinance regulates the terms, order, and ways to organize and implement the protection of forest territories from diseases, pests, and other damages. The responsible bodies (EFA, Forest Protection Stations, National Commission on Forest Protection), their coordination and cooperation are also herein identified.

2.4.8. Ordinance № 2 on the Terms and Conditions for Plantation in Forest Areas and Agriculture Lands Used for the Creation of Special, Protection and Production Forests and of Forests in Protected Areas, Inventory of the Created Plantations and their Registration

90. The ordinance regulates the terms, order, and ways to organize the process for creation of new plantations. It is highly relevant to CCA because it defines the future species composition

of new plantations. The Ordinance has been updated in 2013 and reflects the classification scheme of the forest habitats and the optimal future tree species composition.

91. Other ordinances supporting sustainable forest management and implementing climatic adaptation actions at the field level include Ordinance № 18 from 07.10.2015 on the inventory and planning of forest territories and the Ordinance on the conditions and procedures for the awarding of the implementation of activities in forest territories – state and community property and for the use of timber and non-timber resources (order 316/24.11.2011 last modified on 07.07.2017). In addition, many additional legal instruments such as orders, instructions, and so on, control forestry activity.

2.4.9. Instruction on Identification and Mapping the Forest Types and Habitats and Determination of Dendrocenoses Composition (2011) and Classification scheme of the types of forest habitats in the Republic of Bulgaria

92. The instruction is the main document, describing the process of identifying and mapping of the various forest habitats. It is in line with the Program of Measures to Adapt the Forests in the Republic of Bulgaria and Mitigate the Negative Impact of Climate Change on them 2012–2020 and recognizes the processes of natural changes of forest ecosystems related to climate change. This instruction and the classification are the basis for defining the optimal future tree species composition, which is the foundation of silviculture activities and plantation actions and therefore of high importance for the CCA process. Both the instruction and the classification were updated in 2011.

2.4.10. Hunting and Game Protection Act

93. The law and the rules for application of the Law on Hunting and Game Protection arrange the relations concerning the ownership, protection, and management of the game as well as trade with game. It sets, among others, specific requirements for protection and enrichment of biological diversity, guaranteeing of biological minimum, habitat improvement, and protection and regeneration of game.

2.4.11. Fishery and Aquaculture Act

94. The act arranges the relations concerning the ownership, protection, and management of fish resources in the waters of Bulgaria, the trade with fish and other water organisms, sustainable management of the fish resource, recovery and protection of biological diversity and enrichment of the fish recourses in the water ecosystems.

95. It determines the responsible bodies (Ministry of Agriculture, food, and forestry [MAFF], Executive Agency on Fisheries and Acquaculture [EAFA], MoEW, and so on), their coordination, cooperation, and control, and identifies the financial sources.

96. Bearing in mind the multifunctional role of forests, it shall be known that forestry legislation reflects this cross-relevance with all concerned areas and the related legislation – Water Act, Nature Protection Act, Act on Waste Management, Biological Diversity Act, Plant Protection Act, Act on Protection of Agricultural Lands, Law on Protection from Disasters, Act on the National System for Emergency Calls on Single European Emergency Number 112, Act on Health, Act on Local Self-Governance and Local Administration, Law on Vocational Education and Training, Higher Education Act, Act on Protection from Disasters, Act on the

Ministry of Interior, Spatial Planning Act, and so on, as well as the rules for their implementation, and other acts and related secondary legislation.

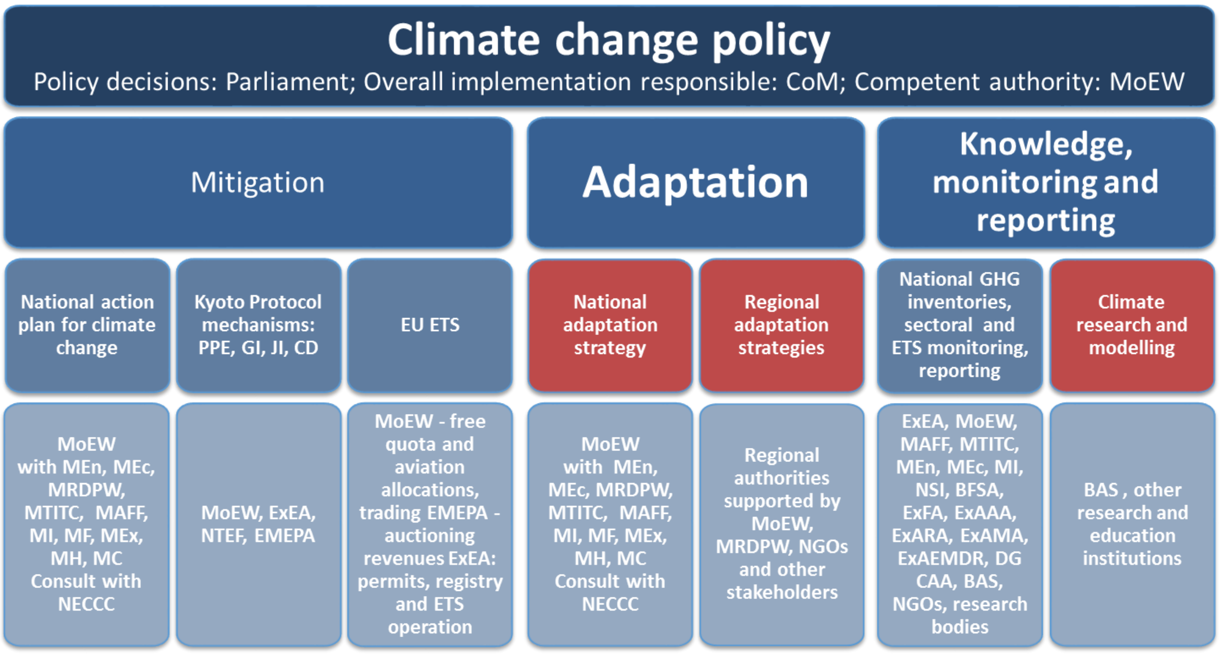
> The forestry sector governing strategic documents - national strategy and plans for its implementation and monitoring - are in place. The legal framework in force has established the grounds for further upgrading in line with the climate change/CCA United Nations (UN) and European policies. The forestry sector measures take into consideration the environmental, social, and economic impact of their implementation and respect the potential changes in cross-sectoral interrelations.
>
> Additional legislative measures shall be taken to strengthen the CCA capacity in the sector.

2.5. Institutional Framework and Stakeholder Community in Bulgaria

2.5.1. Ministry of Agriculture, Food, and Forestry

97. Through its core structures and supportive agencies, state enterprises, and the education and scientific entities, the ministry is responsible for the sustainable development of agriculture and forestry. The vulnerability of the forestry sector to climate changes is addressed mainly by the commercial companies and State Forest Enterprises Directorate, Land Use and Land Consolidation Directorate, Maritime and Fisheries Directorate, the EFA, and the State Enterprises under the FA. Though the ministry does not have a specific unit responsible for CCA, each of its activities is governed by the existing legislation in the area.

Figure 15. Structure and main actors in implementing the Bulgarian climate change policy



Note: All abbreviations used in this figure could be found within the Abbreviations and Acronyms section.

Source: World Bank design.

2.5.2. Directorate Commercial Companies and State Enterprises[11]

98. The directorate is responsible for, among others, activities directly and indirectly related to and influencing the CCA processes. These responsibilities include the following:

a) Development and actualization of the National Strategy on the Development of the Forestry sector;
b) Support for the minister and participate in the development of the legislative framework in the area of forestry, hunting, and game protection;
c) Support for the minister in coordination and monitoring of the implementation of the National Strategy on the Development of Forestry Sector and its Strategic Plan, as well as the annual programs for realization of priorities and other documents;
d) Support the participation of state enterprises according to the FA in the fulfillment of European projects, strategies, action plant, and others; and
e) Participation in the acceptance of the results from the National Forest Inventory (NFI), as well as the implementation of the forest management plans of the state-owned forest territories.

2.5.3. Maritime and Fisheries Directorate

99. The Maritime and Fisheries Directorate takes part in drawing up strategies, legal acts, programs, and projects for the development of fisheries and the protection of fish resources, which are compliant with the EU Common Fisheries Policy. It coordinates the activities of the MAFF with the MoEW and other entities and organizations to be related to fish resources sustainable management.

2.5.4. Land Use and Land Consolidation Directorate

100. This directorate coordinates the activity on the execution of the Law on Property and Use of Agricultural Lands, the Law for the Restitution of the Ownership over the Forests and Forest Lands and also the relevant secondary legislation. It controls the establishment of a register of the activities linked to the land-use change.

2.5.5. Executive Forest Agency

101. This structure supports the minister of MAFF in implementing the state policy in forestry, prepares the strategic plans for the development of the forestry sector and controls the implementation of state policies on sustainable forestry, coordinates and controls the protection and preservation of forests, the forest seed control, works on the implementation of national and international programs and projects in the forestry sector, participates in the work of consulting bodies in the field of forestry for the European Commission (EC), coordinates the contacts with other international organizations, provides information and consultations of forest owners and other interested parties as well as state structures on questions, related to forests, and performs interrelations with NGOs to assist for their participation during the process of forming and implementing governmental policy in the area of forestry. The agency is also legally responsible

[11] Rules for Operation of the MAFF, last amended in State Gazette 55/07.07.2017. Note that the translation of the name of the directorate into English was not available at the time this report was completed. Therefore, the name 'Directorate Commercial Companies and State Forest Enterprises' is unofficial.

for executing the NFI, which has not yet commenced.

102. To fulfill its activities the EFA is organized into nine directorates, 16 Regional Forest Directorates, two Forest Seed Control Stations (Plovdiv and Sofia), three Forestry Protection Stations (Sofia, Plovdiv and Varna), and the publishing house of Gora (Forest) magazine.

103. The EFA is responsible for the management of the NPs, through 11 specialized territorial units, established for this purpose – he Nature Park Directorates, which are third-level state budget spenders, functioning on the basis of their specific rules of operation. For the sustainable management of these territories ten-year management plans are developed and adopted. The 11 NPs are NP Balgarka, NP Belasitsa, NP Persina, NP Rilski Manastir, NP Rusenski Lom, NP Shumensko Plato, NP Sinite Kamani, NP Strandja, NP Vitosha, NP Vrachanski Balkan, and NP Zlatni Pyasatsi. The EFA holds a crucial role for the mitigation of climate change impacts and has significant inputs through its 'Program on the Measures for Adaptation of Forests in the Republic of Bulgaria and the Reduction of the Negative Climate Change Impact on Them'**.**

2.5.6. State enterprises

104. The FA provides for the establishment of state forest enterprises, which operate under the provisions of the FA, the Commercial Act, and the Rules for the Organization and Activity of the State Enterprises under Article 163 to the FA. For the management of the forest territories – state ownership, which are not disposed to institutions or legal persons, six state enterprises are established (North Eastern State Enterprise, North-Central State Enterprise, North Western State Enterprise, South Eastern State Enterprise, South Western State Enterprise, and South-Central State Enterprise). The enterprises are legal persons having a status of state enterprises under Article 62, Paragraph 3 of the Commercial Law. The regions of the State Enterprises are determined by the Minister of Agriculture, Food, and Forestry (formerly before May 2017, this ministry was the MoAF). They have a two-level structure: (1) central office, and (2) territorial units – state forestry and state hunting enterprises. Among other activities, the state enterprises perform the following:

a) Implementation of the forestry plans for the forest territories – state ownership;
b) Implementation of the hunting enterprises plans in the state hunting enterprises and in the state forest enterprises;
c) Implementation of maintaining and/or restoration activities in forest territories – state ownership, envisaged in the protected territories management plans;
d) Organization and holding initiatives on protection of forest territories – state ownership;
e) Organization and holding of anti-erosion initiatives;
f) Maintaining the diversity of the ecosystems and preservation of the biological diversity in them;
g) Creation of new forests on farm territories; and
h) Protection of forest territories – state ownership.

2.5.7. Non-governmental and professional organizations with direct relationships with the forestry sector

105. The **Association 'Municipal Forests'** represents the 60 municipalities owning forests in Bulgaria. The activity of the Association is governed by Statutory Rules, the FA and other related acts, and secondary legislation. The Association is member of the European Federation of Municipal Forest Owners.

106. The **National Association of Non-State Forest Owners** '**Gorovladelets'** was established in 2002 by seven forest cooperatives in Chepelare. Its members are 22 forest cooperatives, one municipality, two forestry enterprises, two joint-stock enterprises, 15 persons. The association represents about 85,000 forest owners.

107. The **Union of Bulgarian Foresters** (UBF) is a nonprofit, autonomous public professional organization, which has its own statute and forest policy program. As an NGO, the UBF aims at being an independent public defender of the national interest by implementing forest policy and working to enhance the rights and reputation of Bulgarian foresters. The structure of the UBF consists of a general assembly, a management body, 16 regional assemblies, and 151 regional associations. It is a member of the Union of European Foresters.

108. In Bulgaria, there are also several active NGOs that work on topics related to the management of forest resources and climate changes. Among them are the World Wildlife Fund-Bulgaria, the Bulgarian Society for Protection of Birds, the Association of Parks in Bulgaria, the Bulgarian 'Biodiversity' Foundation, 'Za zemiata (For the Nature)' Association, 'Green Balkans' Federation, and others.

2.5.8. Entities developing forest management plans and inventory

109. 'BULPROFOR – the Union of Practicing Foresters and Forest Entrepreneurs in Bulgaria' is a member of the Union of European Foresters and European Network of Forest Entrepreneurs, certified under ISO 9001:2000 Certified QM System by Moody's International Q070203. Its members are 12 legal persons and 72 physical persons.

110. The companies involved in the development of forest management plans and inventory of the forest territories are traders, registered into the public register under Art. 241 of the FA. Their number is 8 in total: Agrolesproekt OOD (state owned), Proles Injenering OOD, Silva 2003 OOD, Kaveko Injenering OOD, Ayko-1991, Nishava KiT, Prizma Info EOOD, and Geosistem OOD.

2.5.9. Hunting and fishing lobby

111. The hunters and fishermen in Bulgaria are represented by the National Hunting-Fishing Association – Union of the Hunters and Fishermen in Bulgaria and Bulgarian Hunting-Fishing Association. These are nonprofit organizations for sustainable management, regeneration, and protection of game and fish, conservation of environmental balance and biodiversity, development of hunting and fishing sports. The associations are governed by Statutory Rules. By the end of 2014, the number of registered hunters in Bulgaria amounted to 109,128.

2.5.10. Forest harvesting contractors

112. The forest harvesting contractors amount at more than 2,000 according to information from the EFA, responsible for the registration of such companies. Only about 460 are considered active by 2016 as their number is varies greatly.

2.5.11. Timber processors

113. The number of timber processing entities in Bulgaria is significant and includes companies for production of construction elements, furniture industries, pulp and paper production, producers of woody biomass energy carriers, and other industries. The Branch Chamber of Woodworking and Furniture Industry (BCWFI) is a voluntary nonprofit association whose mission is to protect and represent the interests of its members and the industry. The BCWFI is the only official employers' representative in the sectors of furniture, woodworking, and supply of equipment and materials for woodworking and furniture.

> Despite the long-lasting global impact of forest sector and its vulnerability to climatic changes, climate change and CCA-related activities are in most cases not addressed by specialized units in many of the interested organizations. This leads to misevaluation, delays, and even omission of relevant actions. Special attention should be paid to the local authorities and businesses. Most of them are not aware of their role in adaptation, but they are the key actors, as most of the policies and measures are to be implemented in praxis at the local level.

2.5.12. University of Forestry – Sofia

114. The organization and activity of the University of Forestry (UF)) are governed by the Rules for Operation of the University. The governing bodies of the university are the general assembly, the academic council, and the rector.

115. The UF consists of six faculties: Faculty of Forestry with six departments, Faculty of Forest Industry with five departments, Faculty of Ecology and Landscape Architecture with four departments, Faculty of Business Management with five departments, Faculty of Veterinary Medicine with five departments, Faculty of Agronomy with four departments. The most important specialties in terms of climate change are 'Forestry', 'Ecology and Environmental protection' and 'Agronomy'. The UF is the only one preparing specialists with bachelor's and master's degree in forestry in Bulgaria. These specialists are responsible for the management of the state forest enterprises and their subdivisions, the municipal forests, and private forests. The university staff also performs various research tasks and works on different projects related to the general topics of forestry and ecology of forests, including climate changes.

2.5.13. Forest Research Institute to Bulgarian Academy of Science

116. The organization and activity of BAS are governed by the Law on BAS (last amended by State Gazette issue 15/15.02.2013) and its statute. According to its Statute (last amended 19.07.2010) the BAS is a national autonomous organization for scientific research. It consists of 42 scientific institutes, seven academic specialized units, 12 other specialized units, and three subdivisions working without budgetary subsidies. Governing bodies of the BAS are the general assembly, the management board and the chairperson of the BAS.

117. The Forest Research Institute to BAS consists of four departments: forest ecology, forest entomology, phytopathology and game fauna, forest genetics, physiology and plantation forests, and silviculture and management of forest resources department. The last department covers, among others, subjects like forestry, biology, ecology, regeneration, cultivation, and use of forest ecosystems, and evaluation of forests.

2.5.14. Institute on Biological Diversity and Ecosystem Research to Bulgarian Academy of Sciences

118. The Institute on Biological Diversity and Ecosystem Research consists of the Department of Plant and Fungal Diversity and Resources, Department of Animal Diversity and Resources, Department of Aquatic Ecosystems, Department of Ecosystem Research, Environmental Risk Assessment and Conservation Biology, and the Department of Plant and Fungal Diversity and Resources.

119. Significant national and international research is carried out in Institute on Biological Diversity and Ecosystem Research in theoretical and applied aspects of ecology, biodiversity, environmental conservation, and sustainable use of biological resources. The institute is a member of the Consortium of European Taxonomic Facilities.

120. In addition to the abovementioned, there are other universities with faculties of ecology dealing with different aspects of environment including the impacts of climate change.

> Bulgarian science and education is at a traditionally high level. Still, currently there is no specific discipline focusing on climate change/CCA. Having in mind the urgency of CCA action, it is therefore needed to incorporate the topic in all levels of the education process – from appropriate basic knowledge for primary and secondary school education to extensive specific university courses. Considering that political decisions and development of such material in a best-case scenario take at least 2 years, it shall as soon as possible enhance relevant programs for all types of educational institutions, including specialties like civil and forest engineering, economy, tourism, international relations, and journalism.

2.6. Financial and Human Resources in Bulgaria

121. The horizontal climate change/CCA coordination mechanisms are in place within the governance system, with clearly identified division of responsibilities. The MAFF and EFA are part of these arrangements.

122. The 2014 Law on Climate Change Mitigation clarifies the responsibilities of different institutions with regard to climate change, including adaptation. Article 3, paragraph 4 of Climate Change Mitigation Law governs the establishment of the **National Expert Council on Climate Change** as an advisory body to assist the minister of environment and water in the elaboration of positions, statements and taking initiatives to fully implement the state policy on mitigation and adaptation to climate change. It consists of 48 representatives of the governmental sector, National Association of Municipalities in the Republic of Bulgaria, regional governmental authorities, BAS, environmental NGOs, and businesses.

123. The **Coordination Council on Climate Change,** established in accordance with paragraph 1, point 2 to the Environmental Protection Act in relation to Article 4, paragraph 1 to the Climate Change Mitigation Act, consists of 14 deputy ministers and senior experts of

concerned institutions. It has the following functions:

- Supports the minister of environment and water to the integrate the climate change policies in the sector policies;
- Coordinates, develops, and submits positions, statements, and information on matters related to the implementation of the national climate change policies;
- Participates in the development, presentation, and coordination of strategic documents related to the integration of the national climate change policies into the sector policies;
- Participates in the development, formulation, implementation, and reporting of the measures related to the CCA by sectors.

124. Climate change/CCA activities are supported by the budget and the RDP, Operational Programme (OP) Environment, OP Maritime and Fisheries, OP Administrative Capacity, other operational programs for transboundary, transnational, and interregional cooperation for 2014–2020. Other potential sources are the European Fund Solidarity, Framework Program for Scientific Research and Innovations Horizon 2020, LIFE Programme for environment and climate action, Interregional Cooperation Programme (INTERREG) Europe. Donor countries' programs are also a source of financing different climate change/CCA activities and projects.

2.7. Sector Participation in CCA Specific International Cooperation or Information Exchange

125. Bulgaria is party to the UNFCCC, the UN Convention on Biological Diversity (UNCBD), United Nations Convention to Combat Desertification and to other conventions such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora – all of them establishing specific provisions on the protection and sustainable management of forest ecosystems in conditions of adverse climatic impacts. The EFA provides information directly or through the MoEW on regular basis and participates in specific events.

126. The EFA is the focal point for several international initiatives: The United Nations Forum on Forests (UNFF), Forest Europe, Forum 'Balkan Forests', and the European Forest Genetic Resources Programme (EUFORGEN).

127. **Climate adaptation platform** (CLIMATE-ADAPT)[12] is a partnership between the EC (Directorate General CLIMA, Directorate General Joint Research Centre, and other directorate generals) and the EEA. CLIMATE-ADAPT aims to support Europe in adapting to climate change. It is an initiative of the EC which helps users to access and share data and information on: expected climate change in Europe; current and future vulnerability of regions and sectors; EU, national, and transnational adaptation strategies and actions; adaptation case studies and potential adaptation options; and tools that support adaptation planning.

[12] http://climate-adapt.eea.europa.eu/countries-regions/countries/bulgaria

2.8. Bulgarian Sector Specific Ongoing and Foreseen CCA (related) Actions

2.8.1. Program of Measures to Adapt Forests in the Republic of Bulgaria and Mitigate the Negative Impact of Climate Change on them 2012–2020

128. The Program of Measures to Adapt Forests in the Republic of Bulgaria and Mitigate the Negative Impact of Climate Change on them is based on an analysis on the state of the forest ecosystems main components in the context of climate change, climate scenarios based on contemporary data and state-of-art models on the evolution of climate in Bulgaria during the 20th and 21st centuries, definition of the 'zones of vulnerability' in the forest ecosystems, and a program with measures for adaptation of forests to climate change, according to the zones of vulnerability.

129. It contains a certain number of normative, organizational, and investment measures depending on the level of vulnerability: very high vulnerability zone – 50 measures, high vulnerability zone – 26, moderate vulnerability zone – 19, and low vulnerability zone – 11 measures. Estimation of the value and sources of funding, the deadlines for implementation and the responsible institutions/organizations are determined. Specific performance indicators are established.

2.8.2. Third National Climate Change Action Plan 2013–2020

130. The Third National Climate Change Action Plan 2013–2020 defines a small number of adaptation measures in the agriculture and forestry sectors. The first priority axis combines measures to increase the sequestration of GHGs and the necessary measures are associated with increase of the areas of land use categories - sinks of GHGs - forests, pastures, and meadows, and measures for their sustainable maintenance in order to increase the amount of biomass. The increase of green areas in urban territories is also a measure with positive impact on carbon balance. This axis reflects the need for additional legislative and administrative measures to regulate the changes in the designation of areas of land use categories that are sinks of GHGs.

131. The third priority axis contains measures related to increasing the potential of forests for carbon sequestration. There are administrative, regulatory and financial measures aimed at increasing the country's forest resources and improving their condition and potential as a major carbon sink.

132. The fourth priority axis includes measures aimed at the long-term retention of carbon in wood products through the expansion of their use at the expense of other non-renewable materials with high carbon content which can be achieved by raising the awareness and the interest of society.

2.8.3. National Forest Inventory

133. The implementation of a full NFI of critical importance to collect reliable data on the status of forest resources. Forestry covers approximately one third of the territory of the country and has the potential to be a vital indicator of climate change and its effects, informing not only forestry policy and adaptation but also that of other sectors.

134. In reaction to climate change, the forest will change in subtle ways and a full NFI can document those effects in ways that temperature trends and other measures cannot. The first

cycle of NFI provides a snapshot of current forest conditions and forest resources, including an updated and improved basis for GHG reporting and for natural capital accounting. When second and subsequent NFI cycles are accomplished, the gathered information can be used to monitor the effectiveness of adaptation and mitigation policies and actions. At present, there is no activity taking place toward execution of an NFI for Bulgaria even though it is the only EU country without such a process. NFI is an enormously useful data source for large-scale continuous monitoring and research, including those concerned with mortality and reasons for it, regeneration processes which determine the future forest development, and numerous other components of forest ecosystems.

2.9. Gaps and Barriers Hindering Adequate Response to CCA Action; Interface with Climate Change Mitigation

135. There are several gaps and barriers which may hinder adequate response to Climate change and necessary actions in the forests:

- **Lack of adequate knowledge on the various vulnerabilities of forest species and ecosystems.** This includes a wide range of knowledge gaps listed in sub-chapter 2.1. A lot of the modern knowledge is published in other languages, including English, in high-ranking journals, which is not an accessible format for most forestry professionals in Bulgaria. In addition, there is a lack of sufficient experimental work on different management options and their potential to cope with various challenges. Modelling experiments contribute to such knowledge (see ***Annexes***), but additional data must be experimentally gathered to fill the gaps listed in sub-chapter 2.1. Much of expectations and assumptions for management strategies and silvicultural approaches are based on already gained experience and knowledge which was gathered in different climatic, political and economic contexts. Local experimental work could serve as a good knowledge base for decision making and opportunity for demonstration to professionals. This is important for a sector in which traditionally the professionals are conservative and need good examples to be convinced that suggested options are robust.

- **Lack of specific and focused education on climate changes for the forestry professionals.** Currently, the bachelor and master's degree students in the only university of Bulgaria, which prepares higher-level forestry professionals, the UF in Sofia, does not have a specially targeted climate change education course or discipline. It is considered that the wide variety of potential problems related to forests and climate change requires such specific education. There is also a need of Continuous Professional Development Program (and certification) for additional and periodic special education and training for professionals working in the forestry sector.

- **Funding of various activities on CCA** and mitigation measures could be a major problem, especially for long-term programs. There is high reliance on funding from EU operational program. However, in the forestry sector, there could be a serious need for funding of strategic programs with very long duration, where shorter-term project funding is not an appropriate solution. Research institutions and universities in Bulgaria face major problems in finding funding resources for environmental research. Participation in EU-level projects is often hindered for local researchers and teams by inadequate research infrastructure and work conditions, preventing them from obtaining the relevant experience. There is a need to seek opportunities to fund studies with regional and national focus which contribute to directly solve specific national problems.

- **Priorities in management goals and expectations** from society and other economic sectors. There are high expectations from forests to serve as a resource of timber and other commercially valuable ecosystem services. Society in Bulgaria traditionally takes for granted various ecosystem services served by forests such as the provisioning of pure drinking water, erosion control, tourist and recreation activities, and carbon sequestration by forests. However, the maintenance of such functions is sometimes conflicting with other functions such as timber production and comes at a potentially high price.

- **Lack of adequate understanding and awareness** of the potential risks from climate change in society. This could be a general problem for the practical implementation of numerous activities that would require high financial resources or giving up, or decreasing the expectations for social, economic, or biodiversity-based ecosystem services. The long-term nature of forestry can also work against the short-termism that is sometimes prevalent in society.

- **Low level of mechanization in forestry works**. Many of the contractor companies for harvesting rely on old machines and use of animals for much of the operations in forests. It can be expected that in future the share of animal use will decrease and even disappear. The level of mechanization and quality of machines will be of high importance for the proper management, roads protection, soil protection, response in the case of emergencies. The generally poor state of the forest roads network could also be hindering various activities.

- **Additional development of enough resources for production of seedling material** of high variety of tree species and provenances. In the past, Bulgaria had a very well-developed system of seedling nurseries belonging to the forestry enterprises which were specialized mostly in the production of pine seedlings for large-scale afforestation. Currently, there are 143 nurseries in the official list of EFA. Twenty-seven forest nurseries of national significance are listed in Annex № 2 to the FA. Annually a planning list for the necessary seed material is issued (for 2017, containing 57 forest tree species). The seed production is followed closely and governed by two Forest Seed Control Stations in Sofia and Plovdiv. There is a wealth of experience and knowledge on the growth of provenances form various commercially important species, but this was directed mostly to the aim of selecting and testing high-productivity provenances. However, in future, it is much more likely that highly resistant provenances will be of greater importance and therefore work in this direction is needed. There are high chances that natural regeneration of many species will face problems due to harsher climate conditions and therefore there will be a need to support regeneration of valuable or rare species by planting seedlings. In addition, possible measures for adaptation to climate changes will be creation of plantations from locally sourced trees that are highly resistant to harsh conditions. Such actions would require the availability of nurseries with sufficient capacity for production of seedlings of different species, provenance, and clonal material, either through seed, seedling or vegetative propagation. For that reason, the nursery network must be maintained and adapted to be capable of handling future challenges and planning on a longer-term basis.

- **Lack of joined up thinking across the sector.** An example of the complexities here relates to the fact that forest growth mitigates climate change by sequestering carbon. Using timber in long-lived forest products locks away the carbon even after the trees are felled and if the forest is managed sustainably, there is a strong cumulative storage effect. There needs to be a recognition along the timber-based value chains of this effect and a pull-dynamic created for long-lived forest products that encourages its use in this way. Climate change can also have negative impact on the growth of forests, thereby reducing the ability of the forest to sequester carbon. Encouraging climate-adapted species choice in afforestation or reforestation, targeting the production of long-lived (and generally higher value) forest products will raise the return on investment while maintaining or increasing output and long-term carbon sequestration. The topic is further complicated by using wood for energy, which has the benefit of displacing non-renewable fuels. There is a necessity for development of National plan for utilization of wood biomass, which should synchronise the potentially higher demand of wood for energy production, the need of modern facilities for energy production to maximise the efficiency of the use of the renewable wood resource, the need to create plantations for wood production and in the same time the numerous potential restrictions and trade-offs. Such a plan should guarantee that the used wood will not lead to general decrease of sequestered carbon and will not violate other important ecosystem functions of forests, especially in sensitive ecosystems. Another complex topic is the provision of road access. The poor quality and low density of the current forest road network is a challenge to fire management and control, as well as the maintenance and enhancement of forest production. If inaccessible forests are damaged due to natural or other disturbances, then timber recovery and reforestation cannot take place. A limited road network is causing intense use of accessible forests while others are not being thinned and the production is lost to natural mortality. Improving access to the forest must not be achieved at the expense of the forest resource and all its functions. Threats from illegal logging and other unsustainable activities undermine the desirability of opening the road network, and until these risks are tackled, it may be difficult to proceed. Indeed, anything that negatively impacts the economic performance of forestry is also a threat to CCA, as the scope to reinvest and build resilient forest resource will be limited. Opening forest access also threatens biodiversity: Bulgaria may need to confront its priorities in a changed climate and focus on the protection of high conservation value areas while allowing an intensification of forest production in others. The erosion control, flood abatement, water protection and temperature control functions of forestry are significant. Some 16 percent of Bulgarian forests are designated to have protection functions, and this has a significant impact on other economic functions. Hunting, ecosystem services, tourism and recreation are also beneficiaries of healthy forests. Recognition of the cross-sectoral benefits of forestry is not often recognized and until this happens the continued supply of these benefits in a changed climate will be under threat. The development of regional management plans could be one of the ways to partially overcome the lack of joined up thinking across sectors, because it requires long-term priority setting at the regional level achieved through a consensus between various stakeholders.

2.10. Conclusions

136. At the general political level in Bulgaria, there is awareness of the potential future consequences of climate change which is reflected in acts, programs, and strategies. The forestry sector has recognized the need for CCA and has already worked on it during the last decade. The National Strategy for Development of the Forest Sector in the Republic Bulgaria 2013–2020 outlines the necessary steps as does the Program of Measures to Adapt the Forests in the Republic of Bulgaria and Mitigate the Negative Impact of Climate Change on them 2012–2020. The third National Climate Change Action Plan 2013–2020 defines some adaptation measures in the agriculture and forestry sectors.

137. Successful adaptation to climate changes requires significant financial resources, professional action, and understanding of the social context of the various challenges. Specialists within the management of forestry enterprises and Bulgaria's higher forestry sector management are aware that climate change is likely to contribute to many growth and health problems in forests and that it may cause further problems. However, the understanding in the wider society is not so strong. This could jeopardize taking the appropriate political decisions and securing the necessary financial resources. In addition, the sector faces several knowledge gaps regarding the potential consequences of climate change. These include (1) a lack of in-depth knowledge on the potential effects of climate change on tree species, (2) the low level of awareness in society and the education level of personnel involved in forestry and wood-processing activities, (3) a lack of joined-up thinking across sectors, and (4) the low level of mechanization in forestry works. This situation may hinder the adaptation of the Bulgarian forests to climate change.

138. Another big obstacle for effective CCA is the lack of an NFI. There is an urgent need to start the execution of an NFI which is the most important tool for large-scale, continuous monitoring of forest resources and the effect of various actions in them. Without regular NFI surveys it will be impossible to measure the effectiveness of adaptation measures and the effects of climate change may go unmeasured.

139. Very positive in the forestry sector is the number of governmental, nongovernmental, and professional organizations, and the existing UF and other research and educational institutions that have a focus on ecosystems. These provide the possibility to quickly build the necessary knowledge and management capacity for successful climate change adaptation with well-designed and targeted actions.

Chapter 3. Adaptation Options

Introduction

140. Successfully adapting the forest sector to climate change will have the added benefit of increasing its mitigation effect as more carbon will be sequestered from the atmosphere. In specific years, for example from 1990 to 1994, the forests of Bulgaria have offset 22 percent of all industrial carbon emissions and it is the country's single largest sink. Additionally, the role of forests for mitigation of climate change effects and the associated needs for forest adaptation were specifically recognized and addressed in the Paris 2015 Agreement, which was ratified by Bulgaria. It should be noted that owing to their high species and genetic richness, Bulgarian forests have a high adaptation potential. However, climate change is likely to move too fast to rely solely on natural adaptation. Therefore, well-designed adaptation interventions and changes to current management practices are needed to assist the process. The adaptation options described here will help safeguard the sector so that its many services will continue to be delivered for society.

141. In the short term, the forest will be protected by improved fire detection and control; meanwhile research and development will be underway to map out what trees will grow best and where, under the new climate. New information channels will ensure that practical guidance reaches those who are active in operational roles. The capacity to identify, collect seed, store, propagate, and grow the best tree species and genotypes will be reinforced. Trends in forest disturbances will be mapped and incidents caught early so that action may be planned. Resilience will be improved by expanding and diversifying the forest resource using agricultural land and by enriching state forests with additional trees and species. The situation regarding abandoned agriculture lands will be regularized in a way that encourages the landowner (including through financial incentives) to switch their land use to forestry and avoid the occasional use of fire as a management tool. This and the use, for example, of short rotation forestry will also alleviate some of the pressure on state forests as a source of fuelwood. Finally, the financial sustainability of the forest sector and its ability to invest in climate change actions will be improved by encouraging the use of timber in construction, whereby, the production of higher-value forest products will also have the benefit of storing carbon on a long-term basis within energy efficient structures.

142. Many of the actions are envisaged in the 'Strategic Plan for the Development of the Forestry Sector in the Republic of Bulgaria 2014–2023' and the further development of these adaptation options should be in coordination with the delivery of this plan.

143. Regarding the prioritization of these adaptation options, it is expected that the country will apply the Guidelines on Developing Adaptation Strategies put forward by the EU.[13] This analysis should include a set of criteria, such as:

- Urgency with respect to already existing threats;
- Early preparatory action (to avoid future damage costs);
- Range of effect (options covering multiple risks might be favored);

[13] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52013SC0134 (06/28/2017)

- Cost-benefit ratio;
- Time-effectiveness;
- Robustness under a broad range of likely future impacts;
- Flexibility for adjustments or reversibility in case of diverging developments;
- Political and cultural acceptability;
- Enhancement of learning and autonomous adaptive capacity, and so on.

3.1. Identified Adaptation Options

3.1.1. Research, education and extension

CLIMATE CHANGE ADAPTATION OPTIONS	
I.	**Research, education and extension**
1.	Establish a research and development coordination body for climate change mitigation and adaptation
2.	Create a National Forestry Extension Service and a system for dissemination of results
3.	Build capacity in government organizations, forest management structures and private companies, university and higher education staff
4.	Update the climate-change scenarios models for the territory of Bulgaria using the most up-to-date versions of climate models
5.	Review and update the existing models of productivity of the most important tree species currently, and those species which may have potential in Bulgaria in a future changed climate.
6.	Model the potential performance of all these species and the forest ecosystems, over the entire territory of the country and under different climate change scenarios and different timescales
7.	Continue the scientific study of genotype variability and suitability for various climate conditions for the most important, endangered and highly vulnerable tree species
8.	Develop spatially explicit risk models for disturbances such as windthrow, fire, insect and disease damage
9.	Continuously monitor forest ecosystems and the effects of climate change, management, adaptation and mitigation measures at micro (projects) and macro scales (NFI)
10.	Conduct research and planning to ensure the availability of reproductive material in a timely manner
11.	Assess the impact of changing wood resources on the processing sector and adaptation strategies to support long-term resilience and value-adding potential
12.	Research additional use of wood and forest products to foster and promote diverse uses of wood and increase the potential for value addition

144. Solid knowledge on the potential effects of climate change on forest ecosystems and continuous analysis of available data is key to informed decision making and adaptive management. Such knowledge can be obtained by careful analysis of international experience, targeted local research aimed at answering questions specific to Bulgaria, and a good system of knowledge transfer to (and from) the various stakeholders in the forestry sector.

145. Research and education in the Bulgarian forestry sector is generally underfunded which decreases the potential to address the abovementioned challenges. Therefore, a necessary step is to **design a research program**, which would mobilize the available research, education and training resources to solve the urgent and specific Bulgarian forestry sector questions.

146. Specific topics of research include the following, implemented roughly in this order to build on the preceding steps:

1) Updating the climate change scenario models for the territory of Bulgaria using the most up-to-date versions of climate models.
2) Reviewing and updating the existing models of productivity of the most important tree species, and those species which may have potential in Bulgaria under a changed climate. Amending these models, if necessary, to use climate-related, soil and relief parameters.
3) Modeling the potential performance of all these species and the forest ecosystems over the entire territory of the country and under different climate change scenarios and different timescales. Various ecosystem services should be included in this modeling task.
4) Producing digital suitability maps for the analyzed tree species for the territory of Bulgaria. This will allow modeling of the suitability of potential habitats under different climate change scenarios. The results from this modeling should be used in the periodic updating of the forest classification scheme and other DSS tools used by forestry professionals to reflect the best practical guidance in the face of climate change.
5) Continuing the scientific efforts on studying genotype variability and suitability for various climate conditions for the most important and endangered or highly vulnerable tree species. Setting specific long-term experiments for studying the potential for survival and growth under different climate conditions and at different development phases of the tree species.
6) Continuous monitoring of forest ecosystems and the effects of climate change, management, adaptation, and mitigation measures to provide the basis for analysis of the effectiveness of various measures and the need to further adapt management strategies.
7) Working closely with forest reproductive material specialists and nurseries in projects and programs for conducting research and planning for the availability of such reproductive material on time.
8) Assessing the impact of changing wood resources on the processing sector and adaptation strategies to support long-term resilience and value-adding potential.
9) Developing spatially explicit risk models for disturbances such as windthrow, fire, insect and disease damage.
10) Researching the additional use of wood and forest products as a way to foster and promote diverse uses of wood and increasing the value-adding potential.
11) Disseminating research findings to practitioners and engaging with forest extension service to ensure effective communication.

147. The research program should not rely solely on external funding but should use specifically-targeted resources to enable the forming of interdisciplinary research teams with participants from various research and education organizations and potential involvement of NGOs. To begin, a small governmental **research and development coordination body** should be established to administer national research funds and identify international sources, set research priorities, and disseminate research findings. The managing board of such a body should comprise members from across the forest sector. This body would also commission research on a competitive basis from interested parties and manage the performance of such work. It would not directly employ researchers or extension workers. External funding opportunities that may be targeted will include EU Life Climate Action, European Structural and Investment Funds, and Horizon 2020.

148. A crucially important step would be to design and **implement a system for dissemination of results** from research to stakeholders at various levels. Various potential users of knowledge have different needs of detail and ways to present. Examples include political subjects, professionals, students, and ordinary society members. Specifically, for the professionals in the forestry sector, **a National Forestry Extension Service** is needed, as envisaged in the document 'Strategic Plan for the Development of the Forestry Sector in the Republic of Bulgaria 2014–2023'. This is essential because the potential climate change effects on forest ecosystems are highly varying and loaded with uncertainty and therefore, continuously updated knowledge gains should quickly reach relevant professionals.

149. Additional need exists in the area of promoting policies for open data access, use of modern data formats, and easy data sharing among institutions. Forestry management relies on a broad variety of data across fields of expertise. At the same time, much of these data are needed by other institutions and stakeholders for them to ease the planning and management of their activities. The same goes for data from sectors such as climate, biodiversity, soil and erosion, and water use.

150. A key need to ensure the understanding of the potential risks of climate change and proper conducting of adaptation activities for the forestry sector is supporting and **building the capacity of staff** in government institutions, forest enterprises, research and educational institutions, private companies in forestry activities, and the wood-processing industry. Capacity building is directly related to all other adaptation options and activities. Capacity building and enhancing transparency were specifically addressed by the Paris 2015 agreement (Article 13). Governmental institutions and the state forestry enterprises need good understanding of climate change issues and must receive appropriate training on the topic to be able to prepare and conduct policies in this direction. This would also improve the necessary coordination among institutions because CCA options in the forestry sector will often be directly related to other sectors, for example biodiversity, agriculture, water, energy, and urban development. There is also a need to upscale general economic and market knowledge among forestry operators and along the wood processing chain so that the forestry sector can anticipate climate change and ensure sector resilience.

3.1.2. Building resilience in regeneration, expanding and strengthening the forest resource

CLIMATE CHANGE ADAPTATION OPTIONS
II. Building resilience in regeneration, expanding and strengthening the forest resource
13. Work with research and extension activities, enhance the Bulgaria's forest nursery capacity, as a key component in climate adaptation
14. Strengthen the existing forest resource through enrichment planting and pro-active management of at-risk plantations
15. Rehabilitate highly damaged by natural disturbance or die-back forest areas and afforestation to improve water and soil protection functions
16. Maintain and create new forest shelter belts in agriculture lands
17. Create forest corridors to link existing forest patches in the lowlands
18. Establish short-rotation biomass plantations
19. Tackle the various legal, area-aid, stakeholder, bureaucratic, ownership and other challenges to ease the transition to forestry from other land uses and consider what incentives could be provided through state or EU aid
20. Continue collecting seed from valuable tree species and their provenances (especially southern-most) and testing their performance in experiments simulating different climate conditions.
21. Maintain a seed bank for endangered species or provenances, which would enable their support in case of regeneration failures
22. Gain experience with production of seedlings for rare and endangered species (including establishment of them in the field) so that they may be conserved
23. Experiment with the production of seedling tree material that are more resistant to for example fire, insect, disease or other disturbance

151. Expanding the forest resource is a very direct way of addressing climate change mitigation through carbon sequestration and adaptation, as a relatively rapid means to raise the resilience of the resource through species and provenances choice, increased diversification, and so on. Bulgaria has long-term experience in afforestation and strong competence in seed production using preselected natural 'seed production forests', selected provenances, and clonal material as well as seed orchards for some of the economically most important tree species. Other areas of expertise include general planning for seed production and their storage and experience in nurseries for the production of saplings. However, the targets in the past century were mostly for selection of highly productive provenances, while the ongoing climate change and expected future climate changes pose the need for selection of regeneration material on a different basis. As a key component in CCA the existing **capacity in forest nurseries needs to be enhanced**.

152. Strengthening the existing forest resource through **enrichment planting** (supplementing the existing forest cover with additional trees) within the existing forest territory is an opportunity to raise diversity levels and begin to introduce species or genotypes that may be more suitable in a changed climate. This may also cover the **rehabilitation of areas**

damaged by natural disturbance or die-back caused, for example, by species being incompatible with the site or elevation. The health status of many coniferous plantations at low elevation is deteriorating severely. Many of these forests are on steep slopes and if the natural regeneration of these sites is insufficient or too slow, they pose a high risk of increased erosion and floods. **Establishment of new forests in these and other erosion-prone areas** should be considered, and priority areas identified with the use of geographic information system (GIS) analysis and other objective tools and criteria (see the adaptation option relating to long-term disturbance monitoring). Site-specific management plans for these plantations are needed that are informed by climate change mitigation principles.

153. Another specific need which could be supported through afforestation is to **maintain and create forest corridors** to link existing forest patches in the lowlands. This is highly needed to support biodiversity protection, migration of animal and plant species, gene exchange, and in certain cases, to assist agriculture through protection from wind erosion and snow removal from strong winds.

154. The different types of activity for which a **financial support mechanism** would be envisaged are listed below:

1) Continuing the work on collection of seeds from valuable tree species and their provenances and testing their performance in experiments simulating different climate conditions;
2) Including provenances that are marginal for the specific species locations, especially the southern-most;
3) Expanding to include rare species and gain experience with production of seedlings from them and planting in natural conditions;
4) Producing seeds from endangered species or provenances, which would enable their support in case of regeneration failures;
5) Experimenting with the production of seedling tree material that are more resistant to, for example, fires, insects, diseases, or other disturbances;
6) Supporting erosion control forests, enrichment planting, and regeneration of disturbance-hit forests in state, communal and private sector forests, including management plans for at-risk forests;
7) Establishing a program to maintain and restore the forest shelterbelts in the agriculture lands; and
8) Establishing a program to create and maintain forest corridors linking isolated forest patches in the lowlands.

155. A necessity related to the expected increase in the demand of wood for technological reproduction and wood for energy production is afforestation for the establishment of new forests for **short-rotation production of wood.**

156. This Adaptation Option would also include tasks to **tackle the various legal, area-aid, stakeholder, bureaucratic, ownership, and other challenges** that exist to clear the path for agricultural land to be used for forest production. In the case of abandoned land, the succession process may already be underway naturally. To accelerate this transition and create an asset that

will appreciate in value for the landowner, specific silvicultural treatments could be supported. Alternatively, or in addition, more resistant genotypes or different species could be used in enrichment planting to more quickly establish a more resilient forest resource. A common solution to clearing otherwise unused agricultural land is burning and this poses substantial risks. Regularizing the position with regard to scrubland and allowing it to transition into forestry as a viable land use for the landowner is an attractive alternative.

157. Between 2003 and 2010, the area under permanent grassland and meadows has increased fourfold[14] whereas cattle levels have reduced by 12 percent and the agricultural labor force by 45 percent over the same period. It does raise the question as to how much land could more productively be assigned to forestry as a sustainable land use for the landowners involved. This should be considered now, while the EU subsidies could be available to assist in such a transition, rather than later when they may not be available.

158. To support this afforestation, the following measures can be suggested:

1) Settle, through legislation or otherwise, the legal, financial, and other impediments to agricultural land transitioning to forest land without any diminution in landowner rights or income loss through loss of EU area aid payments.
2) Establish a program to support the creation of plantations for biomass production on unused lands, mostly agricultural.

159. It is proposed that any subvention program used be correctly controlled and administered, with clear quality standards and penalty clauses. Legal or contractual safeguards or payment incentives would ensure that the forest would need to be persisted with for a number of years before being eligible for harvest.

Box 9. Expanding and strengthening forest resources: synergies with the Common Agricultural Policy

Under the Common Agricultural Policy, the measure of afforestation of agricultural land is being implemented since 1992 (Reg. 2080/1992 and Reg. 1257/99). According to this measure, owners of marginal productivity agricultural land are encouraged to transform it into forest land by planting forest tree species. This way, the afforested area in the EU increases with favorable consequences. Beneficiaries of this measure receive subsidies to cover planting and maintenance costs for up to 5 years after planting tree species, and support for the construction of windbreaks, fire lanes and an annual support payment per hectare afforested (up to 20 years) to cover income losses resulting from land use change (Chalikisa and Christopoulou 2010). Not in all EU countries, have the national specific regulations favored the implementation of this part of the Common Agricultural Policy. In many cases, the bureaucracy and low priority of the measure lead to poor results. In Greece, the implementation of Regulation EEC/2080/92 from 1993 to 2001 resulted in the establishment of 35,840 hectares of forest plantations mainly of black locust, poplar, and walnut (Chalikias and Christopoulou 2010).

[14] http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_Bulgaria

3.1.3. Maintenance of biodiversity and genetic diversity

CLIMATE CHANGE ADAPTATION OPTIONS
III. Maintenance of biodiversity and genetic diversity
24. Preserve available hotspots of biodiversity, old-growth patches and clusters of habitat trees
25. Promote management strategies that maximize species, genetic and structural diversity and limit the spatial extent of homogenous areas
26. Identify rare species with serious risk of extinction and, together with research and nursery specialists, protect their current status, but plan for their regeneration and potential migration
27. Implement measures to limit the potential of invasive species, especially insects and fungi, to enter forest ecosystems
28. Participate in the European Information System on Forest Genetic Resources

160. One of the key aspects of maintaining resilience of forests and increasing their potential to better adapt to unexpected challenges, including climate changes, is preserving biodiversity and genetic diversity. Plant and animal species have long adaptation histories and have often been able to overcome various challenges. Thus, in natural ecosystems there is high chance that there are available genotypes which are capable of successfully handling a variety of conditions. Past management practices were often directed toward simplification of species composition of forests, structural complexity, and choice of specific genotypes which showed better potential to produce higher quality wood. However, this trait may run contrary to its forest resilience characteristics. In addition, in a situation with high degree of uncertainty for future conditions certain species, which are not highly valued now due to lower potential economic income from them, might be the ones capable of handling the future conditions better. It is therefore crucially important to preserve and maximize biodiversity and genetic diversity. In this context, various measures, which have already been planned or started should be undertaken. Such measures include the following:

1) Preserving available hotspots of biodiversity, old-growth patches, and clusters of habitat trees (in Bulgaria also called 'biotope trees') and maintaining suitable corridors between them, ensuring connectivity and the potential for migration of individuals and genes exchange. Measures should be implemented to support such forest areas, even those outside NATURA 2000 or Forest Stewardship Council (FSC) certified forests, or in privately-owned forests.
2) Limiting aggregation of forest areas with management strategies that use lower structural heterogeneity and species richness (for example, plantations for biomass production from one species or clones). Protecting the natural species composition of forests and connectivity between such forest patches in such areas is extremely important.
3) Continuing the efforts to identify key habitats and maintaining them to ensure the actual *in situ* protection of species with limited distribution.
4) Identifying rare species with serious risk of extinction and assisting their regeneration and potential migration. Climate and species distribution models indicate that migration

rates should be more than 1,000 m per year to allow plants to follow the predicted shifts in their current climatic niches, which could be about ten times higher than the potential migration rates of many species. This, together with often isolated growth niches and competition from better adapted species means that some endangered species will not be capable of migrating to find new growth niches and should be actively supported to survive.

5) Promoting management strategies, which will ensure high species and structural diversity and natural regeneration. Examples are silvicultural systems with long rotation periods, which ensure gradual transition between the forest generations and less stress in the ecosystems. This measure is among the potentially most important for natural adaptation to climate change because it stimulates the protection of genetic diversity, natural hybridization, and protection of biodiversity.
6) Widening the participation of Bulgaria in the European Information System on Forest Genetic Resources.[15]
7) Implementing measures to limit the potential of invasive species, especially insects and fungi to enter forest ecosystems. Besides strict sanitary control, there is the necessity to limit the use of species with proven invasive character while planting next to roads, park areas, gardens (including private), and agriculture lands close to forests. These are usual ways for invasive species to receive the potential for wider spread, including in forest areas. In addition, measures should be implemented to remove such species where there is wider spread and substitute them with suitable local species. There is need of designing appropriate risk assessment protocols for known invasive species and serious education work among both professionals in various areas and society members to adequately address the problem.

Box 10. Research, education and extension services: vulnerability and adaptation research at the local and regional levels in Europe

The Dutch government implemented the Climate Changes Spatial Planning Program which, aimed to make a scientific input into the development of the Dutch National Adaptation Strategy. The Climate Changes Spatial Planning Program had a focus on spatial planning to support decision-making on the future development of the Netherlands. The program is based on assessing the knowledge demands for eight so-called 'hotspots' or case study regions. Gaps in knowledge will be identified and addressed by the scientific community. The understanding thus obtained is then made readily available to the hotspot regions with a view of enabling them to adapt to the impacts of climate change (Swart et al. 2009).

In the United Kingdom, the Natural Environment Research Council is a key organization in funding the development of science on climate change impacts and vulnerabilities; it funds several major research programs and projects. In addition, an ambitious research program Living with Environmental Change, was implemented by a consortium of U.K. funding bodies including the National Environment Research Council and the Department for Environment, Food, and Rural Affairs starting from 2008. One of the most recent programs under this header is the five-year program, 'Adaptation and Resilience to a Changing Climate', which builds on

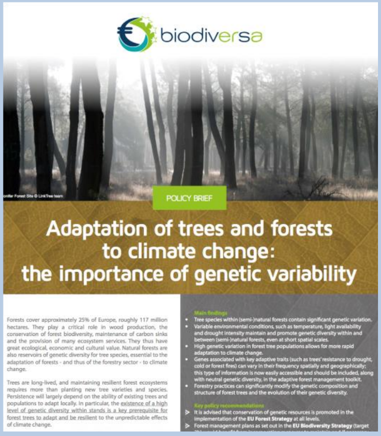
[15] See http://portal.eufgis.org/

earlier programs such as 'Building Knowledge for a Changing Climate'. All the above mentioned programs include forestry-related research.

In Finland, the adopted CCA strategy included key recommendations regarding the establishment of a five-year Finnish Climate Change Adaptation Research Programme (ISTO) aimed at filling gaps in knowledge and providing relevant knowledge on adaptation for policy makers (Swart et al. 2009, Martilla et al. 2005).

Box 11. Biodiversity and genetic diversity maintenance: enhance genetic diversity to improve the resilience of ecosystems – LinkTree project 2011

Figure 16. LinkTree project policy brief

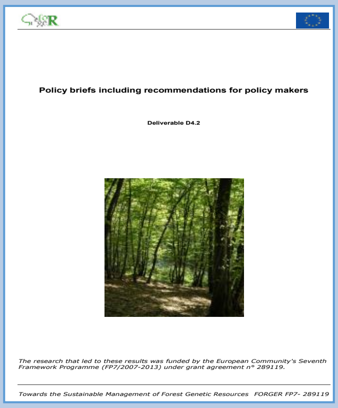


Enhancing genetic diversity has proved to be one important approach for increasing forest resilience in the context of expected climate change. The BiodivERsA-funded project LinkTree examined genetic variations within forest tree population in five European countries and assessed how this variability and its management could help forests adapt to environmental changes. The main findings highlighted that high genetic variation in a forest tree population allows for more rapid adaptation to climate change (Grivet et al. 2011) and forestry practices can significantly modify the genetic composition and structure of forest and the evolution of their genetic diversity (Sagnard et al. 2010). The policy recommendation delivered by the project are being currently taken into serious consideration both at national and European level: EU member states should strengthen forest genetic conservation at level that are even higher than those already stated in the EU Forest Strategy; the EU and National CCA strategies would benefit from including knowledge regarding genes involved in local adaptation in models forecasting climate-induced range shifts, improvement in implementation of the EU Strategy for Adaptation to Climate Change by inclusion and promotion of practical guidance on adaptive forest management using genetic diversity and resources, and so on.

Sources: http://www.igv.fi.cnr.it/linktree/ (05.17.2017), http://www.biodiversa.org/ (accessed on May 17, 2017)

Box 12. Biodiversity & genetic diversity maintenance: enhance genetic diversity – FORGER

Figure 17. FORGER policy brief



The FORGER project (Towards the Sustainable Management of Forest Genetic Resources FORGERFP7-289119) aims at integrating and extending existing knowledge to provide science-based recommendations on the management and sustainable use of forest genetic resources for EU-policy makers, national stakeholders, forest managers, and managers of natural areas. It was implemented based on a partnership between the Netherlands, Austria, Germany, France, Finland, Hungary, Italy and Poland. Among the results of the project a series of guidelines have been elaborated, with direct applicability in developing approaches and tactics in enhancing genetic diversity for increased forest ecosystems resilience: guidelines for seed harvesting in forest seed stands,[16] guidelines for the choice of forest reproductive material in the face of climate change[17] as well as policy briefs (Kramer et al. 2015).

Source: http://www.fp7-forger.eu/about-forger (accessed on May 17, 2017)

3.1.4. National systems for rapid forest fire detection, long-term disturbance monitoring, and forest resource monitoring, including NFI

CLIMATE CHANGE ADAPTATION OPTIONS
IV. National Systems for Rapid forest fire detection, Long term disturbance monitoring and forest resource monitoring, including NFI
29. Build a National system for rapid fire detection and response to this and other natural calamities
30. Build a National system for long-term disturbance monitoring
31. Execute a National Forest Inventory
32. Integrate existing and novel information systems in modern National Information System for Forest Resources

161. The collection of reliable data on forestry resources and the long-term monitoring of various changes in it are critically important for successful CCA and for the fulfilment of the Intended Nationally Determined Contributions (INDCs), which are an obligation under Article 14.7 of the Paris 2015 Agreement: *"Each Party shall regularly provide the following information: (a) A national inventory report of anthropogenic emissions by sources and removals by sinks of greenhouse gases, prepared using good practice methodologies accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement; (b) Information necessary to track progress made in implementing and achieving its nationally determined contribution under Article 4."* Therefore, an urgent need exists to commence the **execution of the NFI**. Further, the protection of forest resources from large-scale losses due to forest fires and other disturbances is among the key tasks for the protection of resources and all related ecosystem services. Adaptation actions should cover both short- and long-time horizons. Forest fire is already a significant and growing threat. As the growing stock of the Bulgarian forest resource rises, so too does the impact of fires. To limit the damage, rapid detection is vital, and the MAFF has been very active in managing this threat, and this topic is covered very well by the 'Strategic Plan for the Development of the Forestry Sector in the Republic of Bulgaria 2014–2023'. In the midterm review recently conducted into the implementation of this plan, certain actions were less well-progressed than others, including plans for a *"**national system for early warning and awareness at regional and local level** aiming at timely informing and raising of effective protection of population in cases of calamities and disasters, protection from floods and technological risks, as well as introduction of **unified radio system for interaction and coordination**"* which has strong cross-sectoral links. It is understood that this activity has been delayed due to lack of funding, but it is vital for adequate response and has **strong cross-sectoral benefits**. It addition, it is necessary to model the risk of occurrence and spread of forest

[16] http://www.fp7-forger.eu/uploads/SeedHarvest_forweb.pdf (05.17.2017)
[17] http://www.fp7-forger.eu/uploads/ForestReproductiveMaterial_climatechange_web.pdf (05.17.2017)

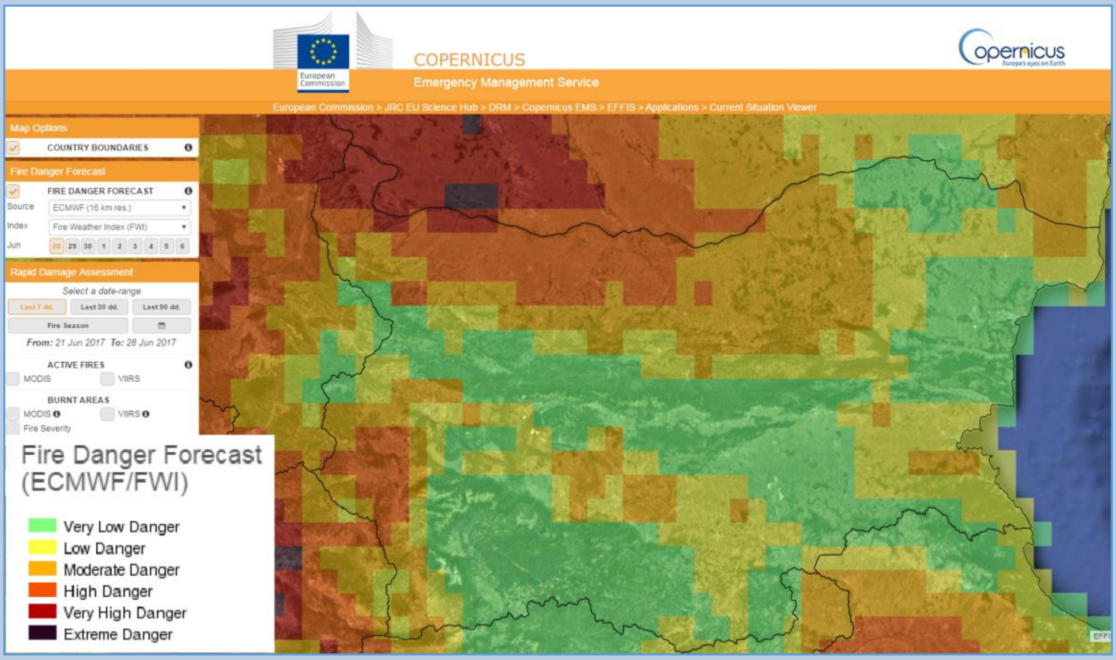
fires in relation to the type of forest, characteristics of burning materials, anthropogenic, topographic, and meteorological factors.

Box 13. Copernicus Emergency Management Service European Forest Fire Information System – Fire Danger Forecast

The fire danger forecast module of the European Forest Fire Information system (EFFIS) generates daily maps of 1 to 10 days of forecasted fire danger level using numerical weather predictions. Fire danger is mapped in six classes (very low, low, medium, high, very high and extreme) with a spatial resolution of about 16 km. The fire danger classes are the same for all countries and maps show a harmonized picture of the spatial distribution of fire danger level throughout the EU.

Source: http://effis.jrc.ec.europa.eu/media/cms_page_media/82/EFFIS%20User%20Guide%20ver1.pdf (accessed on June 28, 2017)

Figure 18. Fire danger forecast for Bulgaria for June 27, 2017



162. A **national disturbance monitoring system** would involve remote sensing with, as appropriate, field surveys to calibrate detection models. This would be a synoptic tool which, unlike the sample-based approach being pursued in the NFI, would analyze the entire territory of Bulgaria. One fifth of the territory of Bulgaria is flown annually to capture orthophotography used in the EU Land Parcel Identification System. Additional sensors should be considered to add to this campaign covering near-infrared and LiDAR to maximize its usefulness for forest vitality, damage assessment, and biomass and fire fuel loading. LiDAR is a highly precise distance measurement tool which can create not only a very detailed 3D model of the tree canopy and biomass but also the microtopography of the entire territory and is widely used internationally in flood risk and erosion modeling. The number of freely available datasets is growing rapidly with remote sensing sources such as European Space Agency Sentinel I and Sentinel II, Landsat, and MODIS being particularly useful. Analysis tools such as Google Earth Engine and the MODIS-based Rapid Damage Assessment operated by the EU Copernicus

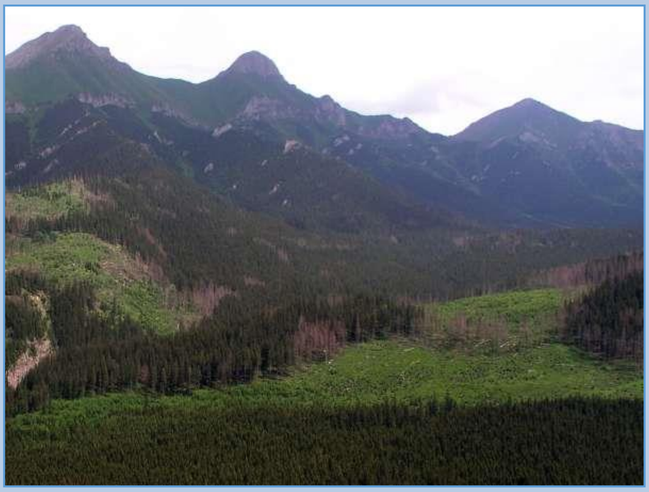
Programme[18] could also be used (see ***Box 13***). The Copernicus 'Emergency Management Service' is an umbrella service for remote sensing support for all natural and man-made calamities. Building a time series of imagery and associated spatially explicit damage records covering a variety of disturbance types will facilitate improved risk modelling and enhance resilience and adaptation activities and represent a strong cross-sectoral opportunity. In the longer-term, systems for disturbance and resource monitoring could be one of the components of a national information system for forest resources. The databases for the Bulgarian forests are built on modular principle and do not use the strengths of modern GIS-based databases. **A national forestry information system** could enable in-depth analysis of the available resources, various risks, and enable better planning.

Box 14. Long-term disturbance monitoring: Assessment of the impact risk of bark beetle as example of system application and verification – High Tatra Mountains

In a study (Netherer and Nopp-Mayr 2005) including more than 450 individual management units in High Tatra Mountains scientists tested an assessment system for bark beetle attack risk based on different factors as climatic conditions, terrain and soil characteristics, stand composition, structure, vitality, and so on. Among the stands in the research area attacked by the spruce bark beetle, 96 percent were composed of more than70 percent of spruce. Most mixed-species stands were sound units with no salvage cutting. Damage was clearly concentrated on stands aged more than 60 years. These findings lead to recommendations regarding specific management actions such as changing the rotation length to decrease the period a stand is vulnerable to insect pests.

The idea that the specific site- and stand-related characteristics influence the probability of damage caused by a certain disturbance agent was confirmed by the results of the application. Consequently, decision making may be supported independent of geographical range or spatial scale, by the indication of hazardous zones or of areas representing different potentials for forestry and of possible ways of damage prevention by silviculture. Same efforts for better monitoring and modeling the bark beetle infestation can be mentioned in Dinaric Mountains of Slovenia (Jurc et al. 2006). Modeling has also been used for predicting the necessary sanitary felling of Norway spruce due to spruce bark beetle (Ogris and Jurc 2010). The Tatra Case Study was examined using a newly developed model iLand[19] that helps to simulate various components of forest dynamics, including disturbances under different scenarios, and solve various questions in CCA processes.

Figure 19. Bark beetle attack in Tatra Mountains



Source: Netherer and Nopp-Mayr 2005; https://data.lter-europe.net/deims/site/ (accessed on May 16, 2017).

[18] http://gwis.jrc.ec.europa.eu/about-gwis/technical-background/rapid-damage-assesment/

[19] See http://iland.boku.ac.at/

3.1.5. Improving the potential for long-term use of higher-valued wood products

CLIMATE CHANGE ADAPTATION OPTIONS
V. Improving the potential for long-term use of higher-valued wood products
33. Review and expand the current building standards to improve the position of wood as a material
34. Establish a timber marketing board
35. Create a wood specifiers guide needs to provide all the required knowledge needed by technical professionals to ease the use of this material with confidence
36. Novel wood-based specifications should be established and promoted amongst municipalities as a pilot, for example for the construction of wooden bridges

163. Wood products are suited to almost all new-build and renovation construction. Wood structures can be used in different applications in buildings, be they small houses or extensions to tall tower blocks, large halls, or bridges. Construction in wood is normally faster than conventional techniques and results in low energy structures with a high degree of stored carbon. Approaches include timber frame with on-site construction, hybrid systems with prefabrication, cross laminated timber panels, box elements, column-and-beam, and so on. Building standards that include the use of wood for structural components are now very common, with wood structures up to 12 stories in height now permitted in certain countries.[20] Many of the construction elements use panel boards or glue-laminated beams and are thus not overly reliant on a high-quality round wood timber resource. However, a significant amount of structural grade solid timber can also be used, representing a real opportunity for added revenue from Bulgaria's forest resource.

164. At present the environment for the utilization of wood in construction is challenging. This option would review and expand the current building standards and stimulate the full acceptance in construction of standard Eurocode 5 (EN 1995-1-1); This will improve the position of wood as highly-valued constructing material. An associated output would be a wood specifiers guide, which would match the wood resources available in Bulgaria to their best use on a more informal basis than the official standard. Dissemination and promotion of wood as a building material would also be required. Fire service personnel also need to be further convinced of the safety of wood structures.

165. The message that wood is a high-quality construction material needs to be communicated to the Bulgarian public and technical specialists. Recovery of the traditional trust in wood as a building material, and promotion of its place in modern construction as a highly energy efficient, light and strong material that allows rapid construction, needs to be established. **A timber marketing board needs to be established** to promote the acceptance of wood by the public, in addition to strengthening the contacts between the various specialists along the chain of planning, designing, producing, and finally accepting wood constructions. In addition, research in the field of new wood products should be promoted.

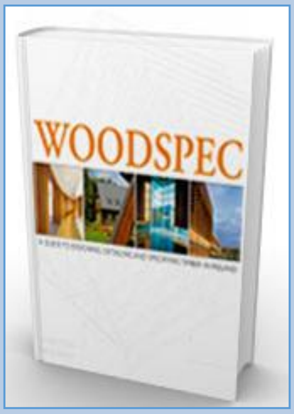
[20] https://structurecraft.com/projects/framework (accessed June 25, 2017)

Box 15. Wood Marketing Federation in Ireland

The Wood Marketing Federation in Ireland works for making partnerships between a wide range of companies and organizations – state and private - to promote wood as a renewable and sustainable natural material with wide range of use. By issuing the WOODSPEC book (www.woodspec.ie) it provides ready know-how and necessary information on the use of wood, from examples to detailed drawings and specifications.

Source: http://www.wood.ie/ (accessed on October 10, 2017)

Figure 20. WOODSPEC collection book



Box 16. New standards for wood utilization in constructions: new bridge construction standards in Sweden

Wood can replace other construction materials in many structures while providing the same functionality. One example is that in the Swedish bridge standards (Bronorm) wooden bridges can be designed for the same function and service life as steel and concrete bridges. Such a material substitution could bring significant climate benefits, where wood replaces materials whose production requires fossil fuels and causes high carbon emissions.

Source: https://www.swedishwood.com/use_wood/construction/a_variety_of_wooden_structures/wooden_bridges/ (accessed on June 28, 2017).

Figure 21. Wooden bridge in Virserum (Sweden) designed and built based on the new bridge construction standards in Sweden

3.1.6. Improving the potential for sustainable and more environmentally-friendly use of wood biomass for production of energy

CLIMATE CHANGE ADAPTATION OPTIONS
VI. Improving the potential for sustainable and more environmentally-friendly use of wood biomass for production of energy
37. Establish a program to promote the installation of modern energy and heat production systems for households, businesses and small communities
38. Develop a strategy for forest biomass

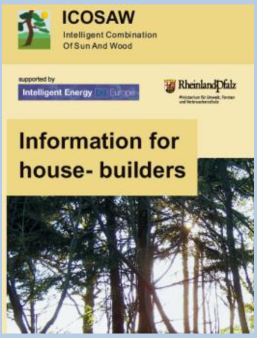
166. The widespread burning of large quantities of wood for household heating using ineffective and highly polluting stoves and boilers is a critical problem in Bulgaria. Firewood accounts for more than half of the annual harvest, undermining long-term forest management. **A program is needed to promote the installation of modern energy and heat production systems for households, businesses, and small communities**. Such a measure would encourage the more efficient use of wood for energy, decreasing the demand for firewood, and at the same time significantly decreasing fine-particle pollution.

167. Burning timber for energy displaces fossil fuels as an energy source, which is positive. However, the full life cycle of the product, including transport costs, needs to be factored into the assessment of its carbon footprint. In addition, alternative timber products, such as for construction, have a much longer period of use (often more than the length of a normal forest rotation) and so can be a source of carbon sequestration that accumulates over time. Even so, wood salvaged from such uses is often burned for energy at the end of its useful life. These long-lived products also have a higher selling price, the proceeds of which can be used to re-invest in forests. A **strategy for forest biomass is required** to ensure the best balance between these issues, and that, for example, agricultural land (which is currently a source of emissions) can be included as a potential option for biomass production rather than existing forest resources.

Box 17. Intelligent Combination of Sun and Wood for Producing Warm Water and Heating for Private Houses (EU project ICOSAW)

Wood can be very efficiently used to produce energy for household and communal heating facilities. The latest developments regarding solar systems provide an opportunity to combine both sources of renewable energy. The project ICOSAW promoted modern combinations of heating facilities in Germany, Poland, Sweden, and Slovakia. Special financial instruments were developed to support the installation of systems in Germany. These facilities have multiple environmental and economic benefits.

Figure 22. ICOSAW Information for house-builders



Source: https://ec.europa.eu/energy/intelligent/projects/en/projects/icosaw

3.2. Adaptation Options Assessed

168. The assessment of adaptation options should be carried out considering the potential benefits from the fulfilment of certain actions, consequences of inaction and necessary resources. In forestry, many actions should be evaluated considering the very high potential negative effects for various economic sectors and society in cases of forest degradation.

169. Forests can be considered as a strategic resource, providing multiple services and benefits while having very high value, of which only a small portion can be used at a time. In Bulgaria, the full variety of economic and social benefits from forests is still not accounted for and evaluated. Forests represent a natural capital with high non-market value and the sector holds great potential for the economy. The assumption of the cost-benefit analysis (CBA) presented below is that climate change can negatively affect the productive functions of forests and, therefore, adaptation measures can help prevent losses and keep forestry revenues high.

170. The CBA for the sector (further explained in detail in ***Annex 3***) focuses on the assessment of soft adaptation measures. The benefits gained from their implementation are best exemplified through the quantification of their effect on the main performance indicator, total available wood stock. Considering the complex impact of the adaptation options on the Forestry sector, these were not separately quantified in the current CBA. The net present value (NPV) in ***Table 3*** illustrates the monetary value of avoided losses as a result of implemented adaptation measures, while the cost effectiveness quantifies the benefits achieved in relation to the required investments/costs.[21] It should be noted that forests are a natural resource and, therefore, a positive net present value (NPV).

Table 3. Benefits of adaptation measures in the Forestry sector under different climate scenarios until 2050 (in €, million)

Climate scenarios	NPV (€ million)	Cost-effectiveness (Benefit/Cost ratio)
Realistic scenario +2°C	22,323.47	435.88
Optimistic scenario +2°C	38,176.67	744.66
Pessimistic scenario +2°C	6,470.26	127.02
Realistic scenario +4°C	37,240.01	726.33
Optimistic scenario +4°C	53,093.21	1,035.10
Pessimistic scenario +4°C	21,386.80	417.66

171. The projection shows that on average, under the +2°C realistic scenario, the total cash flow in NPV is €22.3 billion, and €37.2 billion under the realistic scenario at +4°C. Under the optimistic scenario, the projected cash flow in NPV is €38.2 billion under the +2°C scenario and €53.1 billion under the +4°C scenario. Even under the pessimistic scenario, the future cash

[21] The NPV of an adaptation option is given by the present value of the estimated benefits and costs. If NPV is more than zero, this indicates that the investment is efficient and incremental benefits of adaptation exceed the incremental resource costs. If NPV is <0 or B/C is <1, then the adaptation measures add no net benefit to the Forestry sector. If NPV is >0 or B/C is >1, then it adds positive benefits. The positive value of NPV confirms that investments for adaptation are efficient.
The benefit-cost ratio (B/C) is the ratio of the present value of benefits to the present value of costs. When the B/C ratio is more than one, the present value of the option's benefits is larger than the present value of its costs.

flow in NPV is projected at €6.5 billion at +2°C and €21.4 billion at +4°C.

172. Within the current analysis, the cost-effectiveness of the adaptation measures is used to quantify the effect of investments under each scenario.[22] Under the +2°C realistic scenario, the benefit/cost ratio is €435.88 (that is, the benefits achieved per Euro spent), and €726.33 under the +4°C realistic scenario. The benefit is higher at +4°C temperature rise. In that case, the benefit is €1,035.10 per one Euro of investment under the optimistic scenario and €417.66 per one Euro of investment under the pessimistic scenario.

173. The overall effects of the adaptation measures will be cost saving because of potentially decreased forest damage from climate change and sustained potential for revenues from forestry activities. The NPV calculation shows that investments in adaptation measures are economically efficient. Moreover, combining measures will generate synergetic effects.

174. To roughly plan the potential financial costs, the cost grades with ranges of invested funds is used. The suggested grading is the following:

- **Cost grade A** - Major investments related to new infrastructure at a wider scale. Country-level investment programs and compensatory payments; range of several hundreds of millions of Euros.
- **Cost grade B** - Big investments, related to research projects and trials including IT and new infrastructure; projects on motoring and fast-response systems, and so on, In the range of one million to several tens of millions of Euros.
- **Cost grade C** - Small investments related to smaller-scale research activities, capacity building, and knowledge transfer; modification of routine operations; required new personnel, external experts, event organization, running costs; and in the range of tens to hundreds of thousands of Euros.

175. The presented assessment is per generalized groups of adaptation options. Specific suggested actions are listed in sub-chapter 3.2.

CLIMATE CHANGE ADAPTATION OPTIONS	
I. Research, Education, and Extension	
Research and development	
Time	Ongoing Need to establish immediately
Budget	Annual budget from central government, at least 80 percent to be dispensed as research grants. Partnership on external projects should be a bonus, not a requirement **Cost grade B**
Benefits	This applied research will support an informed response to climate change threats in forestry. It requires a stable multiannual commitment of funding and will be long term in nature, in alignment with the long-term nature of forestry. This is a strategic investment in a land use that occupies over one third of the territory of Bulgaria.
Indicators	Establishment of management board

[22] The cost-effectiveness refers to all measures.

	Securing government funding Value of disbursed grants Proportion of funding spent on administration Effectiveness of research activities
Institutional	This should be an entity independent of any research body, controlled by government, with research priorities based on the entire forestry sector
Consequences of inaction	Continued lack of coordinated response to long term trends in climate change Loss of forest productivity and all other functions through low resilience

Capacity building	
Time	Needs to be started soon
Budget	Annual budget to support additional staff costs and development of educational materials and media and organizing trainings **Cost grade C**
Benefits	Various actors in the sector are making decisions that reflect national and international policies and best practices
Indicators	Rating by target interviews
Institutional	No institutional impact
Consequences of inaction	Low awareness of CCA and needs; Actions and activities not coordinated between institutions

Forestry Extension Service	
Time	Needs to be established soon.
Budget	Annual budget to support staff costs and development of demonstration sites, extension materials, and media **Cost grade C**
Benefits	Various actors in the sector are making decisions that reflect best available advice
Indicators	Rating by target beneficiary interviews
Institutional	It is expected that forest extension service be a function of the MAFF directly, implemented through Region Forest Directorate structures. There should be possible extension of the National Agricultural Advisory Service. It should provide good links with university and research professionals, administrations, and be directly involved in forestry and wood processing activities personnel.
Consequences of inaction	Awareness of CCA low and decision making too short term in nature.

II. Building resilience in regeneration and expanding and strengthening the forest resource	
Strengthening the nursery capacity and development of regeneration materials	
Time	Review of the status of the current entities in this area is required quickly before institutional ‘memory’ is lost and structures weakened
Budget	Re-instate previous budgets for this work and expand by, for example, 20 percent to cover CCA focus **Cost grade B**
Benefits	The availability of the correct material to regenerate forests is a basic requirement in climate adaptation for forestry; improvement of approaches and technologies for recovery afforestation after disturbances will help for better-adapted to future conditions forests

Indicators	Seed collection, seedling production in alignment with forest extension instructions, and development of afforestation options. Afforested area
Institutional	The status of the relevant bodies and their alignment with national objectives will need to be reviewed
Consequences of inaction	Nursery and seed collection and storage resources are a vital component in climate adaptation. If this resource is absent or diluted, then the practical implementation of many tasks could fail Inaction could result in potential loss of forest resource, erosion processes, contribution to flooding

Expanding and strengthening the forest resource	
Time	3–10 years
Budget	To support afforestation activities, revision of legal approaches for successional forest and compensation for lost entitlements to area aid. Grant administration and control costs should be included **Cost grade B**
Benefits	Reduced incentive for burning of scrubland; increased forest cover for sequestration; reduced pressure on state forests to emphasize firewood production; expanded provision of protection and shelterbelt forests; and increased renewable fuel production
Indicators	Rising forest area and forest growing stock
Institutional	Would require establishment of a grants unit
Consequences of inaction	Lost opportunity to capture abandoned lands which would create more lasting value as biomass forest, shelterbelts, biodiversity corridors, and so on, than as under-utilized grassland. Continued reliance on state forests as primary source of energy wood

III. Maintaining biodiversity and genetic diversity	
Time	Ongoing Need to establish immediately
Budget	Reinstate previous budgets for this work and expand by, for example, 20 percent to cover CCA focus. Insure budget for compensatory payments **Cost grade B**
Benefits	Insuring the increase and maintenance of forest resilience and capabilities to handle new conditions
Indicators	Area of forest patches ensuring preservation of biodiversity and genetic diversity; percentage of all forest areas in a region; forest connectivity
Institutional	No institutional impact
Consequences of inaction	High risk of losing or decreasing the potential of potentially very important genotypes and species

IV. National systems for rapid response, disturbance and resource monitoring	
National rapid forest fire detection and response preparedness	
Time	12–18 months
Budget	Required for rollout of response preparedness **Cost grade B**
Benefits	In Bulgarian forestry, the blocks with the highest timber volume per unit area are also the largest spatially and the most vulnerable to fire, especially in a changed

	climate. A system of rapid detection and response is vital to prevent the spread of fire and damage to life and property.
Indicators	Degree to which fires that occur are detected and controlled efficiently
Institutional	Limited institutional impact likely
Consequences of inaction	Gross loss of forest area and all its functions: biodiversity, erosion control, recreation, water protection, hunting, employment, value creation, and the significant risk to human health and property.

Long-term disturbance and resource monitoring	
Time	Ongoing after an initial 12–18-months setup time
Budget	Execution of NFI Staffing costs to maintain the disturbance database **Cost grade B**
Benefits	Establish an international standard NFI process. Maintain an objectively acquired estimate of disturbance events over the whole territory. Identify trends in damage and objectively assess, for example, forest vitality through remote sensing techniques. Wherever possible, identify disease or insect attack outbreaks using remote sensing and change detection. Have an early diagnosis of issues to allow remediation. Better anticipate future trends. Forest resource monitoring using near-infrared bands affords a highly-detailed picture of the forest resource, including where growth has been adversely affected.
Indicators	NFI survey completed, disturbance geospatial database established, algorithms developed to guide damage assessment or outbreak detection
Institutional	Disturbance database could perhaps be part of unit assessing forest health at the MAFF.
Consequences of inaction	No comprehensive and objective assessment of the effectiveness of forest policy and adaptation. Disturbances will not be identified until later when further preventable losses may have occurred. Trends will not be established to identify emerging threats. Risk models will not be amended considering objective observations.

V. Improving the potential for long-term use of higher-valued wood products	
Time	May take some years (2+) and involve many stakeholders.
Budget	Required for technical documentation, consultation, and drafting as well as lobbying. Promotional work is also required to encourage use of wood as a material. **Cost grade C**
Benefits	Is a strategic investment in raising the value of forest output? This will also raise the revenues needed to implement silvicultural activities. Will mobilize an otherwise un-innovative processing sector.
Indicators	Standard Eurocode 5 widely accepted and in use User friendly 'Wood specifiers guide' published Volume of housing units constructed with wood-based structural elements Category prize in place in annual architectural awards
Institutional	May need new arrangements in, for example, Ministry of Economy to cover structural wood as a new product category.
Consequences of inaction	No impetus for the industry to pursue forest management and silviculture that will yield high-value products. Average unit revenue from timber sales not

	sufficient to allow reinvestment in the forest resource and the type of silviculture that is required. Similarly, low unit value cannot justify control of illegal logging and other protection activities. Missed opportunities for development of the Wood Processing sector.

VI. Improving the potential for sustainable and more environment-friendly use of wood biomass for production of energy	
Time	May take some years (2 to 6 years) to prepare the project, secure funding, and involve the many stakeholders.
Budget	Required for technical documentation, lobbying, securing financial instrument Promotional work is also required to encourage the use of modern facilities **Cost grade B**
Benefits	Improved, more efficient use of wood biomass, which cannot be used for long-term products; decreased pollution; improved energy independence of household and communal (that is, schools) facilities
Indicators	Number of installed facilities and heat capacity
Institutional	Will require cross-sectoral agreements and actions, that is, energy and forestry sectors.
Consequences of inaction	Continuing low-efficiency burning of large amounts of wood Continuing high pollution with fine-particles in small cities and villages

3.3. Cross-cutting Issues, Trade-offs and Synergies of Adaptation Options

176. Forest ecosystems occupy large territories in Bulgaria and directly relate to many other economic sectors and the well-being of society. Therefore, adaptation to climate change of the forestry sector inevitably cross relates with other sectors.

177. Measures for successful adaptation of forests will mostly be beneficial for other sectors as well (***Table 4***). The most important positive effects are related to the ability of forests to serve highly valued ecosystem services. If ranked, the leading services are related to maintaining biodiversity and genetic diversity and thus ecosystems' integrity and resilience. Provision of pure drinking water highly depends on the condition of forests which makes that all measures for successful forest adaptation, especially in mountain areas, positively affects the water sector. This should be borne in mind when taking measures related to catchment and use of water. A special financial program to support by compensatory payments the provided ecosystem services will increase their value (and hence incentive) to manage forests with a focus on the balanced delivery of the full spectrum of services they provide.

178. Positive effects can also be expected in the agriculture sector, where forest shelterbelts decrease wind erosion, help uniform snow deposition on soils in the winter, and thus increase crop productivity, contributing at the same time to the maintenance of biodiversity in the valleys. Furthermore, the use of short-rotation tree crops can be a good way to use abandoned agriculture lands, mainly pastures, and at the same time provide renewable energy and timber source and contribute to medium-term carbon sequestration. However, such use of agriculture land will require good coordination between interested stakeholders.

179. Adaptation measures for forests mostly have beneficial effects on human health, tourism, transport, and the urban environment. However, some limitations will have to be

imposed. For example, one of the risks for forests related to invasive species requires minimizing the use of potentially invasive species in afforestation next to roads, in city parks, and private gardens close to natural forests. The minimization of this risk requires good coordination between institutions, specific legalization, and education measures.

180. Forest adaptation may have a double-sided effect on the energy sector. On the one hand, forests provide a source of renewable energy (that is, wood). On the other hand, the carbon sequestration function of forests is very important in mitigating climate change. Long-term use of wood must be promoted as this is far superior than the use of wood as an energy source, especially for household heating using stoves. Currently, more than half of the annual harvest is used as firewood, primarily in small cities and villages, contributing to serious air pollution and decreased opportunities for carbon sequestration. Transition to modern heating systems will contribute to decreasing pollution and preserving public health, decreasing demand for wood as a fuel, increasing demand of other energy sources, and increasing the potential for carbon sequestration. Such a process requires adequate coordination and active measures among and across a variety of (public) institutions.

Table 4. Cross-sector effects of adaptation of forest ecosystems to climate change

Affecting ➔	**FORESTRY SECTOR**	
CC effect in... *(see below)*	**Positively**	**Negatively**
Agriculture	• Active use of abandoned lands • Shelterbelts to attenuate climate effects • Erosion control • Response preparedness system will benefit many other sectors	• Reduced availability of agricultural lands for food production
Biodiversity and Ecosystems	• Building resilience • Creating forest corridors to allow migration • Fire detection and control, a major advantage in ecologically important sites • Assignment of permanent grassland to forest could positively impact on its biodiversity for species which prefer forest ecosystems	• Use of short rotation forestry may result in a decrease in biodiversity but this should be minimal regarding lands previously in agricultural use • Assignment of permanent grassland to forest could adversely impact its biodiversity. Affected will be species, which prefer open grass-lands communities. In the case of presence of such species no afforestation should be allowed.
Tourism	• Protection of important recreational assets • Improved national preparedness for fires and other calamities will also minimize risks to visitors	
Energy	• Additional renewable energy source	• The wish to use wood in long-term products with higher value contradicts the present use of

Affecting ➔	FORESTRY SECTOR	
CC effect in... *(see below)*	**Positively**	**Negatively**
	• Increased use of wood in construction will result in improved energy efficiency of housing stock	large amounts of wood as cheap energy source for households
Human Health	• Improved protection from damaging flood events through increased forest cover • Employment could also be enhanced through expanded forest cover • Improved prevention and control of fire events (and other calamities) • Reduced pollution effects from decreased usage of wood for fuel • Improved conditions for recreation and recovery of health	
Transport	• Improved coordination and control of fire events and limitation of erosion and landslides • Response preparedness system will benefit many other sectors	
Urban Environment	• Redirection of forest output to higher value products could reduce the affordability of firewood and thus decrease its use in urban environments, thus alleviating pollution	
Water	• Decreased risk of floods • Increased water-provisioning services of forest	

3.4. Priority Setting Approach

181. Identification of CCA options is an important step in the process of establishing resilience to climate change. However, it is not realistic to expect that all identified adaptation options can be implemented simultaneously. Therefore, adaptation options are normally scored to establish a priority order for their implementation. The framework of this report, following EU guidance, has prioritized the adaptation options specifically identified for the forest sector.

182. In support of the priority setting, a prioritization meeting was organized in Sofia in October 2017, inviting a variety of stakeholders from the sector. The meeting used a basic version of the multicriteria analysis (MCA) approach. MCA is an approach as well as a set of techniques that aims at providing an overall ordering of options, ranging from the most preferred to the least preferred. It represents a way of looking at complex problems that are characterized by a mix of monetary and nonmonetary objectives. MCA breaks down options into more manageable pieces by using a set of criteria. The two groups of criteria used for the analysis were those of 'net benefits', further broken down into economic, social, and environmental benefits, and 'implementation risks', further broken down into financial, social, institutional, technical, and technological risks. This approach allows data and judgements to focus on the separate pieces that are then reassembled to present a coherent overall picture.

183. In carrying out the MCA (that is, 'scoring the different adaptation options'), the meeting benefited from the presence of stakeholders with professional knowledge and experience in the sector. Nevertheless, this priority setting effort must be considered as indicative and tentative for three main reasons. First, the effort was carried out at an early stage in the process of developing a strategic view and planning of sector-specific CCA options. Second, not all those who were invited to the prioritization meeting used this invitation to attend the meeting. And third, a broader understanding of underlying information and notions at the side of the stakeholders would be beneficial to allow them to make more founded scores. Therefore, the current priority list only serves as a 'first feel' about the main direction of the actions to be taken first.

184. At a later stage, further attention should be paid to the priority-setting process, both for this sector, and across all economic sectors that play a role in the planning of Bulgaria's CCA actions.

185. The five main priority adaptation options that were tentatively and indicatively identified for the forest sector on the prioritization meeting are:

1) Maintain and strengthen the seed collection and orchard system gaining experience with new provenances and species;
2) Enrichment planting to speed up the introduction of resilient species and genotypes;
3) Assessing the impact of changing wood resources on the processing sector;
4) Continuous monitoring of forest ecosystems and the effects of climate change, management, adaptation and mitigation measures; and
5) Identifying rare species with serious risk of extinction and assisting their regeneration and potential migration.

186. The main option headings and individual actions are listed in ***Table 5***. A rough prioritization exercise was conducted by combining the results of the abovementioned workshop with the national and international experience of the report authors. Actions were categorized in descending order of priority from 1 to 3 (1 being the highest priority):

Table 5. Draft prioritization of adaptation options

Option	Action	Priority
1. Research and Development, Capacity-building, and Forestry Extension Service	1.1. Establish a research and development coordination body	**1**
	1.2. Design and implement a research program	**1**
	1.3. Implement a system for dissemination of results	**2**
	1.4. Create a National Forestry Extension Service for forestry professionals	**3**
	1.5. Provide training to practitioners on new approaches and tools	**2**
2. Building resilience in regeneration expanding and strengthening the forest resource (using a	2.1. Collect seeds from valuable tree species and their provenances and test their performance under different simulated climates.	**2**
	2.2. Test provenances that are marginal for the specific species locations, especially southern-most.	**3**

Option	Action	Priority
financial support mechanism)	2.3. Test rare species and gain experience with production of seedlings from them and planting in natural conditions.	**3**
	2.4. Produce seeds from endangered species or provenances, to enable their support in case of regeneration failures.	**3**
	2.5. Experiment with the production of seedling tree material that are more resistant to for example fire, insect, disease or other disturbance	**2**
	2.6. Support erosion control forests, enrichment planting and regeneration of disturbance-hit forests in state and private sector forests, including management plans for at-risk forests.	**2**
	2.7. Establish a program to maintain and restore the forest shelterbelts in the agriculture lands	**3**
	2.8. Establish a program to create and maintain forest corridors linking isolated forest patches in the lowlands.	**3**
	2.9. Support short-rotation production of wood.	**3**
	2.10. Settle, via legislation or otherwise, the legal, financial and other impediments to use agricultural land for forest production	**2**
3. Biodiversity & genetic diversity maintenance	3.1. Preserve hotspots of biodiversity and maintain suitable corridors between them	**3**
	3.2. Limit forest areas using planting materials that lowers structural heterogeneity and species richness	**2**
	3.3. Continue to identify key habitats and maintain them to insure the in-situ protection of species with limited distribution.	**3**
	3.4. Identify rare species with serious risk of extinction and assist their regeneration and potentially migration.	**3**
	3.5. Promote management strategies, which insure high species and structural diversity and natural regeneration.	**1**
	3.6. Widen the participation of Bulgaria in the European Information System on Forest Genetic Resources.	**3**
	3.7. Implementing measures to limit the potential of invasive species	**2**
4. National systems for rapid forest fire detection, Long-term disturbance monitoring and forest resource monitoring, including NFI	4.1. Execute the National Forest Inventory	**1**
	4.2. Establish a national system for early warning and awareness at regional and local level	**1**
	4.3. Establish and maintain a national disturbance monitoring system	**1**
5. Improving the potential for long-term use of higher-valued wood products	5.1. Review current building standards to promote wood use	**2**
	5.2. Develop a wood specifiers guide and promote wood use	**1**
6. Improving the potential for sustainable	6.1. Develop a strategy for the sustainable use of wood biomass for energy	**2**

Option	Action	Priority
and more environment-friendly use of wood biomass for production of energy	6.2. Develop financial instruments to support the improved efficiency of wood biomass use, including burning technologies	**3**

Supporting notes on prioritization

1. Category *Research and development, capacity-building and forestry extension service*

(1.1. Establish a research and development coordination body; 1.2. Design and implement a research program)

187. Specific topic areas are highlighted which may form part of the approved research program, including modelling the potential performance of economically important and of rare species and the forest ecosystems they build, over the entire territory of the country and under different climate change scenarios and different timescales. Various ecosystem services should be included in this modeling task.

188. In general, this is the real basis for informed decision making on all climate-change adaptation actions. In forestry, authorities and practitioners cannot work in a specific direction without knowing which species have the highest chances and where. Biodiversity cannot be maintained without awareness which endangered species are expected to face further trouble, where they can be supported and migrated, if needed. Proper planting operations are not possible without full awareness of the species that are likely to show high performance, good productivity, but are also resilient to climate change challenges.

189. This task is closely related to all other tasks in the category of Research and Development. It cannot be performed without updated and solid climate change modeling for the country. It requires solid knowledge about species' performance (and focused studies), and knowledge about genotypes of species.

190. Another selected very important task from the pool of research topics is 'Developing spatially explicit risk models for disturbances such as windthrow, fires, insects, and diseases damage'. Considerable problems are expected with disturbances. Higher intensity, magnitude, and many more affected areas which will bring serious economic problems. The logic would be to outline the most problematic forests and think ahead about what can be done to increase their resilience. Furthermore, in case of major disturbances, these are the places where urgent action is needed – forestry activities aiming in a specific direction (for example, changing the focus from one species to another [or better to several species] and promoting these species in silvicultural activities), planting to support faster forest recovery in areas with a potential risk for other damage (erosion, floods), and so on. This requires 'thinking ahead'. Good risk models could be beneficial in this process. Managing the response to climate change on an incremental basis as we see it unfold is unlikely to be a successful strategy.

3. Category *Biodiversity and genetic diversity maintenance*

(3.5. Promote management strategies, which ensure high species and structural diversity and natural regeneration)

191. This is a highly critical measure. In forestry, the biggest and most important tool is

silviculture – how to manage forests to direct their future development and prepare them to meet challenges. The general opinion is that strategies, that aim at having a low (not abrupt) impact on ecosystems, relying on natural regeneration and genotypes, and maintaining the highest possible diversity (both in terms of species and structure), create the highest level of forest resilience. Forest resilience is the ability of forests to cope with challenges and recover to a stable state (or find a new stable state if conditions have changed much). However, this measure requires vast background knowledge and information about species, potential performance, productivity forecasts, and so on. It also requires skilled foresters, which is directly related to capacity building. Such strategies are often not the most profitable and their real use requires good governance (again capacity building), real implementation of the ideas of ecosystem service evaluation, and payment for ecosystem services.

4. Category *National Systems for rapid forest fire detection, long-term disturbance monitoring and forest resource monitoring, including NFI*

(4.1 Execute the National Forest Inventory;
4.2 Establish a national system for rapid fire detection and response to this and other natural calamities;
4.4 Establish and maintain a national disturbance monitoring system)

192. Bulgarian forests are a large natural indicator of the impact of climate change. The NFI is one of the very few programs that will be able to consistently measure trends over a long period of time. The scale of the threat is large. The vast diversity of the Bulgarian forests is at stake, including their productive and regenerative capacity. The NFI will provide solid evidence to target climate change measures and ensure they have maximum impact. Given the natural or semi-natural state of forest resources, climate change effects will be easier to discern in this resource than in other forms of land use. The NFI will not only will be useful for the forestry sector, with regard to measuring climate change, it will be important for the country as a whole.

193. Policy, strategic, and management interventions are needed to ensure that the Bulgarian forest resources continue their current performance, meet existing and upcoming challenges, and take advantage of opportunities that will arise. An NFI will deliver the information that is needed in a clear and statistically robust manner, in line with internationally recognized standards. Bulgarian forest resources have the capacity to sustain higher levels of activity and contribute to achieving the country's climate change commitments. Only the NFI can demonstrate its sustainability to all stakeholders, national, and international.

194. The latter two options are directly needed to decrease the high losses that follow from all types of disturbances and switch from 'post-disturbance response' to 'planned' actions to limit the potential for forest disturbances and the losses from them. The country must exactly know its resources, damages that occur to it, and where they occur. Such information base is an indispensable prerequisite for professional policy development based on a proper risk assessment and for the planning of action. A serious decision-making process cannot do without this data. These systems should be built with the idea to gradually expand, take in other information systems, and eventually result in a generalized information system for forests.

3.5. Conclusions

195. Successfully adapting the forest sector to climate change will have the added benefit of increasing its mitigation effect as more carbon will be sequestered from the atmosphere and the economic importance of the sector will grow. In several years, Bulgarian forests offset 22 percent of all industrial carbon emissions and are the country's single largest carbon sink. Adaptation of Bulgarian forests to climate change and its potential consequences, reducing the overall vulnerability of the forestry sector, and increasing its economic viability and resilience, is crucial for the quality of life of the Bulgarian population. It is recommended that Bulgaria engages in several groups of adaptation measures. Among the most important groups of measures are (1) research, education, capacity building and knowledge extension to provide a solid foundation for an informed decision making process and adaptive management, (2) building resilience in regeneration, expanding, and strengthening the forest resource to increase forests' resilience and meet challenges in recovery operations and higher demand of wood, (3) maintenance of biodiversity and genetic diversity thus helping forests meet the climate-change challenges as a result of their high species and genotype richness, (4) building and maintaining a national rapid forest fire detection, long-term disturbance monitoring and forest resource monitoring systems (including NFI) and in this way minimizing the losses from disturbances and enabling proper strategy development and management planning and adapting of forests in areas with the highest risks, (5) improving the potential for long-term use of higher-valued wood products, thus raising the revenues from wood-processing industries, and (6) improving the potential for sustainable and more environment-friendly use of wood biomass for the production of energy.

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Annex 1. Potential Climate Change Impacts on the Forestry Sector in Bulgaria

Table 6. Potential climate change impacts on the forestry sector in Bulgaria

Affected Forestry Sector aspects	High temp		Low temp		Prolonged rainfall		Drought		Water table rise		Sea level rise		Specific effects of CC relevant for forestry				Extreme Weather Events											
													Invasive species		Wet snow and ice		Electric storms		Fog		Floods		Avalanches		Land-slides		Storms	
	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P
Species reaction	M	H	L	L	M	L	H	H	M	L	M	L	H	H	H	H	-	-	L	L	M	M	-	-	-	-	M	H
Timber production	M	H	L	L	L	L	H	H	M	L	L	L	L	H	H	H	-	-	M	L	L	M	L	H	M	L	H	H
Disturbances – wind, snow, ice	L	H	L	L	L	L	L	H	-	-	-	-	H	H	H	H	-	-	L	L	L	M	L	H	H	L	H	H
Forest fires	H	H	L	L	H	L	H	H	L	L	L	L	U	U	M	H	-	-	M	L	M	L	L	L	U	U	M	H
Pests and diseases	H	H	L	L	L	L	H	H	L	L	U	-	H	H	H	H	-	-	M	L	L	L	L	L	L	L	H	H
Contribution to CC mitigation	M	H	L	L	L	L	H	H	M	L	L	L	L	H	H	H	-	-	M	L	L	M	L	H	M	L	H	H
Water provisioning services	H	H	L	L	H	L	H	H	H	L	L	L	U	U	L	H	-	-	M	L	L	M	L	H	M	L	M	H

Legend: *D = damage; P = probability of occurrence by 2050 at latest; U = unknown; H = high; M = medium; L = low*

red = negative impact; green = positive impact; blank = neutral impact

Annex 2. Climate Change Adaptation Options in Detail

Table 7. Adaptation options presented in detail

CLIMATE CHANGE ADAPTATION OPTIONS					
I. Research, education and extension					
1. Establish a research and development coordination body for climate change mitigation and adaptation in forestry					
Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service	
	X	X	X	X	
Description	A small governmental research and development coordination body should be established to administer national research funds and identify international sources, set research priorities and disseminate research findings. The managing board of such a body should comprise members from across the forest sector. This body would also commission research on a competitive basis from interested parties and manage the performance of such work. It would not directly employ researchers or extension workers. External funding opportunities that may be targeted will include EU Life Climate Action, European Structural and Investment Funds (ESI Funds), Horizon 2020. This applied research will support an informed response to climate change threats in forestry. It requires a stable multi-annual commitment of funding and will be long term in nature, in alignment with the long-term nature of forestry. This is a strategic investment in a land use that occupies over one third of the territory of Bulgaria.				
Option's relevance: Economic ++; Ecologic +++; Social +					
Opportunities that arise	Coordination will bring coherence, efficiency, ability to mobilize grant funding, increased scale and collective impact.				
Cross-cutting relevance	YES	Research will need coordination across biodiversity, agriculture and other sectors.			
Risks addressed	Empirical evidence is required to support decision making. Continued incremental 'adaptive management' in response to changing climate and conditions will be detrimental due to the long term nature of forestry: changes to practice now that appear to satisfy the latest impacts may be overtaken by changes that are forecast to happen in coming decades. Lack of coordination in building fact-based advice will cause waste of resources, missed opportunities, overlaps, lack of scale, potential for confusion and inefficiency.				

2. Create a National Forestry Extension Service and a system for dissemination of results					
Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service	
	X	X	X	X	
Description	A crucially important step would be to design and implement a system for dissemination of results from research to stakeholders at various levels. Various potential users of knowledge have different need of detail and ways to present. Examples include political subjects, professionals, students, ordinary society members. For the professionals in the forestry sector there a National Forestry Extension Service is needed, as envisaged in the document 'Strategic plan for the development of the forestry sector in the republic of Bulgaria 2014–2023'. This is highly needed given the fact that the potential climate change effects on forest ecosystems are highly varying and loaded with uncertainty and therefore continuously updated knowledge gains should quickly reach the professionals.				
Option's relevance: Economic +++; Ecologic ++; Social +					
Opportunities that arise	Establish a channel for communication on all forestry issues of interest to state and private foresters and other stakeholders. Two-way communication will ensure insights and feedback will flow from the field and inform actions and research.				
Cross-cutting relevance	YES	Potential for interdependency with other land uses and their extension services, for example agriculture. Common issues may also affect biodiversity.			
Risks addressed	If there is no extension service to communicate research findings in a simple and coherent manner the impact will be lost. Audience appropriate materials, field meetings and multi media (and social media) interventions are needed.				

3. BUILD CAPACITY IN GOVERNMENT ORGANIZATIONS, FOREST MANAGEMENT STRUCTURES AND PRIVATE COMPANIES, UNIVERSITY AND HIGHER EDUCATION STAFF					
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			A key need to insure the understanding of the potential risks of climate change and proper conducting of adaptation activities for the forestry sector is supporting and building the capacity of staff in government institutions, forest enterprises, research and educational institutions, private companies in forestry activities, and the wood-processing industry. Capacity building is directly related to all other adaptation options and activities. Especially governmental institutions and the state forestry enterprises need good understanding of climate change issues and must receive appropriate training on the topic to be able to prepare and conduct policies in this direction. This would also improve the necessary coordination among institutions because CCA options in the forestry sector will often be directly related to other sectors as for example Biodiversity, Agriculture, Water, Energy and Urban development. There is also a need to upscale general economic and market knowledge among forestry operators and along the wood processing chain, so that the forestry sector can anticipate climate change and ensure sector resilience.			
Option's relevance						
Economic	Ecologic	Social				
++	++	+				
Opportunities that arise			Various actors in the sector are making decisions that reflect national and international policies and best practices.			
Cross-cutting relevance			YES	Education needs to be coherent with other sectors regarding risks, and so on.		
Risks addressed			Lack of deep understanding of Climate Change risks, mitigation and adaptation will hamper the adoption of recommended actions.			

4. UPDATE NATIONAL CLIMATE-CHANGE SCENARIOS						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Updating the climate-change scenarios models for the territory of Bulgaria using the most up-to-date versions of climate models.			
Option's relevance						
Economic	Ecologic	Social				
+++	++	+				
Opportunities that arise			The potential to engage donor agencies or for example EU funds will be greater if actions are based on strong empirical evidence.			
Cross-cutting relevance			YES	Need to use the same national forecasts of climate change as all other sectors.		
Risks addressed			If the best and most up to date models are not used actions will be ineffective and a waste resources.			

5. REVIEW AND UPDATE THE EXISTING MODELS OF TREE PRODUCTIVITY						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Review and update the existing models of tree productivity of the most important tree species currently, and those species which may have potential in Bulgaria in a future changed climate.			
Option's relevance						
Economic	Ecologic	Social				
+++	+	+				
Opportunities that arise			This could be an opportunity to supplement the existing yield models in use in forestry.			
Cross-cutting relevance			Yes	Other sectors relying on forests – Biodiversity, Water, Agriculture, and so on.		
Risks addressed			Lack of information on how trees grow under a changed climate will severely limit the ability to advise on actions now which will be 'future proof'.			

6. MODEL THE PERFORMANCE OF FORESTS INTO THE FUTURE					
Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service	
	X	X	X	X	
Description	Model the potential performance of all relevant species and the forest ecosystems, over the entire territory of the country and under different climate change scenarios and different timescales.				
Option's relevance: Economic +++, Ecologic ++, Social ++					
Opportunities that arise	When matched with updated scenarios for climate change, tree growth information will provide the basis to plan for forest composition into the future.				
Cross-cutting relevance	Yes	Other sectors relying on forests – Biodiversity, Water, Agriculture, and so on.			
Risks addressed	Lack of modelling will restrict the ability to advise and test the sensitivity of this advice to different assumptions. This sensitivity analysis will aid research prioritization and investment decisions.				

7. CONTINUE THE SCIENTIFIC STUDY OF GENOTYPE VARIABILITY AND SUITABILITY FOR VARIOUS CLIMATE CONDITIONS FOR THE MOST IMPORTANT, ENDANGERED AND HIGHLY VULNERABLE TREE SPECIES					
Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service	
	X	X	X	X	
Description	Bulgarian forests have outstanding biodiversity with the vascular flora alone consisting of 4,102 species. There is a high number of endemic species, which are found either only on the Balkan Peninsula or only in certain locations in Bulgaria. This sets the country as one of the richest in biodiversity in Europe. This heritage must be protected and to do so we must fully understand what we have and how 'plastic' is its biology and its chances of survival under different climate scenarios.				
Option's relevance: Economic +++, Ecologic ++, Social +					
Opportunities that arise	Gain an improved understanding of biodiversity in Bulgaria.				
Cross-cutting relevance	Yes	Other sectors relying on forests – Biodiversity, Water, Agriculture, and so on.			
Risks addressed	The risk of losing valuable biodiversity will be reduced if it is better understood. Where resources are constrained these may be directed to cases which have a chance of benefitting rather than those that have no ability to react to the changing climate.				

8. DEVELOP SPATIALLY EXPLICIT RISK DISTURBANCE MODELS					
Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service	
	X	X	X	X	
Description	This will build on the monitoring framework mentioned elsewhere to allow modelling of these events such as windthrow, fire, insect and disease damage. This will inform policy and management to attempt to reduce the impact of these events.				
Option's relevance: Economic +++, Ecologic +, Social ++					
Opportunities that arise	Trends may be identified that were previously hidden and give rise to new, effective actions.				
Cross-cutting relevance	Yes	Other sectors relying on forests – Biodiversity, Water, Agriculture, and so on.			
Risks addressed	Many disturbances are influenced by location. Modelling them will reduce the risk of missing key actions that can be organized on a local or regional scale.				

9. CONTINUOUSLY MONITOR FOREST ECOSYSTEMS						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Continuous monitoring of forest ecosystems and the effects of climate change at micro (projects) and macro (NFI) scales. Measure the impact of policy, management, adaptation and mitigation measures in order to provide the basis for analysis of the effectiveness of various measures and the need to further adapt management strategies.			
Option's relevance						
Economic	Ecologic	Social				
++	+++	+				
Opportunities that arise			A feedback mechanism is very important to see how ecosystems are reacting to adaptation actions and responding to climate change. Opportunities may arise for new research and actions on foot of this analysis.			
Cross-cutting relevance			YES	Strong relationship with biodiversity.		
Risks addressed			The effectiveness of various policies, strategies and measures needs to be monitored, otherwise there is a high risk that the measures will be ineffective and emerging trends or unexpected effects will be missed.			

10. CONDUCT RESEARCH AND PLANNING TO ENSURE THE AVAILABILITY OF REPRODUCTIVE MATERIAL IN A TIMELY MANNER						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
				X	X	X
Description			This task would support the nursery sector and ensure there is a strong linkage between research, extension and supply of materials to implement whatever new guidance is produced and disseminated via the various extension channels. In practice, this would mean a coordination group being established.			
Option's relevance						
Economic	Ecologic	Social				
+++	++	+				
Opportunities that arise			Close cooperation across the sector could strengthen the resource and provide for increased forest productivity in certain areas and species.			
Cross-cutting relevance			Yes	Other sectors relying on forests – Biodiversity, Water, Agriculture, and so on.		
Risks addressed			Nursey production must align with advice. There is always a lag period between new research and the availability of seedlings for planting. This mechanism would handle that reality through careful planning and coordination.			

11. ASSESS THE IMPACT OF CHANGING WOOD RESOURCES ON THE PROCESSING SECTOR AND ADAPTATION STRATEGIES TO SUPPORT LONG-TERM RESILIENCE AND VALUE-ADDING POTENTIAL						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
				X		X
Description			This analysis will align future forest output with current and forecasted demand. Climate change scenarios will inform the analysis. A strategy may be required to address mismatches between supply and demand.			
Option's relevance						
Economic	Ecologic	Social				
+++	+/-	++				
Opportunities that arise			It may be timely to start improving the viability of the sector generally now, rather than when changes occur. There may be opportunity to consolidate and improve logistics, for example, increasing the performance of the many small entities.			
Cross-cutting relevance			Yes	Economy		
Risks addressed			There may be mis-matches between projected supply and demand. Unless these are addressed the sector will suffer from competition over a reducing resource.			

12. *Research additional use of wood and forest products to foster and promote diverse uses of wood and increase the potential for value addition*					
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
				X		X
Description			Product development and testing of wood and timber product properties will be needed. New species will be assessed for use and their properties will need to be assessed. An effort to move to more value added products will require development work.			
Option's relevance						
Economic	Ecologic	Social				
+++	+/-	++				
Opportunities that arise			A diversified industry will be more resilient and improved understanding of different species will allow niche products to emerge, possibly enlarging the market.			
Cross-cutting relevance			Yes	Economy		
Risks addressed			The wood processing sector has suffered in the past from low levels of innovation and limited development of new products. The sector will need to diversify and become better linked to forest management to maintain its competitiveness.			

II. Building resilience in regeneration, expanding and strengthening the forest resource

13. *Work with research and extension activities, enhance the Bulgaria's forest nursery capacity, as a key component in climate adaptation*						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			A review is needed of the nursery sector and how it should be structured to meet the needs of forestry in a changing climate. Investment will be needed to enhance facilities and expand staffing.			
Option's relevance						
Economic	Ecologic	Social				
+++	++	+				
Opportunities that arise			Higher productivity or other desirable traits may be uncovered through operational research and deployed via the nursery system.			
Cross-cutting relevance			Yes	Other sectors relying on forests – Biodiversity, Water, Agriculture, and so on.		
Risks addressed			A viable, dynamic nursery sector that is staffed and equipped to produce a large variety of seed and seedling material is essential to the success of climate adaptation. Research, advice and resources will all be wasted if there no raw material to implement them with.			

14. *Strengthen the existing forest resource through enrichment planting and pro-active management of at-risk plantations*						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
				X	X	X
Description			Identify forest areas that would benefit from enrichment, draw up plans and implement them.			
Option's relevance						
Economic	Ecologic	Social				
+++	++	+				
Opportunities that arise			This action will raise the density of forest resources and would normally lead to higher thinning yields.			
Cross-cutting relevance			YES	Biodiversity component.		
Risks addressed			Reducing forest cover and homogeneity of forest cover.			

15. Rehabilitate damaged areas by natural disturbance or die-back and afforestation to perform water and soil protection functions

Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service
	X	X	X	X

Option's relevance		
Economic	Ecologic	Social
+++	++	+

Description	Identify forest areas that need rehabilitation and previously unforested areas that would provide strong protection functions. The identification process would use objective measures such as remote sensing and topographical analysis. Draw up plans using sophisticated approaches based on hydrological modelling and catchment based analysis. During implementation, conduct monitoring and evaluation to learn from this phase.
Opportunities that arise	Strong opportunities exist to convert monocultures to more diverse species and structure profiles.
Cross-cutting relevance	YES – Biodiversity component; Water use
Risks addressed	Areas of existing die-back and damage could be reforested with species that are ill suited and offer lower resilience to climate change in the future. Large scale clearing of these damaged stands without understanding the hydrological effects would be very risky for the water and other protection functions.

16. Maintain and create new forest shelter belts in agriculture land

Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service
	X	X	X	X

Option's relevance		
Economic	Ecologic	Social
++	++	++

Description	Establish shelter belts to provide forest cover, corridors of forest and biodiversity, as well as shelter from the extreme weather events, heat and drought expected under a changed climate.
Opportunities that arise	There may be opportunities to increase the biodiversity component of the classical shelterbelt approach.
Cross-cutting relevance	YES – Biodiversity and Agriculture components.
Risks addressed	Modern, open areas of arable and pasture lands are vulnerable to sun, wind and snow.

17. Create forest corridors to link existing forest patches

Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service
	X		X	X

Option's relevance		
Economic	Ecologic	Social
	+++	

Description	Establish corridors of forest cover between otherwise isolated blocks, particularly in lowland areas.
Opportunities that arise	May be combined with shelterbelt actions.
Cross-cutting relevance	YES – Biodiversity and Agriculture components.
Risks addressed	Mobility Is the key to forest adaptation. Forest corridors will provide the means of escape to many otherwise landlocked species.

18. Establish short-rotation biomass plantations						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
				X		X
Description			Establish short-rotation biomass plantations on forest land (under certain circumstances) and on private agricultural lands.			
Option's relevance						
Economic	Ecologic	Social				
+++	+/-	+				
Opportunities that arise						
Cross-cutting relevance			YES	Energy, agriculture.		
Risks addressed			Reliance on forest cover to provide firewood may be reduced by offering the output from biomass plantations.			

19. Provide a pathway for land to transition between forest cover and agriculture and vice-versa						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
				X		X
Description			Tackle the various legal, area-aid, stakeholder, bureaucratic, ownership and other challenges that block the transition to forestry from other land uses and consider what incentives could be provided through state or EU aid.			
Option's relevance						
Economic	Ecologic	Social				
+++	++	++				
Opportunities that arise			EU Common Agricultural Policy (CAP) is due to be reformed. This is an opportunity to incentivize the transfer of lands that are difficult to farm out of agriculture and into a more environmentally beneficial and productive land use.			
Cross-cutting relevance			YES	Agriculture		
Risks addressed			At present there are incentives in place to keep land in agriculture even though it yield very little in terms of real economic output. Lands are burned to clear them of scrub and so on in order that they still qualify for CAP area aid payments. This poses a risk to neighboring lands and forests.			

20. Continue collecting seed from valuable tree species and their provenances (especially southern-most) and testing their performance in experiments simulating different climate conditions.						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
				X	X	X
Description			Continue collecting seed from valuable tree species and their provenances (especially southern-most) and testing their performance in experiments simulating different climate conditions.			
Option's relevance						
Economic	Ecologic	Social				
++	+					
Opportunities that arise			There may be an opportunity for productivity increases in one or more suitable habitats.			
Cross-cutting relevance			NO			
Risks addressed			The most important tree species may underperform in their current locations and result in reduction of forest increment. Ultimately this could begin impacting on the allowable annual cut, resulting in reduced annual harvest and increased fuelwood cost, illegal logging and constrained economic output of the sector.			

21. Maintain a seed bank for endangered species and provenances						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
					X	X
Description			Establish and maintain a of seed bank for endangered species or provenances, which would be enable their continued use in case of regeneration failures.			
Option's relevance						
Economic	Ecologic	Social				
++	+++					
Opportunities that arise			These may prove suitable for use in new or unexpected areas, which may be identified during climate modelling.			
Cross-cutting relevance			Yes	Biodiversity		
Risks addressed			In the event of significant climate change and extreme weather events whole populations may be affected to the point where they may be beyond recovery in those locations.			

22. Gain experience with production of seedlings for rare and endangered species (including establishment of them in the field						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
					X	X
Description			Gain experience with production of seedlings for rare and endangered species (including establishment of them in the field them) so that they may be conserved.			
Option's relevance						
Economic	Ecologic	Social				
++	+++					
Opportunities that arise			Will expand knowledge and skillsets of nursery staff and provide a means of using these plants in the field. Skills may be transferrable to other species.			
Cross-cutting relevance			Yes	Biodiversity		
Risks addressed			Seed may be obtained for these species but the true test is in establishing them in the field. Without developing this full process there is a risk of failure.			

23. Experiment with the production of seedling tree material that are more resistant to for example fire, insect, disease or other disturbance						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Conduct trials to identify tree species or provenances that combine adequate growth and survival with resistance to the damaging agents of fire, disease, insect attack, and so on.			
Option's relevance						
Economic	Ecologic	Social				
+++	++	+				
Opportunities that arise			These could also be used as a barrier or shelterbelt, if appropriate.			
Cross-cutting relevance			NO			
Risks addressed			There is a risk of a lost opportunity in terms of using damage resistant planting stock. This could save significant resources if successful and create forests that are far more resilient to climate change.			

III. Maintenance of biodiversity and genetic diversity

24. *Preserve available hotspots of biodiversity, old-growth patches and clusters of habitat trees.*

Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Applying a variety of techniques, preserve, if possible, the most valuable hotspots of biodiversity.			
Option's relevance						
Economic	Ecologic	Social				
+	+++	++				
Opportunities that arise			More resilient and productive forests; Lower chances for loss of species; Better capabilities to support biodiversity at different levels; Better abilities to serve various Ecosystem Services.			
Cross-cutting relevance			YES	Biodiversity; Tourism.		
Risks addressed			Rich stores of biodiversity are immensely valuable to the health and balance of ecosystems. Permanent loss of such rich habitats can have widespread damaging effects.			

25. *Promote management strategies that maximize species, genetic and structural diversity*

Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Promote management strategies, through new guidance and training for forest planners and other practitioners that maximize species, genetic and structural diversity and limit the spatial extent of homogenous areas.			
Option's relevance						
Economic	Ecologic	Social				
+++	+++	+				
Opportunities that arise			More resilient and productive forests; Lower chances for loss of species; Better capabilities to support biodiversity at different levels; Better abilities to serve various Ecosystem Services.			
Cross-cutting relevance			YES	All sectors related to forests		
Risks addressed			Resilience to climate change is directly related to the genetic richness of the resource. Homogenous forests have much higher risks attaching.			

26. *Identify rare species with serious risk of extinction and, together with research and nursery specialists, protect their current status but plan for their regeneration and potential migration*

Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X		X	
Description			Needed set of actions to continue the identification of species at risks in new environmental conditions and efforts to support them by protection of their habitats, assisting regeneration, promoting ex-situ conservation and potentially migration.			
Option's relevance						
Economic	Ecologic	Social				
+	+++					
Opportunities that arise			Species at risks will be supported to decrease the chances of extinction.			
Cross-cutting relevance			YES	Biodiversity and Ecosystems, Agriculture.		
Risks addressed			Species loss, biodiversity loss.			

27. IMPLEMENT MEASURES TO LIMIT THE POTENTIAL OF INVASIVE SPECIES, ESPECIALLY INSECTS AND FUNGI, TO ENTER FOREST ECOSYSTEMS						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Invasive species often have advantage compared to local species and could cause limited spread of local species or heavy losses in the cases when the invasive species causes diseases and mortality. There is need of array of actions to limit the potential of spread of invasive species - strict sanitary control, education of various specialists, control of use of organisms in agriculture, forestry, landscape architecture and associated activities.			
Option's relevance						
Economic	Ecologic	Social				
++	++					
Opportunities that arise			Limited spread of invasive species will decrease the potential losses and negative effects.			
Cross-cutting relevance			YES	Biodiversity and Ecosystem Services, Urban, Agriculture.		
Risks addressed			High risk of losses of forest resource and biodiversity.			

28. PARTICIPATE IN THE EUROPEAN INFORMATION SYSTEM ON FOREST GENETIC RESOURCES						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	
Description			Good knowledge and understanding on genetic resources enables appropriate use of resilient genotypes, which are better capable of meeting the challenges of climate change.			
Option's relevance						
Economic	Ecologic	Social				
++	++					
Opportunities that arise			More resilient forests.			
Cross-cutting relevance			YES	Biodiversity and Ecosystem Services, Agriculture		
Risks addressed			Decreased forest resilience and associated decreases in growth potential and abilities to overcome various challenges.			

IV. National Systems for Rapid forest fire detection, Long term disturbance monitoring and forest resource monitoring, including NFI

29. BUILD A NATIONAL SYSTEM FOR RAPID FIRE DETECTION AND RESPONSE TO THIS AND OTHER NATURAL CALAMITIES						
Relevant to:			Resilience	Production	Biodiversity	Other Eco-Service
			X	X	X	X
Description			Forest fires are a major and growing threat for the forest resources and ecosystems in general. As the growing stock of the Bulgarian forest resource rises so too does the impact of fires. There is urgent need to improve the potential for rapid fire detection and response. There is also urgent need to better modelling of fire risk dependent on forest type, relief, climate conditions and other factors, which will improve the planning of needed operations.			
Option's relevance						
Economic	Ecologic	Social				
+++	++	+				
Opportunities that arise			A well-established system would allow quick discovery of fires and timely actions for limiting their spread thus loosing less forest resource.			
Cross-cutting relevance			YES	Biodiversity and Ecosystem Services, Civil Protection, Economy.		
Risks addressed			If the action is not taken the losses from fires are expected to continuously grow.			

30. BUILD A NATIONAL SYSTEM FOR LONG-TERM DISTURBANCE MONITORING					
Relevant to:		Resilience	Production	Biodiversity	Other Eco-Service
		X	X	X	X
Description Option's relevance Economic: ++ / Ecologic: + / Social: +		Besides fires other types of abiotic and biotic disturbances are major threat to forest ecosystems. Often they have a spreading character (that is bark beetle outbreaks, various diseases), which requires quick detection and targeted limiting actions. A national Disturbance Monitoring System will use the advances of novel remote sensing technologies and on-ground based instruments (for example from the National Rapid Fire Detection System) and the processing power of modern computing machines. It should enable the storage and processing of data in GIS-based systems, which will allow spatial analysis of disturbances and modelling of risks dependent on numerous factors.			
Opportunities that arise		A well-established system would allow quick discovery of various disturbances and timely actions for limiting their spread thus loosing less forest resource. The system will allow analysis and modelling of the risks from various disturbances.			
Cross-cutting relevance	YES	Biodiversity and Ecosystems, Civil Protection, Water Sector (through Water-provisioning services), Economy.			
Risks addressed		If the action is not taken the losses from various disturbances are expected to continuously grow.			

31. EXECUTE NATIONAL FOREST INVENTORY					
Relevant to:		Resilience	Production	Biodiversity	Other Eco-Service
		X	X	X	X
Description Option's relevance Economic: +++ / Ecologic: ++ / Social: ++		The National Forest Inventory (NFI) is critically needed to collect timely and precise information on the forestry resources and the whole array of processes going on in forest ecosystems. It allows periodic monitoring of forest development, quick discovery of processes on small or large-scale, evaluation of the effectiveness of various actions in forests, including climate-adaptation and mitigation actions.			
Opportunities that arise		NFI allows to have precise data on the forestry resources and trends; This is need for the proper management and planning of all activities in Forest Ecosystems; It is also needed for reporting to EU and all-related sectors, which need reliable data.			
Cross-cutting relevance	YES	All sectors which are directly related to the country territory, social and economical development.			
Risks addressed		A not running NFI does not allow to have precise data on the forestry resources and timely monitoring of ongoing processes in the forests. Lack of such data limits appropriate planning of all actions in the Forestry sector and directly related sectors. Limited opportunities for comprehensive and objective assessment of the effectiveness of forest policy and adaptation.			

<table>
<tr><th colspan="7">32. INTEGRATE EXISTING AND NOVEL INFORMATION SYSTEMS IN MODERN NATIONAL INFORMATION SYSTEM FOR FOREST RESOURCES</th></tr>
<tr><td colspan="3" rowspan="2">Relevant to:</td><td>Resilience</td><td>Production</td><td>Biodiversity</td><td>Other Eco-Service</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td colspan="3">Description</td><td colspan="4" rowspan="4">A well-integrated National Information System on Forest Resources will use the data from all-subsystems for collection of data on forest resources. It will use the opportunities provided by modern computing systems, including GIS tools. It will enable fast analysis of data for forest resources including spatial components.</td></tr>
<tr><td colspan="3">Option’s relevance</td></tr>
<tr><td>Economic</td><td>Ecologic</td><td>Social</td></tr>
<tr><td>+++</td><td>++</td><td>+</td></tr>
<tr><td colspan="3">Opportunities that arise</td><td colspan="4">Data on forest resources will be used and analyzed with higher precision and time-effectiveness. This will support and improve all activities on planning in forests and actions in forest ecosystems.</td></tr>
<tr><td colspan="3">Cross-cutting relevance</td><td>YES</td><td colspan="3">All sectors which are directly related to the country territory, social and economical development.</td></tr>
<tr><td colspan="3">Risks addressed</td><td colspan="4">The data on forest ecosystems will be spread among different information systems, which limits the opportunities for quick data management, analysis and all related activities. Limited opportunities for comprehensive and objective assessment of the effectiveness of forest policy and adaptation.</td></tr>
</table>

V. Improving the potential for long-term use of higher-valued wood products

<table>
<tr><th colspan="7">33. REVIEW AND EXPAND THE CURRENT BUILDING STANDARDS TO IMPROVE THE POSITION OF WOOD AS A MATERIAL</th></tr>
<tr><td colspan="3" rowspan="2">Relevant to:</td><td>Resilience</td><td>Production</td><td>Biodiversity</td><td>Other Eco-Service</td></tr>
<tr><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td colspan="3">Description</td><td colspan="4" rowspan="4">Building Standards should be reviewed and expanded to fully recognize and use Standard Eurocode 5 to enable the increased use of wood as a material with long-term use in constructions;</td></tr>
<tr><td colspan="3">Option’s relevance</td></tr>
<tr><td>Economic</td><td>Ecologic</td><td>Social</td></tr>
<tr><td>+++</td><td></td><td>++</td></tr>
<tr><td colspan="3">Opportunities that arise</td><td colspan="4">the wider use of wood as construction material will be improved. This will improve the timber market and provide new opportunities for wood processing, architecture and construction.</td></tr>
<tr><td colspan="3">Cross-cutting relevance</td><td>YES</td><td colspan="3">Economy</td></tr>
<tr><td colspan="3">Risks addressed</td><td colspan="4">If action is not taken then the utilization of timber will remain insufficient. This leads to missed opportunities for employment and low economical relevance of silviculture measures.</td></tr>
</table>

<table>
<tr><th colspan="7">34. ESTABLISH A TIMBER MARKETING BOARD</th></tr>
<tr><td colspan="3" rowspan="2">Relevant to:</td><td>Resilience</td><td>Production</td><td>Biodiversity</td><td>Other Eco-Service</td></tr>
<tr><td>X</td><td>X</td><td></td><td>X</td></tr>
<tr><td colspan="3">Description</td><td colspan="4" rowspan="4">A timber marketing board will enable interaction between stake holders in the Forestry Sector and improve the potential to promote wider use of wood products and expand the market of wood products.</td></tr>
<tr><td colspan="3">Option’s relevance</td></tr>
<tr><td>Economic</td><td>Ecologic</td><td>Social</td></tr>
<tr><td>+++</td><td></td><td>++</td></tr>
<tr><td colspan="3">Opportunities that arise</td><td colspan="4">Improve the timber products market.</td></tr>
<tr><td colspan="3">Cross-cutting relevance</td><td>YES</td><td colspan="3">Economy</td></tr>
<tr><td colspan="3">Risks addressed</td><td colspan="4">If action is not taken then the utilization of timber will remain insufficient. This leads to missed opportunities for employment and low economical relevance of silviculture measures.</td></tr>
</table>

35. *CREATE A WOOD SPECIFIERS GUIDE NEEDS TO PROVIDE ALL THE REQUIRED KNOWLEDGE NEEDED BY TECHNICAL PROFESSIONALS TO EASE THE USE OF THIS MATERIAL WITH CONFIDENCE*

Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service
	X	X	X	X

Option's relevance: Economic	Ecologic	Social
+++		

Description	A wood specifiers guide and other similar specialized literature would improve the opportunities of various specialists to use wood products at wider scale. It could facilitate development of new opportunities for long-term and high-value use of wood.
Opportunities that arise	Improve the timber products market.
Cross-cutting relevance	YES – Economy.
Risks addressed	If action is not taken then the utilization of timber will remain insufficient. This leads to missed opportunities for business and employment.

36. *ESTABLISH NOVEL WOOD-BASED SPECIFICATIONS AND PROMOTE AMONGST MUNICIPALITIES*

Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service
	X	X	X	X

Option's relevance: Economic	Ecologic	Social
+++		

Description	The wood-based specifications could ease the wider use of construction wood for various constructions in urban environment. Such constructions are well-appreciated in society and provide the opportunity for quick results due to use of standardized elements. This will promote the market of high-value wood, the wood-reprocessing industry, architecture and construction business.
Opportunities that arise	Improve the high-value timber market; Promote wood-processing industry; Promote new architecture and construction development.
Cross-cutting relevance	YES – Economy, Urban environment.
Risks addressed	If action is not taken then the utilization of timber will remain insufficient. This leads to missed opportunities for business and employment.

VI. Improving the potential for sustainable and more environmentally-friendly use of wood biomass for production of energy

37. *ESTABLISH A PROGRAM TO PROMOTE THE INSTALLATION OF MODERN ENERGY AND HEAT PRODUCTION SYSTEMS FOR HOUSEHOLDS, BUSINESSES AND SMALL COMMUNITIES*

Relevant to:	Resilience	Production	Biodiversity	Other Eco-Service
		X	X	X

Option's relevance: Economic	Ecologic	Social
+++	+	+

Description	The widespread burning of large quantities of wood for household heating using ineffective and highly polluting stoves and boilers is a critical problem in Bulgaria. Firewood accounts for more than half of the annual harvest and undermines long-term forest management. A program is needed to promote the installation of modern energy and heat production systems for households, businesses and small communities. Such a measure would encourage more efficient use of wood for energy, decreasing the demand for firewood and at the same time decreasing fine-particle pollution significantly.
Opportunities that arise	Improved, more efficient use of wood biomass, which cannot be used for long-term products; Decreased pollution; Improved energy independence of house-hold and communal (that is schools, hospitals) facilities.
Cross-cutting relevance	YES – Directly related to energy sector and indirectly to urban sector.
Risks addressed	If action is not taken then there is risk of continuing low-efficiency burning of large amounts of wood; continuing high pollution with fine-particles in small cities and villages.

Annex 3. Cost-benefit Analysis

1. General Description

The conceptual framework of the cost-benefit-analysis (CBA) was developed based on climate change affecting the Forestry sector.

The purpose of this section is to:

- Estimate the parameters of a relationship between performance indicators and climate change indicators for the forestry sector (temperature +2° C and +4°C, and precipitation changes). It is considered that climatic drivers associated with the impact assessment are average temperature and average precipitation.
- Develop a CBA model – apprising the costs and benefits of adaptation actions, thus measuring the efficiency of investments. It quantifies the anticipated costs and benefits of adaptation options with the aim of comparing them and determining whether the benefits outweigh the costs. Benefits are the advantages or positive effects of adaptation measures. Costs are the resources required to deliver adaptation measures. The effects are expressed as a decrease in costs because adaptation measures taken.
- Evaluate and rank the adaptation measures in terms of economic efficiency.

1.1. Description of the methodology

Climate effects were evaluated in an integrated assessment model, which combines a regression (or sensitivity) analysis with CBA, that is, assesses the value of the costs and benefits of each adaptation action - giving a net present value (NPV) - and compares the costs (investment expenditure) and benefits (costs avoided). Costs and benefits are expressed in monetary terms and a discount rate is used to determine the NPV of the adaptation measures.

The regression analysis - as a technique to assess adaptation measures under uncertainty - identifies those factors that have most influence on main sectoral indicators. The effect can be positive or negative.

The estimation of the negative and positive effects of climatic changes was developed according to distinct scenarios at +2°C and +4°C temperature rise by 2050. These main scenarios are divided into sub–scenarios: optimistic, realistic, and pessimistic. The sub-scenarios are considered in the context of efficient and effective implementation of the proposed climate change adaptation measures.

The projected effects of adaptation measures are expressed as a logarithmic function, which is a tool to measure the effects of investments that would be gradually made until 2050.

An assessment was carried out of the NPV and the benefits until 2050, holding all other aspects constant. The monetary value of the effects was discounted by 4.5 percent for public funding and by 8 percent for private funding.

The benefits are defined as the positive effect of the implementation of climate change adaptation measures in the forestry sector.

1.2. Data collection procedure

The primary data used for the CBA was obtained from the Action Plan that is part of a draft proposal for a National Climate Change Adaptation Strategy and Action Plan for Bulgaria, and from official statistical data, as far as available.

The correlation determined whether there is a relationship between the performance indicators and climate factors. The relationship indicates which indicators are significantly dependent on climate change. Estimation of the correlation coefficient (dependence between each sectoral indicator and climate change factors [temperature and precipitation]) is used to stand out and select the critical variables (variables, which are highly sensitive to climate factors).

1.3. Model specifications - assumptions and limitations

A number of assumptions were made when preparing and carrying out the CBA. These include:

- The projected trend value of each sector indicator based on historical data (1960–2015).
- The main performance indicators included in the analysis are: total afforested area, hectares (ha), total wood stock expressed in thousands of cubic meters, total annual increment expressed in thousands of cubic meters per year, average annual increment expressed in cubic meters per one ha, wood harvesting expressed in thousands cubic meters per year. Given the available long-term and prognosis data (in the case used from Kostov and Raffailova, 2009, see ***Annex 4***) the most relevant of these indicators is the total available wood stock. The current Bulgarian inventory system uses this indicator to assess the increment indicators and to plan possible wood harvesting. The total wood stock is also an indirect indicator of forest health, accumulated carbon, the overall condition of the forests and the overall ability of forests to serve a wide variety of ecosystem services. However, the total wood stock is a very specific indicator because it is a resource that cannot be readily used at any given moment. The use of the resource is long-term, at small portions of it (the annual harvest), which must not exceed the annual increase of the resource (annual increment). Only in this way the long-term stability and availability of the resources can be assured. In addition, it must be stressed that, besides wood, forests provide a number of services to society that are not yet fully evaluated in Bulgaria. These are called ecosystem services (for example water purification and regulatory function; soil protection function; carbon sequestration function; provision of forested areas for recreation and tourism, and so on) and most of them are directly related to the condition of the forests. Therefore, forests can be considered as a strategic resource, providing multiple services and benefits while having very high value, of which only a small portion can be used at a given time moment.
- Climate projections (temperature and precipitation) were applied to historical variances experienced in Bulgaria (1991–2015). The input data for climate factors consist of annual temperatures (maximum, minimum, and average) and precipitation (maximum, minimum, and average).
- A baseline scenario is used to evaluate the development trend of the performance indicators under the +2°C and +4°C temperature rise scenarios. The baseline scenario reflects a continuation of current policies and plans, that is, a future in which no new measures are taken to address climate change.

- The benefits are defined as the positive effect of the implementation of climate change adaptation options in forestry sector.

2. Results of the Regression Analysis

The regression analysis between climate change factors and sectoral performance indicators could not be made because of insufficiently available statistical data for all parameters for the forestry sector and multiple of additional factors affecting the main indicators besides solely climate variability. This limited information availability hinders the correct accounting of the relationship between performance indicators and climate change parameters.

Additionally, in Bulgaria, the regular forest inventory has not started yet, which hinders the availability of detailed up-to-date data for the annual increment of forest types.

In Bulgaria, the full variety of economic benefits from forests is still not accounted and evaluated. Currently, only the wood production function, production of forest fruits and mushrooms, and game hunting, are accounted. The whole variety of ecosystem services from forests still has to be monetarily evaluated.

3. Results CBA Forestry Sector

A baseline scenario was used to evaluate the development trend of the performance indicators in the +2°C and +4°C temperature rise scenarios without taking into account climate change adaptation measures. This baseline scenario reflects a continuation of current policies and plans (that is, a future in which no new measures are taken to address climate change).

Forests represent a natural capital with a high non-market value. The forestry sector has great potential for the economy. The assumption of the CBA is that climate change can negatively affect the production functions of forests and, therefore, adaptation measures can help preventing losses and keeping forestry revenues high.

The cumulative sector effects presented in ***Table 8*** illustrate the difference between the baseline scenario (that is, without implementing selected adaptation options), and the +2°C and +4°C temperature rise scenarios until 2050.

Table 8. Expected forestry sector effects from climate change without adaptation measures - baseline scenario (in € million)

Performance indicators	Losses +2°C scenario	Losses +4°C scenario
2. Total wood stock	-123,987.92	-247,975.85
4. Average annual increment	-1.46	-2.93
5. Wood harvesting, thousands	-4,374.90	-8,749.81

Overall, the effects of climate change on the performance indicators are negative. According to different models and up-to-date data, increased summer temperatures and decreased precipitation will put pressure on the total wood stock, the average annual increment, and the related possible wood harvesting amounts. Reasons for that are several, such as reduced growth due to combined heat and drought stress during summer, and high losses caused by increased disturbances and mortality (that is, fires, windthrows, die-back due to insect outbreaks, or fungi attacks).

The monetary value of wood stock losses and missed revenues, in case no adaptation measures are taken, would, for the period until 2050, be around €123 billion under the +2°C and €247 billion under the +4°C scenario. The losses for wood harvest are €4.4 billion under the +2°C and €8.7 billion under the +4°C scenario.

The CBA for the sector focuses on the assessment of soft adaptation measures. The benefits gained as a result of their implementation are best exemplified through the quantification of their effect on the main performance indicator, total available wood stock. Considering the complex impact of the adaptation options on the Forestry sector, these were not separately quantified in the current CBA. The net present value (NPV) in ***Table 9*** illustrates the monetary value of avoided losses as a result of implemented adaptation measures, while the cost effectiveness quantifies the benefits achieved in relation to the required investments/costs.[23] It should be noted that forests are a natural resource and, therefore, a positive net present value (NPV) illustrates the monetary value of avoided losses as a result of applied adaptation measures.

Table 9. Benefits of adaptation measures in the Forestry sector under different climate scenarios until 2050 (in €, million)

Climate scenarios	NPV (€ million)	Cost-effectiveness (Benefit/Cost ratio)
Realistic scenario +2°C	22,323.47	435.88
Optimistic scenario +2°C	38,176.67	744.66
Pessimistic scenario +2°C	6,470.26	127.02
Realistic scenario +4°C	37,240.01	726.33
Optimistic scenario +4°C	53,093.21	1,035.10
Pessimistic scenario +4°C	21,386.80	417.66

The projection shows that under the +2°C realistic scenario, the total cash flow in NPV is €22.3 billion, and €37.2 billion under the realistic scenario at +4°C. Under the optimistic scenario, the projected cash flow in NPV is €38.2 billion under the +2°C scenario and €53.1 billion – under the +4°C scenario. Even under the pessimistic scenario, the future cash flow in NPV is projected at €6.5 billion at +2°C and €21.4 billion at +4°C.

The CBA shows that adaptation measures would be effective to avoid losses due to climate change, especially regarding damage to forests and losses in forestry productivity.

[23] The NPV of an adaptation option is given by the present value of the estimated benefits and costs. If NPV is more than zero, this indicates that the investment is efficient and incremental benefits of adaptation exceed the incremental resource costs. If NPV is <0 or B/C is <1, then the adaptation measures add no net benefit to the Forestry sector. If NPV is >0 or B/C is >1, then it adds positive benefits. The positive value of NPV confirms that investments for adaptation are efficient.
The benefit-cost ratio (B/C) is the ratio of the present value of benefits to the present value of costs. When the B/C ratio is more than one, the present value of the option's benefits is larger than the present value of its costs.

Within the current analysis, the cost-effectiveness of the adaptation measures is used to quantify the effect of investments under each scenario.[24] Under the +2°C realistic scenario, the benefit/cost ratio is €435.88 (that is, the benefits achieved per Euro spent), and €726.33 under the +4°C realistic scenario. The benefit is higher at +4°C temperature rise. In that case, the benefit is €1,035.10 per one Euro of investment under the optimistic scenario and €417.66 per one Euro of investment under the pessimistic scenario.

The adaptation measures refer to non-market goods, thus they cannot be ranked because the social and economic benefits are avoided losses of national natural capital.

4. Conclusion

The overall effects of the adaptation measures will be cost saving as a result of potentially decreased forest damage from climate change and sustained ability for revenue generation. The NPV calculation shows that investments in adaptation measures are economically efficient. Moreover, combining measures will generate synergetic effects.

In the forestry sector, the main effect of successfully applying adaptation measures will be the reduction of anticipated losses from the negative effects of climate change. For example, investments in adapting forests to be more resilient to windthrows will decrease the losses from windthrows; investments in all measures to reduce the potential losses from fires will reduce the anticipated huge losses of resources from forest fires. The results of generally improved management strategies, which are directly related to all soft measures and applied research, are less clear but even more effective. They are expressed in future forest composition and structures, that are adapted to anticipated climate conditions and, thus, less prone to decreases in productivity and high losses from mortality.

Therefore, investment in adaptation measures can have very high potential effects, because they are relatively small compared to the potential loss of resources in case of lack of adaptation.

In addition, successful adaptation will make the difference between forests, that positively contribute to the economy and those that do not. The correct choice of species and management provide an opportunity for some species to gain advantage from climate conditions at certain locations (that is from increased duration of the growing season at locations with sufficient moisture), thus setting the potential for high economic benefits.

[24] The cost-effectiveness refers to all measures.

Annex 4. Forest Sector Climate Adaptation Modelling in Bulgaria to Date

General planning for the development of management capacity, actions and resources required to cope with the challenges of climate change in forestry are described in the Third NAPCC, the National Strategy 'Sustainable Development of Forestry in Bulgaria 2013–2020', the 'Program of measures to adapt forest in the Republic of Bulgaria and mitigate the negative effect of climate change on them 2012–2020', OP Environment 2014–2020, RDP 2014–2020.

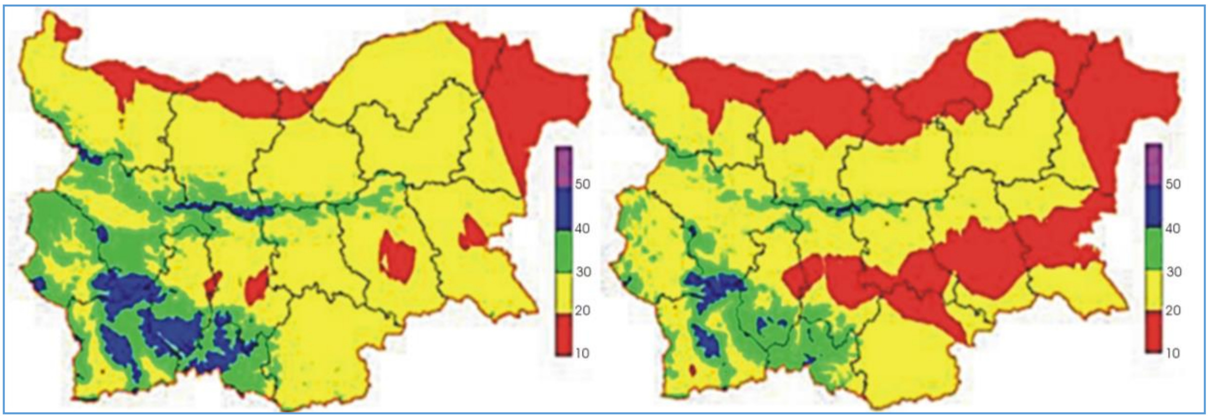
The modeling of the expected changes in forests and their potential effects under different climate scenarios is a key step in the planning process including adaptation measures. For the Bulgarian forests, such modeling has been done in several projects, each of which has both its advantages and disadvantages. Unfortunately, some of the more modern and practical approaches were not used at the country level and results are available only for limited areas and species.

This annex presents a list of the available modeling projects on the development of Bulgarian forests at the national or local level:

1. *Program of Measures to Adapt Forests in the Republic of Bulgaria and Mitigate the Negative Effect of Climate Change on Them 2012–2020*

The main modeling for the territory of the country was compiled for this report and is based on the four Representative Concentration Pathways (RCPs) of IPCC AR5 (IPCC AR5, 2014). The four RCPs (RCP2.6, RCP4.5, RCP6, and RCP8.5) were named after a possible range of radiative forcing values in the year 2100 (+2.6, +4.5, +6.0, and +8.5 W/m2, respectively). For the modeling in Bulgaria RCP2.6 was accepted as an optimistic scenario and RCP8.5 as a pessimistic scenario. The authors of the analysis (Raev et al. 2011) modeled average annual air temperature, annual precipitation, and De Martonne aridity index for the territory of Bulgaria under the different scenarios. Based on the De Martonne index, they divided the country to A, B, C, D, E, F, and G vulnerability zones characterized by decreasing aridity in the order of letters (that is, the most arid is zone A, followed by zone B, and so on). Taking as a basis the present distribution of the main forests species in the zones, the expected future species distribution under the different scenarios was modeled (***Figure 23***).

Figure 23. De Martonne Aridity index for realistic (left) and pessimistic (right) scenarios for 2080 following the Program of Measures to Adapt Forest in the Republic of Bulgaria and Mitigate the Negative Effect of Climate Change on Them 2012–2020



This approach has the advantage of revealing the potential regions where most severe problems in terms of the effects of general climate conditions on tree species may be expected. It provides a good reference especially in the cases when certain tree species already have problems in certain zones and the expected future zoning can provide guidance as to where further problems may be expected. An example are pine plantations, mostly from Scots pine at low altitude (for example, below 700 m a.s.l.), which suffered major problems associated with drought conditions in the last decades. Another application of the approach is to direct attention to the protection of long-established and valuable ecosystems (including NATURA 2000 sites) which are assessed as vulnerable.

However, the approach does not consider the complex interactions between tree species in forests, which may lead to different pathways of development than simply the expected single species adaptability. In addition, extreme climatic conditions and not the average yearly temperatures and precipitation may be of very high importance for species. This could hinder species migrations to zones with generally expected good conditions for certain species. An example is extremely low temperatures which hinder the growth and survival of cold-intolerant Mediterranean species, which may otherwise take advantage of generally warmer conditions and migrate to newly available zones with such conditions. This modeling does not also take into account biotic and abiotic disturbances, which may be a major problem in future.

Under the abovementioned modeling at the optimistic scenario RCP2.6, the average annual air temperature is expected to increase by 1°C - 2°C in lowlands and 0.5°C - 1°C in mountainous regions in 2050. In 2070 the increase would be about 2°C - 3°C in lowlands and 1°C - 2°C in mountain areas, compared to the current climate. At the pessimistic scenario RCP8.5, the increase of the air temperature will be even more significant. By 2050 mean temperatures are expected to rise with 3°C - 4°C in lowlands and with 2°C - 3°C in mountain areas, which is a significant increase compared to the current climate. In 2070, the increase of air temperature continues and is expected to be 1°C higher compared to 2050. The modeled precipitation changes are for serious decreases only in Northeast Bulgaria in the optimistic RCP2.6 scenario. At RCP8.5, a significant reduction of precipitation is expected mainly in northeast Bulgaria, Dobrudzha, southwest Bulgaria, and the Thracian valley. Furthermore, changes in the annual precipitation distribution are expected: increase in winter precipitation and reduction of rainfall during the vegetation period, which will be harmful to most of the tree species in Bulgaria, growing now at conditions of higher, late-spring-early-summer precipitation.

Following these assumptions, the authors of the modeling predict severe problems for the Scots pine plantations, but also some Austrian pine afforestation in vulnerability zones A, B and C, which are below 800 m a.s.l. Although oaks will generally benefit and be capable to cope with the warmer and drier conditions, some forest types, especially those dependent on higher moisture, might be seriously harmed. Beech forests at the altitude zone of 500 m to 900 m a.s.l. are expected to be seriously affected by drought which may promote the expansion of other more drought-resistant species such as the common hornbeam (*Caprinus betulus*) in this zone. In turn beech may further compete with coniferous species above 1,400 m a.s.l. and reduce the territories of drought-intolerant species such as Norway spruce.

2. Two NGO-led projects

Another approach used to classify the potential effect of climate changes on vegetation and forests in Bulgaria was applied in two regional projects for the region of the Kresna Forest Enterprise (southwestern Bulgaria, project 'How to Adapt Forests to Changes in Climate – Innovative Contribution of NGO' accomplished by Balkanka NGO) and the Black Sea coast (project 'Sector Policies Strengthening the Engagement for Improvement of Ecosystem Services in Bulgaria [also called SPECIES]' accomplished by Balkani NGO). The approach was based on the Rivas-Martinez concept for bioclimatic classification. It divides the bioclimates of the world into five macro bioclimatic zones, subdivided into 28 bioclimates with additional variants. This system uses a much more detailed subdivision of climatic parameters accounting for seasonal precipitation distribution, temperature extremes in addition to the usual average values, different seasonality parameters, and specific combinations of these parameters forming bioclimatic indices. In addition, the abovementioned projects used the world hardiness classification based on the long-term average of the absolute minimal temperatures for the coldest month. This classification provides the opportunity to account also for the extreme minimum temperatures, which might be decisive in the hindering of migration and long-term survival of tree species adapted to grow at warmer and drier climate conditions.

Using this approach, the projects described two macro bioclimates with 15 variants for Kresna and one macro bioclimate for the Black Sea coast and then compared them to a detailed mapping of vegetation descriptions using the European Nature Information System habitat classification. Using climate modeling based on the CECILIA project[25] and climate scenario A1B (that is, moderate change of temperatures, high CO_2 emissions until 2050 with gradual decline afterward) future bioclimatic zones were modeled for the period 2050–2100. The CECILIA project provides modeled climate data using the model ALADIN at grid with high spatial resolution (10 km grid), which combined with the GIS terrain modeling provides the opportunity for locally based prognosis that accounts for the relief characteristics. This is highly important in the cases of very diverse relief such as the one for Kresna forest enterprise, where there is a difference in altitude of almost 2,000 m (from 135 m a.s.l. to 2039 m a.s.l.). For each of the main species and habitats, a prognosis was made based on the known information for the plant species plasticity and adaptability. For bioclimate variations, which are not presented in Bulgaria, the vegetation in the closest analogues (in the case in Greece and Turkey) was used as a prediction for potential future analogue.

The advantage of this approach is a much more direct link between climatic parameters and vegetation species biological characteristics, which provides the opportunity for more robust prognosis of what will happen to the current vegetation and what vegetation may arise or be suitable in the future. Such approach has the advantages of the formerly mentioned approach applied for the whole country (Raev et al. 2011). At the same time, this approach requires deep knowledge on the biological characteristics and plasticity of tree and shrub species, which is often missing for the species, and are not widely distributed in Europe. Therefore, the scientific efforts to study them and especially experimental work with potential future climate parameters

[25] http://www.cecilia-eu.org/

was limited. Another disadvantage of this approach is that it does not account for interaction between species, effects of natural and anthropogenic disturbances, and management practices.

The main conclusions of these projects are:

a) A prognosis for dramatic changes in the potential vegetation of the Black Sea region with transition to evergreen Mediterranean vegetation type with dominance of oak species, which are now either not found in Bulgaria or are with limited distribution in southwest Bulgaria. Intensive degradation processes might be expected in many forests with participation of hornbeam, oriental beech and sessile oak.

b) For the Kresna region, the expected changes will be the strongest for moisture-demanding coniferous species such as Norway spruce and fir in the mountain region, sessile oak, chestnut, and black alder at lower altitudes. They will decrease their distribution. Those species which are expected to be able to adapt to warmer and drier climate are Hungarian oak, Turkey oak, Kermes oak (*Quercus coccifera*), Austrian pine, Oriental hornbeam, juniper species, and potentially beech in the mountains, which may migrate higher up and use territories formerly dominated by fir and spruce.

Another general approach to predict the possible effects of climate on vegetation and especially on forests is to use models for forest development on the stand-scale on landscape-scale and feed them with climate data from climate-simulation models. These models have the big advantage of simulating tree recruitment and growth, competition and between-species interactions, and natural disturbances. These processes are dependent on environmental factors such as topography, soil properties, and most important climate parameters. The approach also provides the opportunity to use the model outputs for various value calculations. For the territory of Bulgaria, this approach was used for mountain landscape dominated by coniferous species in the Rhodope Mountains (case study of the project 'Advanced Multifunctional Forest Management in European Mountain Ranges [also called ARRANGE]') (Zlatanov et al. 2015)'[26]; and for oak-dominated forests and pine plantations in low-altitude hilly landscape in Sredna Gora Mountain (case study of the project MOTIVE).[22]

3. *Modeling of the development of coniferous forests and mixed beech-coniferous forests in the Rhodope Mountains as a case-study within the project ARRANGE*

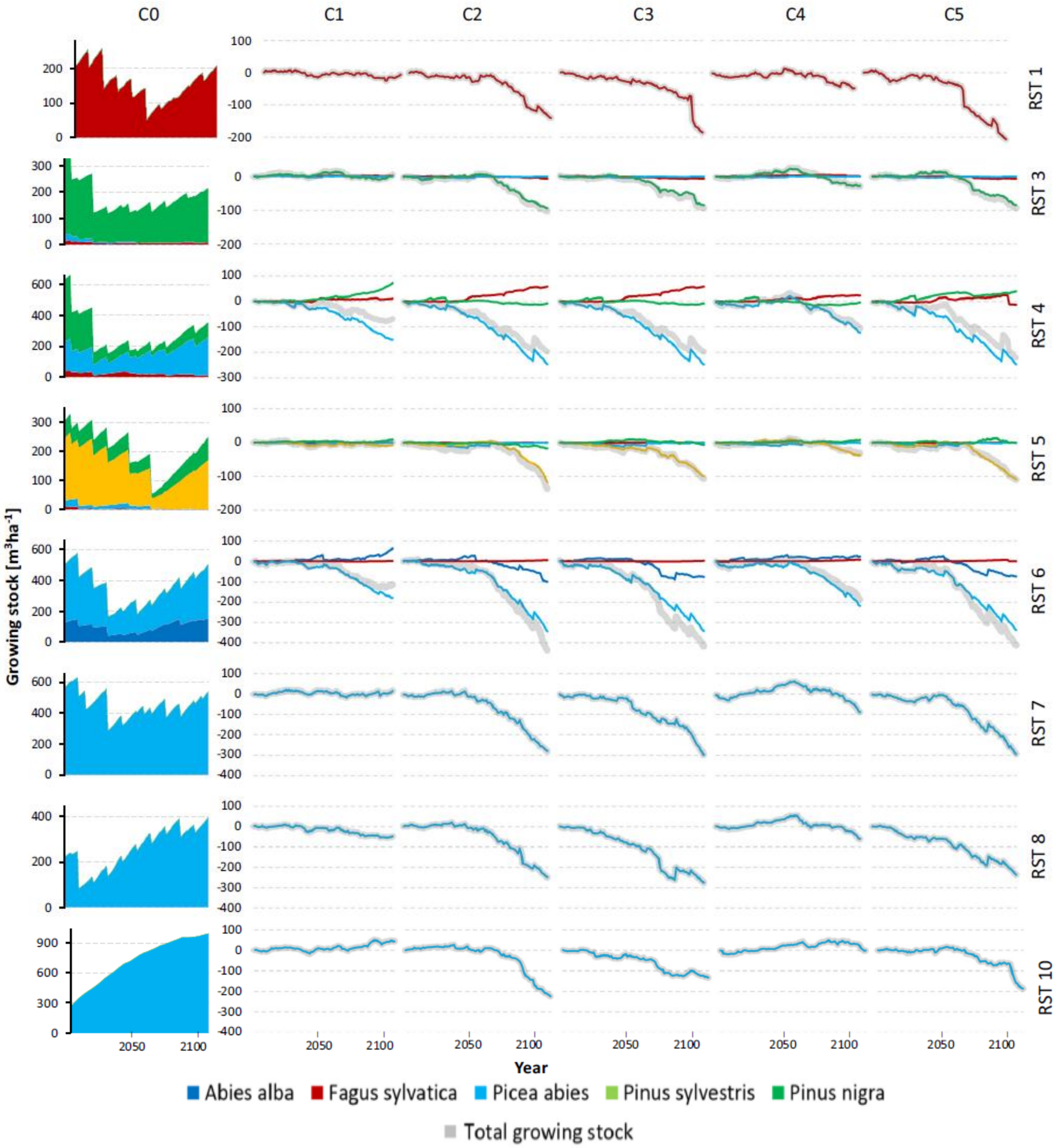
The study area and modeling for the project in the Rhodope Mountains was the valley of Mt. Perelik in the Western Rhodopes. The landscape varies in altitude from 1,000 to 2,100 m a.s.l. and is highly representative of the mountain areas dominated by the most important coniferous species (Norway spruce, Scots pine, Austrian pine, Fir) and beech in the Rhodopes Mountains, Rila Mountains and parts of the Pirin, Vitosha and Stara Planina Mountains. The region is also of high value for tourism being one of the most popular summer and winter mountain recreational destinations in Bulgaria (Pamporovo resort, the villages of Shiroka Laka, Gela, Stoikite). The forest development modeling was based on the stand-scale model PICUS (developed in BOKU University, Austria) and landscape scale model LandClim (developed by ETH, Switzerland). The climate modeling was based on selected regional climate simulations from the EU FP6 project ENSEMBLES[27] for five climate change scenarios. Besides modeling

[26] http://motive-project.net/
[27] http://ensembles-eu.metoffice.com/

temperature and precipitation changes in solar radiation and vapor pressure deficit were also accounted for. The five scenarios in general predict increase in summer temperatures from 3˚C to 4˚C and winter temperatures by 4˚C to 5˚C and decrease of winter precipitation of 5 percent to 20 percent and summer precipitation of 20 percent to 40 percent. Thus, they are similar to the moderate and pessimistic RCPs used in the modeling for the 'Program of Measures to Adapt Forests in the Republic of Bulgaria and Mitigate the Negative Effect of Climate Change on Them 2012–2020'. The management scenarios were (a) business-as-usual (BAU), which for the region is a shelter wood system with three successive regeneration felling (at approximately 90, 105, and 120 years of stand age); and (b) no management for two of the forest types (Austrian pine on steep rocky slopes and Norway spruce at close-to-tree line sites), where actually currently there is also no active management. The main simulated ecosystem services were wood production, carbon stock, soil stabilization, habitat quality for rare birds, and forest species diversity.

The modeling showed that a substantial impact of climate change might be expected (Zlatanov et al. 2015). The most affected forests are expected to be Norway spruce-dominated forests where the participation of the main species will diminish, and the general growing stock will significantly decrease (up to 300 m^3 per hectare under pessimistic scenarios). This is of high importance given the fact that large areas in the Rhodopes and Rila Mountains in Bulgaria are covered by this forest type, hence, numerous other ecosystems services with high importance such as water-provisioning and tourism might be seriously affected. Beech forests at lower altitude are also expected to suffer loss of biomass (up to 200 m^3 per hectare below 1,000 m a.s.l. under pessimistic scenarios) and abundance. However, at more mesic sites, beech are expected to increase their share. Silver fir might be expected to increase its share, which is currently relatively low and also, increase its growing stock in some of the scenarios. Most robust to climate change is predicted to be the Austrian pine and Scots pine on sites with favorable conditions (that is, sun-exposed mountain terrain above 1,000 m a.s.l.). The general biomass quantity is expected to decrease at lower altitude sites. At higher-altitude sites, it might initially increase due to better temperature conditions (in the case, increased temperatures above 1,800 m a.s.l.), but after 2070, decrease due to drought conditions and their negative impact of growth mostly on Norway spruce. Harsher impacts are expected on other ecosystem services at lower altitudes there will be loss in species richness, higher mortality, and associated decrease of the ability of forests to provide soil stabilization. This is of great importance given the fact that most of the water catchments for provision of clean drinking water in southern Bulgaria are in the mountain regions covered with the type of forests studied.

Figure 24. Modeling of the development of growing stock under climate without change (C0) and five climate change scenarios (C1-C5) for different forest types (RSTs) in the Rhodope Mountains



Source: Zlatanov et al. 2015.

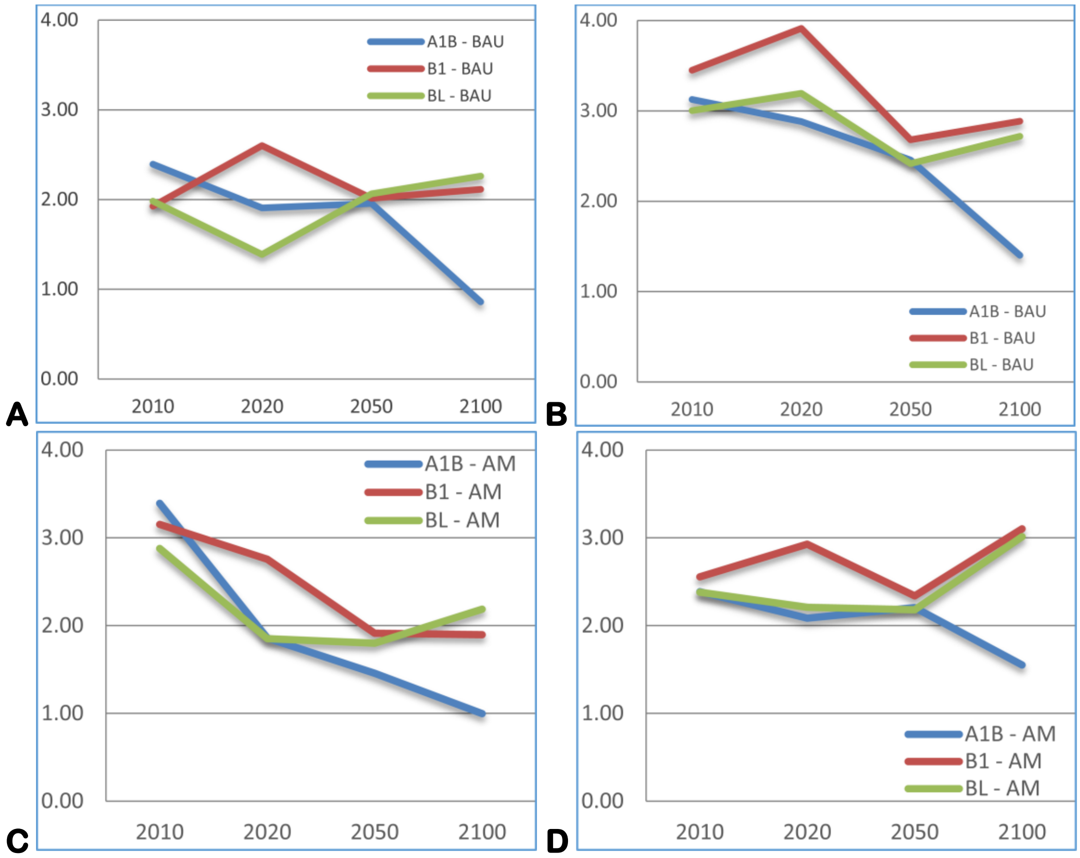
4. *Modeling of the development of oak-dominated forests and pine plantations in low-altitude, hilly landscape in Sredna Gora Mountain as a case study within the project MOTIVE*

The study area used for the modeling of the development of oak forests and pine plantations at lower altitude was in the State Forest Enterprise 'Panagyurishte' in Sredna Gora Mountains. It can be classified as a low-altitude mountain region (350 m to 499 m a.s.l.) with population strongly dependent on the agriculture and forestry sector. Forests are mostly mixed coppice and high forests of Sessile oak (*Quercus petraea*), Hungarian oak (*Q. frainetto*), Turkey oak (*Q. cerris*), Hornbeams (*Carpinus betulus* and *C. orientalis*), Flowering ash (*Fraxinus ornus*) and plantations of Austrian pine, less Scots pine and locust (*Robinia pseudoacacia*). The traditional management of oak forests is conservative coppice with longer rotation period with the aim to transform them to high forests. The forestry territory falls within the transitional continental region in the European subcontinental climatic zone characterized by MATs of 10.6°C, average January temperatures of -1°C, and absolute summer maximum temperatures of up to 36°C. The mean annual precipitation is 600 mm with a late spring maximum and summer minimum characterized by periods of drought lasting over 20 days during the second part of the vegetation period (August– September). High proportion of Bulgaria's oak forests grow in similar environmental and social settings and thus, the case study can be used as a potential model for management planning for such forests.

The climate change scenarios used within the MOTIVE project (A1B and B1) predict an increase in temperature of 1.5°C to 3.5°C during the second part of the 21st century and a decrease in precipitation of between 60 mm and 120 mm and are thus closer to the moderate to pessimistic scenarios of the RCPs used in the modeling for the 'Program of Measures to Adapt Forests in the Republic of Bulgaria and Mitigate the Negative Effect of Climate Change on Them 2012–2020'. The scenario A1B shows higher temperatures after 2050. Two management scenarios were tested: (a) BAU, and (b) alternative management (AM), which is characterized by shorter rotation period for coppice stands and intensive tending and thinning of young stands, increasing the opportunity for natural regeneration and transformation to high forest. The stand-level dynamics were modeled with the model PICUS, v. 1.5.

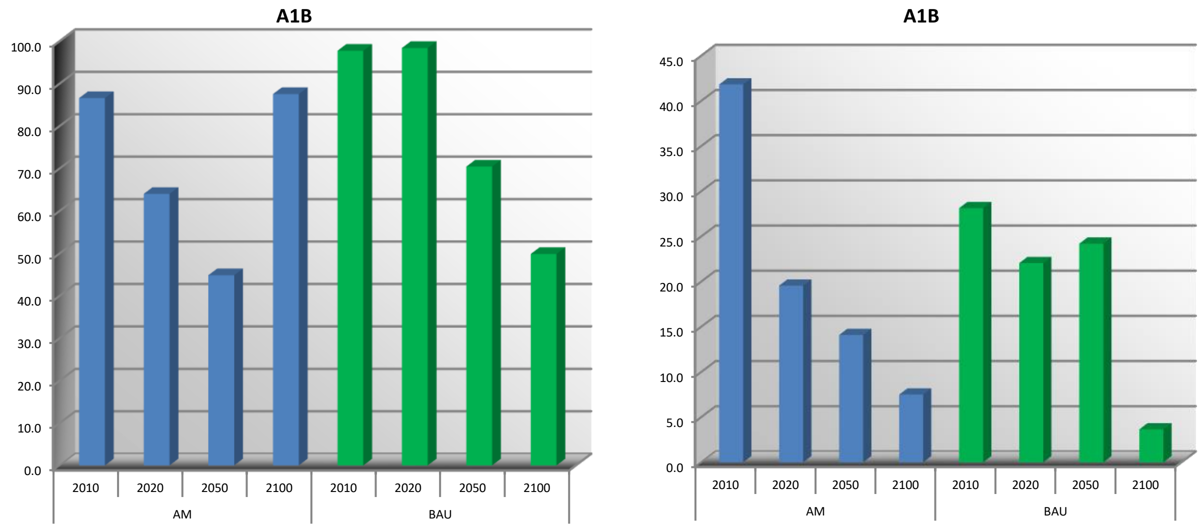
The modeling predicts decreasing vitality of Sessile oak. Hungarian oak and Turkey oak are expected to maintain their vitality, but because the saplings of Hungarian oak have slower growth for the first decades of life, Turkey oak will gradually increase its share in drier climate conditions. Natural regeneration (that is, by seed) for all oaks is expected to be problematic, thus increasing the share of coppice forests and likely requiring direct management even of high stands toward a mixture of high forest and coppice. Pine plantations are expected to suffer from droughts, attacks of insects and fires, which will gradually lead to their replacement by oak species in the absence of afforestation actions. The annual increment will decrease as the result of harsh climate change (A1B scenario) at all management scenarios (***Figure 25***). It is predicted that it will remain relatively unchanged at low climate change scenarios (B1 and BL) for High forests under the BAU management and for coppice forests under AM management. The AM alternative is expected to provide generally higher timber volume, but lower average wood stock than the BAU scenario for oak forests (***Figure 26***). The opportunities for higher species richness are higher at the AM scenario, but at the same time there will be a higher share of young coppice forests as a result of intensive felling, which will decrease the supply with wood in mid-term perspective (that is from 2020 up to 2050) after the initially intensive felling. At the same time the implementation of such management strategy requires a change in the long-term management goals and expectations from oak forests and a flexible adaptive approach.

Figure 25. Average annual increment (cub. m/ha/year) simulation climate scenarios (A1B, B1, BL) for the Panagyurishte forest enterprise



Note: The scenarios are developed under the following management and forest-type scenarios: (A) High oak forests and BAU management; (B) Coppice oak forests and BAU management; (C) High oak forests and AM management; and D) Coppice oak forests and AM management.

Figure 26. Current and projected average volume per hectares (A) and removed timber volume (B) of the coppice oak stands under moderate climate scenario A1B under AM and BAU management for the Panagyurishte forest enterprise



A ***B***

5. Modeling of the total volume accumulation and potential harvest for the economically most important species under different management scenarios

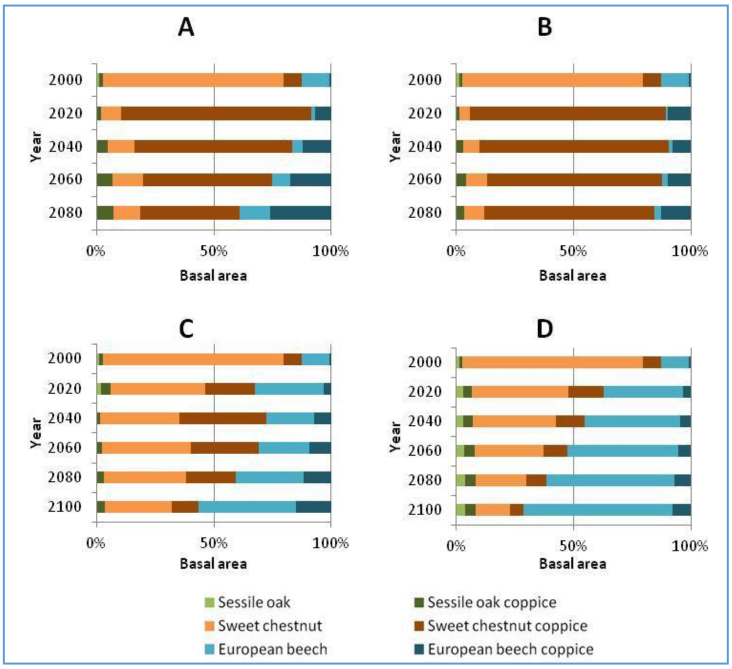
The modeling was performed in the framework of EFA-funded project ‘Dynamic of forest resources in Bulgaria under different management regimes’ (2005–2009). It used the data from the inventories of the forest enterprises in Bulgaria and the model EFISCEN. Four management scenarios were simulated: (a) base (management using traditional approaches), (b) maximum sustainable use (management planning for considerable increase of harvesting), (c) optimistic (‘Handbook scenario’ with slight increase of harvesting and close to the best theoretical forest dynamics), and (d) pessimistic (no increase of harvesting, increase of losses due to disturbances, natural mortality, and so on). These modeling exercises to high degree demonstrated the need to intensify the thinning in some forests, especially young coniferous, because of otherwise expected losses in productivity. In general decreases of increment were predicted due to aging of forests. Under the pessimistic scenario high losses could be expected in coniferous forest, which was mostly related to vitality decrease in Scots and Austrian pine plantations. For those species and for spruce in optimal growth conditions, the modeling showed potential for increases in harvesting. For the high beech forests, there is potential for considerable increase in harvesting, but at the price of loss of old forests, which could be highly undesirable for other ecosystem functions. For the high oak forests, the predictions were for generally stable levels of harvesting with potential for increases only due to thinning operations. The harvesting in the Hornbeam forests, which are currently used mostly for firewood, is expected to increase. In the poplar plantations, where the management is traditionally very intensive, potential increases in harvesting are possible through increases in the area of plantations. High potential harvesting is possible, according to the models in the coppice oak forests. This is dependent on the management strategies. The current form of management of oak coppice forests aims at transforming it into high forests, but there are demands for transition to shorter-rotation coppice management. The modeling using the EFISCEN model is a solid base for management planning but needs to be updated to be in line with the up-to-date European policies and strategies for forest management, climate change scenarios, and increased demands from European society that forests will serve multiple ecosystem services.

6. Modeling of the effects of management and aggressive invasive fungus on the species composition in a vulnerable ecosystem

This modeling was performed as a part of the project ‘State and Prospects of the Castanea Sativa Population in Belasitsa Mountain: Climate Change Adaptation; Maintenance of Biodiversity and Sustainable Ecosystem Management’ funded by the EEA and Norway Grants mechanism. Within the project, a serious health problem caused by the fungus *Cryphonectria parasitica* (Murrill) Barr. causing high mortality in the only autochthonous chestnut (*Castanea sativa*) forests in Bulgaria in the Belasitsa Mountains (‘Belasitsa’ NP) was investigated. The problem is severe because with 15 years of infection, about 60 to 80 percent of the adult chestnut trees have been infected. Within the study, the development of forests under four management scenarios was modeled along an altitude gradient. The modeling was performed with the model PICUS v1.5 with further calibration to include coppice regeneration of chestnut under local conditions. The scenarios were (a) a clear-cut logging with subsequent tending and thinning (A); (b) a clear-cut without any further management interventions (B); (c) group selection cutting with subsequent tending and thinning (C); and (d) no management (D) (for further details see Maroschek *et al.* 2011).

The performed modeling demonstrated that the no-management (D) scenario is not a good option because the share of *Castanea satriva*, which is the primary species at the case, will diminish. The coppice form of management, insured by the scenarios with clear cuts (B and D), shows that the share of chestnut can be maintained high in this way. Taking into account the simulation of the chestnut blight disease the 'no management' alternative was found to be the worst. Because of the high susceptibility of the sprouts to the disease and relatively higher resistance of the seedling the best-preferred option would be to have the management option with intensive and careful tending and thinning helps to maintain the species share in course of stand development (***Figure 27***).

Figure 27. Results of the simulation runs of intermediate altitude site in a modeling experiment for management of chestnut forests in Belasitsa Nature Park in Bulgaria without chestnut blight

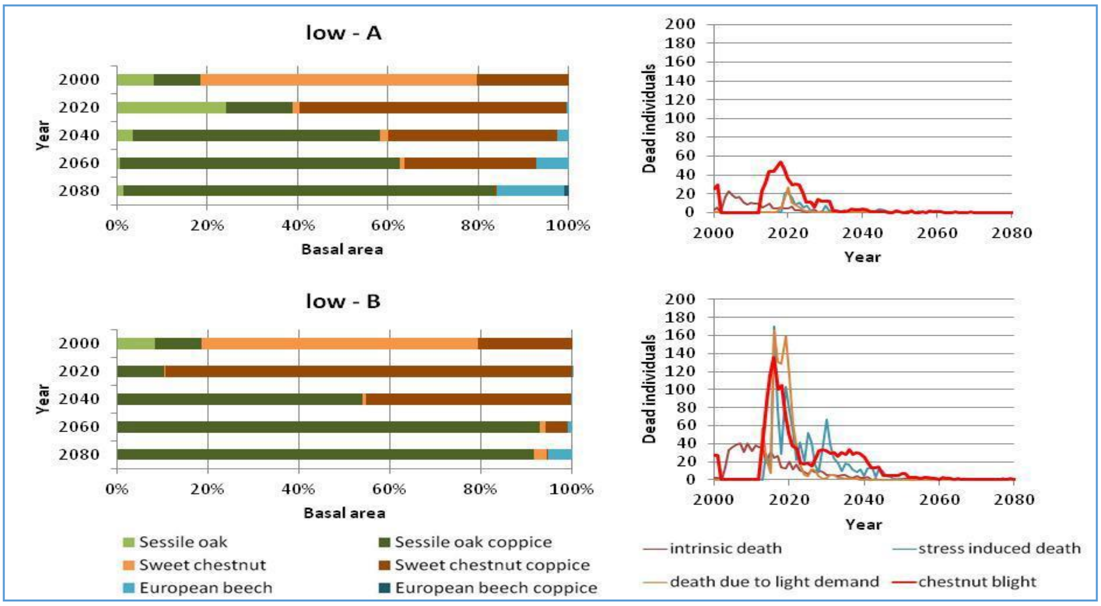


A = clear cut/tending, B = clear cut/no tending, C = group selection/tending, D = no management.

Source: Maroschek et al. 2001.

This approach is a good example of using modeling to support the decision-making process in a complicated situation with the need to support a species with high value, competitive disadvantage to the species directly competing with it and additional problems caused by an invasive species.

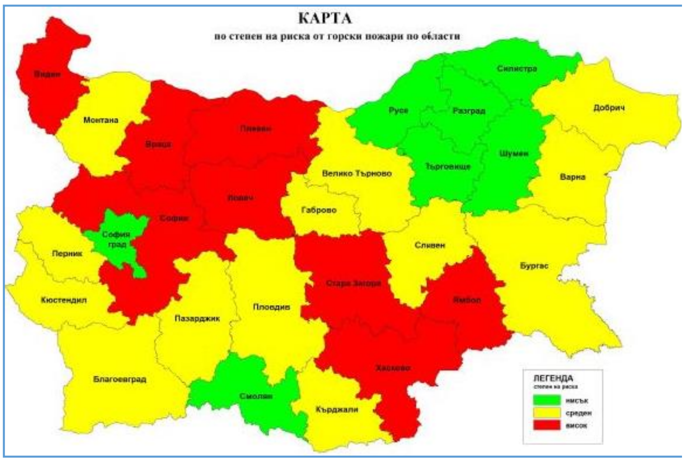
Figure 28. Comparison of mortality reasons of Castanea sativa in a modeling experiment for management of chestnut forests in Belasitsa Nature park in Bulgaria under management (A) (clear-cut with tending and thinning) and (B) (clear-cut without any other management interventions) including chestnut blight for the low elevation site



Source: Maroschek et al. 2011.

7. Evaluation and mapping of the risk of forest fires in Bulgaria

Figure 29. Map of the level of forest fire risk per administrative districts in Bulgaria



Note: The color codes are: Green – LOW; Yellow – MEDIUM; Red – HIGH. Following report for the MoAF project RD 50-130/03.10.2016

The project was realized on request of the Ministry of Agriculture and Food in 2016 (project RD 50-130/03.10.2016) based on the forest fires data for the period 2006–2015. The methodology for calculation of 'Index of Fire Risk' was based on the number of registered fire events and burnt area per region. Based on the Index, maps were created in GIS at the level of administrative districts (provinces) for the country. The fire risk classification was based on three levels of risk – low, medium, and high. The administrative districts with the highest risk are situated in northwestern Bulgaria (Vidin, Lovech, Vratsa, Pleven, Sofia) and the central parts of southern Bulgaria (Haskovo, Yambol, Stara Zagora). This map outlines as most risky in low altitude areas with high share of agriculture lands close to forest areas, which reflects the fact that about 80 percent of all fires in forests are caused by human activities, mostly fires lit to clear grasses in agriculture lands.

8. European-wide modeling of tree species distribution and natural disturbances danger levels in the MOTIVE and PESETA projects

Besides Bulgarian-level and local case-studies modeling projects, European-level modeling could also be used as a relative estimate for the development of Bulgarian forests. An example is the European-wide modeling of tree species distribution in the MOTIVE project, modeling of natural disturbances danger levels in the MOTIVE and PESETA projects.[28] These models provide a good opportunity to estimate the potential impacts of future climate change on forest ecosystems, especially in the cases when this has not been done for certain topics, issues or regions in Bulgaria. For example, deliverable 4.1B from the MOTIVE project provides modeling of the probability from losses from windthrows and bark beetles in Europe, including Bulgaria. Although the scale of mapping is rather coarse, these models clearly point out the risk for coniferous forests in Bulgaria and the need for further research and planning on these risks. For example, the coniferous forests in the Rhodopes, which are the major source of high-quality coniferous wood in Bulgaria are classified to have a critical wind speed of less than 20 ms^{-1} needed to inflict at least 500 m^3 of damage, which is the highest risk class in Europe. Such wind speeds are frequently occurring in storms. In the framework of PESETA II projects, the fire risk in European forests has been modeled (Modeling the Impacts of Climate Change on Forest Fire Danger in Europe, Sectorial Results of the PESETA II Project, 2017). Most of the territory of Bulgarian forests were estimated to have increasing fire dangers under all used climate change scenarios for the period 2070–2100. The southern parts of Bulgaria, where the extensive coniferous forests are situated are among the potentially most vulnerable zones. Such European-wide models also provide a context to describe the potential economic losses due to decline of economically valuable species in the absence of effective adaptation. For example, Hanewinkel et al. (2013) modeled the potential distributions of the main 32 tree species and economically most-important European forest types under the B2 and A1FI scenarios from the IPCC and estimated drastic changes in the main forest types of Bulgaria. Most of the lowlands will be suitable for open Mediterranean-type oak forests with low economic value. Much of the territory of southern Bulgaria will be suitable for pines which are not local (that is, *Pinus pinea*, *Pinus halepensis*, *Pinus pinaster*), which are also grown in Bulgaria but with controversial results due to damages from wet snow and periodic cold spells. Probably the most dramatic economic changes are expected due to the decrease of the suitable areas for Norway spruce forests, mixed Norway spruce-Scots pine, and Scots pine-dominated forests in the Rhodope Mountains which have high economic value and are the main source of high-quality coniferous wood in Bulgaria.

[28] https://ec.europa.eu/jrc/en/peseta