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Republic of Bulgaria

Advisory Services on a National Climate Change Adaptation Strategy and Action Plan

Appendix 2: Assessment of the Biodiversity and Ecosystems Sector

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Country Manager:	Antony Thompson
Practice Manager:	Ruxandra Maria Floroiu
(Co-)Task Team Leaders:	Philippe Ambrosi, Eolina Petrova Milova
Project Coordinator:	Robert Bakx

This report was produced by Svetla Bratanova-Doncheva and Kremena Gocheva (Local Consultants) under supervision of Ian Munro Gray (Senior Program Coordinator at the World Bank). The team worked under the overall guidance of Philippe Ambrosi (Senior Environmental Economist, Task Team Leader), Eolina Petrova Milova (Senior Operations Officer, Co-Task Team Leader), and Robert Bakx (Climate Change Adaptation Expert and Resident Project Coordinator), supported by Dimitar Nachev and Adelina Dotzinska (Team Assistants), Svetlana Aleksandrova (Economist), and Yeni Katsarska (Institutional Expert). The peer review of the report by Junu Shrestha and Stephen Ling was managed by Ruxandra Maria Floroiu (all from the World Bank).

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Abbreviations and Acronyms

a.s.l.	Above sea level
AR5	Assessment Report 5
BAS	Bulgarian Academy of Sciences
BasD	Basin Directorate
BBIS	Bulgarian Biodiversity Information System
BD&ES	Biodiversity and Ecosystems
BEF	Biodiversity Ecosystem Functioning
BES	Biodiversity Ecosystem Services
BFSA	Bulgarian Food Safety Agency
BISE	Biodiversity Information System for Europe
CAP	Common Agricultural Policy
CBA	Cost-Benefit Analysis
CBD	Convention on Biological Diversity
CCA	Climate Change Adaptation
CCMA	Climate Change Mitigation Act
CFP	Common Fisheries Policy
CHM	Clearinghouse Mechanism
CICES	Common International Classification of Ecosystem Services
CLC	CORINE Land Cover
CoM	Council of Ministers
CORINE	Coordination of information on the environment project
CP	Cohesion Policy
DG CAA	Directorate General “Civil Aviation Administration”
DPSIR	Drivers, Pressures, State, Impact, and Response
EbA-CCA	Ecosystems-Based Approach to Climate Change Adaptation
EC	European Commission
EEA FM	Financial Mechanism of the European Economic Area funding programme
EEA	European Environment Agency
EFA	Executive Forest Agency
EIA	Environmental Impact Assessment
EMEPA	Enterprise for Management of Environment Protection Activities
EP	Environmental Policy
EPA	Environment Protection Act
ESENIAS	East and South European Network for Invasive Alien Species

ESENIAS-TOOLS	"East and South European Network for Invasive Alien Species – a tool to support the management of alien species in Bulgaria" project
ESP	Ecosystem Services Partnership
ESS	Ecosystem Services
EU ETS	European Union Emissions Trading System
EU	European Union
EUNIS	European Nature Information System
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
FEMA	Freshwater Ecosystem Services Mapping and Assessment in Bulgaria
GBIF	Global Biodiversity Information Facility
GDP	Gross Domestic Product
GHG	Greenhouse Gas
H2020	Horizon 2020
IAS	Invasive Alien Species
IBBIS	Improving the Bulgarian Biodiversity Information System
IBER-GRASS	Project "Assessment and mapping of GRASSLAND ecosystems condition and their services in Bulgaria"
ILTER	International Long-Term Ecosystem Research
IPA	Institute of Public Administration
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
JRC	Joint Research Center
KP	Kyoto Protocol
LIFE	The EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU
MAES	Mapping and Assessment of Ecosystem Services
MAF	Ministry of Agriculture and Food (until May 2017)
MAFF	Ministry of Agriculture, Food and Forestry (after May 2017)
MBLS	Marine Black Sea
MC	Ministry of Culture
MCA	Multicriteria Analysis

MEc	Ministry of Economy
MEn	Ministry of Energy
MES	Ministry of Education and Science
MetEcoSMap	Methodological Support for Ecosystem Services Mapping and Biophysical Valuation
MEx	Ministry of Exterior
MF	Ministry of Finance
MFORES	'Improved mountainous forest management for sustainable provisioning of ecosystem services under climate change (MFORES)' project
MH	Ministry of Health
MI	Ministry of Interior
MLSP	Ministry of Labor and Social Policy
MoEW	Ministry of Environment and Water
MRDPW	Ministry of Regional Development and Public Works
MSFD	Marine Strategy Framework Directive
MTITC	Ministry of Transport, Information Technology and Communications
NAMRB	National Association of Municipalities in Republic of Bulgaria
NAPCC	National Action Plan on Climate Change
NAS	National Adaptation Strategy
NCEB	National Council of Experts on Biodiversity
NECCC	National Expert Council on Climate Change
NGO	Non-Governmental Organization
NIMH-BAS	National Institute for Meteorology and Hydrology at the Bulgarian Academy of Sciences
NPAF	National Prioritized Action Framework for NATURA 2000
NSI	National Statistical Institute
NTEF	National Trust Ecofund
OP	Operational Programme
PA	Protected Area
PAF	Prioritized Action Framework for NATURA 2000
PES	Payment for Ecosystem Services
R&D	Research and Development
RCP	Representative Concentration Pathway
RFID	Radio-Frequency Identification
RIEW	Regional Inspectorate for Environment and Water
SANS	State Agency for National Security

SMEs	Small and Medium Enterprises
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNSC	United Nations Statistics Commission
WEMA	Wetland Ecosystem Services Mapping and Assessment in Bulgaria
WFD	Water Framework Directive
WGII	Working Group II
WRI	Water Retention Index
WWF	World Wildlife Fund

Glossary[1]

Climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and 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.
Ecological Restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Restoration refers to a complex of long-term interventions typically organized as a project. In this report, we adopt the definitions provided by McDonald et al. (2016) for the elements of the restoration process: Depending on the state of damage to the ecosystem, its desired final state, the availability of nearby similar (reference) ecosystems in good condition and the extent of knowledge (or knowledge gaps) about its baseline condition prior to the degradation, damage or destruction, restoration may include varying degrees of intervention between assisting the spontaneous recovery or environmental repair to improve the regeneration of existing ecosystems in their recovery to the initial state, and the natural or assisted regeneration towards creation of a designer ecosystem that has not previously existed in the location, such as green infrastructure, cropland or urban ecosystems providing a desired level of ecosystem services.
Mitigation (of climate change) is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).
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, the capacity for self-organization, and the 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 probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.
Socio-ecological system is a set of ecosystem and human interactions in a given territory that lead to changes in the state of ecosystems (including abiotic and biotic environments) and, as a consequence, to biodiversity change. The socio-ecological system is typically managed locally through resource ownership and local management policies, such as land use, water and waste management, household,

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

industrial, and agricultural emissions of air, soil, and water pollution. However, it should always be seen in the context of wider effects and interactions between different socio-ecological systems, between urban and agricultural, where the latter provide ecosystem services to the urban population and pollute the environment in rural areas. Consideration of the socio-ecological system is closely related to landscape ecology, which also deals with the interaction between different types of ecosystems.
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.

Executive Summary

Climate Change - Impact on the Biodiversity, Ecosystems, and Ecosystem Services

1. Bulgaria is a country of rich biodiversity. Its diverse physical geography and location on the border of different climatic and vegetation regions creates favorable conditions for the existence of nearly 41,493 plant and animal species—26 percent of European species, including 25 percent of those in the Red Book of Europe. NATURA 2000 sites, which occupy 34.4 percent of the territory, and protected areas with a range of 584,569.19 hectares or 5.3 percent of the country's area, are dedicated for their conservation.

2. According to climate projections, droughts and extreme climate-related phenomena (storms, floods, landslides, winds, hailstorms, and so on) can be expected in the medium term, along with an increase of the vegetation period. Along with seasonal extreme temperature differences, large temperature differences on a daily basis can cause temperature shocks for species in the country. As a result, in the short term, adverse effects can be expected at all levels of ecosystems. Genetic diversity may be reduced due to the disappearance of endangered species—specialists and endemic species with a limited range and opportunities for migration. Climate change can also affect the life cycles and breeding cycles of species, within ecosystems, to affect populations and processes in the ecosystem (food chains and competition for resources), including by invasion of invasive species. These numerous manifestations of climate change are expected to have different impacts on different types of ecosystems and affect biodiversity and ecosystem services in a range of ways including in an abrupt and even catastrophic manner. On the other hand, the projected annual increase in average temperatures may help the adaptation by extending the vegetation periods and allowing for the migration of species in natural ecosystems or the controlled introduction of species for agriculture, green infrastructure, or other adaptation purposes.

Policy Framework

3. The use of ecosystem services and the creation of green infrastructure can contribute to reducing the cost of adaptation to climate change, creating new opportunities for business and society, and mitigating catastrophic and harmful effects. Ecosystems that are rich in biodiversity and in good condition are less vulnerable to climate change. At the same time, they provide more ecosystem services that are not regulated within the current strategic, legal, and institutional framework, thereby creating a bias toward overemphasis and overexploitation of provisioning ecosystem services. Such 'invisible' ecosystem services include regulatory services of great importance for climate change adaptation, such as flood protection, reduction of wind and water erosion, wind protection, microclimate regulation, water supply and retention, and so on. **This is of importance to Bulgaria—a country with rich biodiversity but with low gross domestic product (GDP) and limited resources for climate change adaptation**. Biodiversity policies can complement and reinforce the impact of adaptation policies in other sectors. The full and objective valuation of Bulgaria's natural capital also has the potential of opening new economic opportunities contributing to increasing GDP following other countries' examples where regulating and cultural ecosystem service stocks have been shown to be more valuable than provisioning services.

4. To achieve this goal, climate change adaptation needs to be established in a range of strategic and legal documents and secondary legislation. These can be classified as

- Strategic documents, that is, a new Biodiversity Strategy and Green Infrastructure Strategy;
- Amendments to legal acts on climate change and biodiversity and ecosystems (BD&ES) sectors, such as the Environmental Protection Act, the Biodiversity Act, Climate Change Mitigation Act, and their secondary legislation; and
- Legal documents in sectors that are likely to be negatively affected by the loss of biodiversity or can benefit from ecosystems services, such as water, agriculture, disaster risk management, forestry, and so on.

5. In terms of implementation, the introduction of ecosystems-based monitoring is recommended as a means to simplify the current monitoring of 'environment elements' by streamlining the data collection and interinstitutional exchange of information, allowing for better use of citizen science and environmental impact assessment data, and improving the reporting and use of data for other purposes. Based on monitoring data, collected in such a manner, the creation of more precise regional climate projections and BD&ES models could be facilitated as a means to improve and accelerate climate change adaptation efforts and fill the major knowledge gap identified both at European Union (EU) and at national levels. In addition, greater data availability can be especially beneficial for accelerating other policy decisions in the BD&ES sector, such as the development of management plans and strategic and environmental impact assessments.

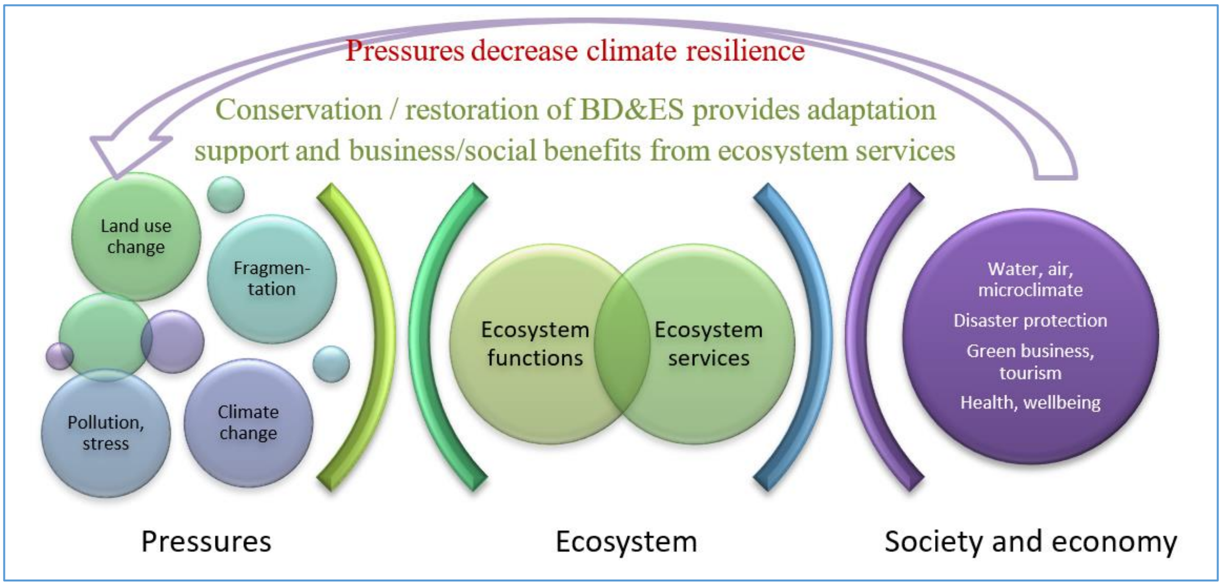
6. An improvement of the interinstitutional interactions and data exchange at central and local levels is needed, along with support to stakeholders and local communities in making informed decisions regarding biodiversity conservation, as an opportunity for business development and prosperity rather than a barrier to the local economy.

Adaptation Options

7. The adaptation options identified in this report are placed in the context of cost-effective socio-economic benefits derived from ecosystem services that can be used for climate change adaptation as well as for increasing the wealth, well-being and social cohesion of the most vulnerable population groups. The feedback received during stakeholder consultations and by written comments was instrumental for improving the scope and structure of adaptation options and we would like to thank for all constructive comments.

8. The diagram in ***Figure 1*** represents the structural and functional links between the conservation and restoration of biodiversity and ecosystem services, on the one hand, and the yield of ecosystem services that can be used for climate change adaptation. The feedback loop between anthropogenic pressures and benefits of the ecosystem services is key to adaptive management. Increases in pollution, fragmentation, extended changes in land use and climate change decrease the provision of ecosystem services and hence also human wellbeing and economic development. In contrast, reduction of pressures, combined with ecosystem conservation or restoration, can support adaptation and provide for economic growth and social benefits accessible to the local communities at lower cost.

Figure 1. Relations between environmental protection, climate change adaptation and socioeconomic benefits



Source: Authors' design.

9. Following this intervention logic, the report identifies five main directions for adaptation. Adaptation to climate change requires both a targeted state policy and specific local governance and business strategies that consider the ecosystem specificities and the resources available.

(a) **Enhance environmental governance.** This group consists of eleven options for central and local policy making and institution building. They cover:

- The development of a Biodiversity strategy and action plan pursuant to Article 115 (1) of the Biodiversity Act, as well as a Green Infrastructure strategy to implement the EU's Green Infrastructure policies in urban and rural areas
- Review of legislation and regional/local adaptation policies to implement the new Biodiversity and Green Infrastructure strategies and link them to climate change adaptation. It is of paramount importance that an ecosystem approach is introduced in addition to the conservation of individuals and species. Such an approach should highlight the benefits from BD&ES to other sectors, particularly from the commercial use of regulating and cultural ecosystem services.
- Ecosystem based monitoring and strategic/environmental impact assessment to allow for uniting data collected for different purposes and its re-use for ecosystem monitoring and climate change adaptation
- Create the institutional framework for carbon ecosystem accounting. According to the European Biodiversity Strategy, by 2020 the natural capital should be reported in national accounts. The carbon environmental accounts relate to climate change policies. Their development will also provide to companies in various economic areas (such as eco- and niche tourism, insurance, and "green business" devoted to ecosystem restoration and maintenance) incentive to include natural capital in the "business as usual" and reap the benefits from increasing it;

- Creating the educational infrastructure to provide ecosystems education at all levels as well as teach new environmental professions for a competitive workforce of businesses engaged in ecosystem restauration or the provision of ecosystem services;
- Support for awareness raising in all parts of society and providing to all stakeholders the tools for communication and joint decision making about ecosystem-based climate change adaptation.

(b) **Knowledge management and stakeholder communication for adaptation**. This group of nine adaptation options focuses on the free exchange of data collected by institutions, stakeholders and volunteers and its use for scientific and management purposes. The measures cover:

- Data interoperability between institutions and stakeholders and the open sharing of data within the limits of protecting privacy, social, environmental and business interests
- Development of scientific infrastructure and funding mechanisms for interdisciplinary research teams. In this manner, scientists will be able to use the available data for climate and ecosystem modelling and projections at the regional or local level.
- Inclusion of other types of knowledge from all parts of society – both the targeted collection of traditional knowledge about local and introduced commercial species, and expansion of citizen science and volunteer sharing to explore and monitor nature.

(c) **Creating a living space for biodiversity**, by reducing fragmentation, replacing grey with green infrastructure and implementing the 'Build Back Better' principle of the Sendai Framework for Disaster Risk Reduction. This group includes two linked adaptation options: the identification of critical natural capital ('red lines' not to be surpassed); and the regional/local programmers to conserve protected biodiversity and restore degraded ecosystems outside the protected areas for increased climate resilience and supply of ecosystem services.

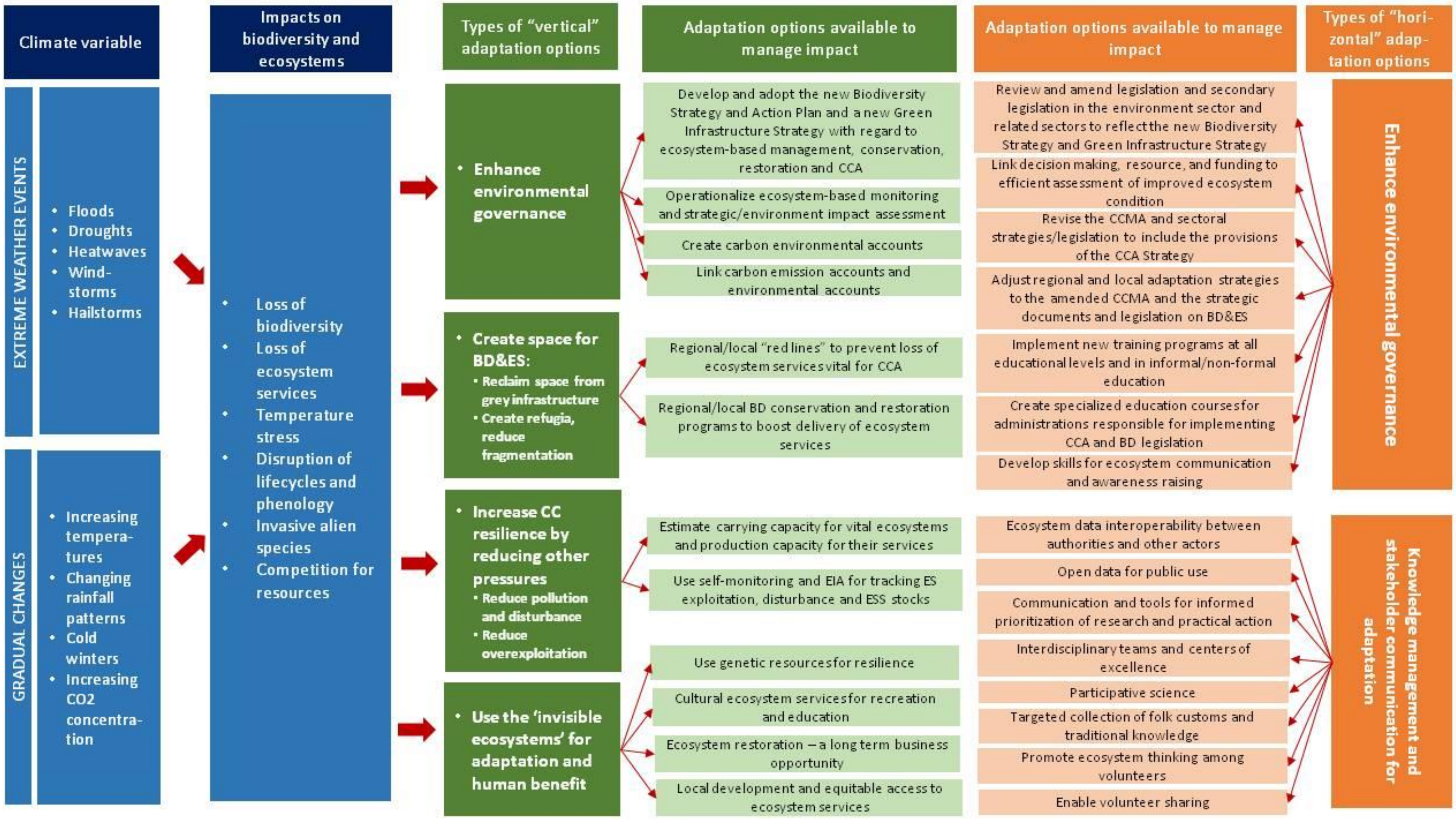
(d) **Reducing other pressures for healthier ecosystems.** Policies such as improving air quality; reducing nitrate pollution, waste, noise, and stress for biodiversity; and avoiding overexploitation of resources will enhance the adaptive capacity of BD&ES to climate change. To this end, we identify two adaptation options: Assessment of the carrying capacity of ecosystems (the limits of all pressures in each location that would not impair ecosystem functioning) and the ecosystems' capacity to produce ecosystem services; and Use of regional/local data (such as self-monitoring and EIA data collected by law) for local projections and effectively tracking pressures.

(e) **Using the 'invisible ecosystems' for adaptation and human benefit.** Healthy ecosystems provide more ecosystem services to society. Protecting biodiversity in synergy with the other options outlined above, allows the efficient use of undervalued ecosystem services—both regulatory and cultural. They have the potential to reduce the adaptation costs and support the development of the local economy, including in the priority tourism sector. This group consists of four adaptation options: (1) the use of genetic resources for adaptation; (2) increasing the role of cultural ecosystem services for recreation and tourism; (3) the long-term business opportunities arising from ecosystem restoration projects; and (4) the benefits to local communities from local 'production' of ecosystem services that provides both employment and welfare.

10. The selection, prioritization, and cost calculation of adaptation options in the sector is difficult because natural capital accounting is not yet institutionalized in Bulgaria. Nonetheless, the report presents examples for selection, prioritization, and cost-benefit analysis scenarios composed of different adaptation options. The principles of multicriteria analysis are presented along with the author's proposed ranking of most important adaptation options. A selection of sample costs for similar options/measures implemented across the EU is also presented for reference.

11. The adaptation options are presented in ***Figure 2*** in the context of climate change impact, vulnerability, and risk factors in the sector.

Figure 2. Simplified illustration of impacts of climate change and identified adaptation options



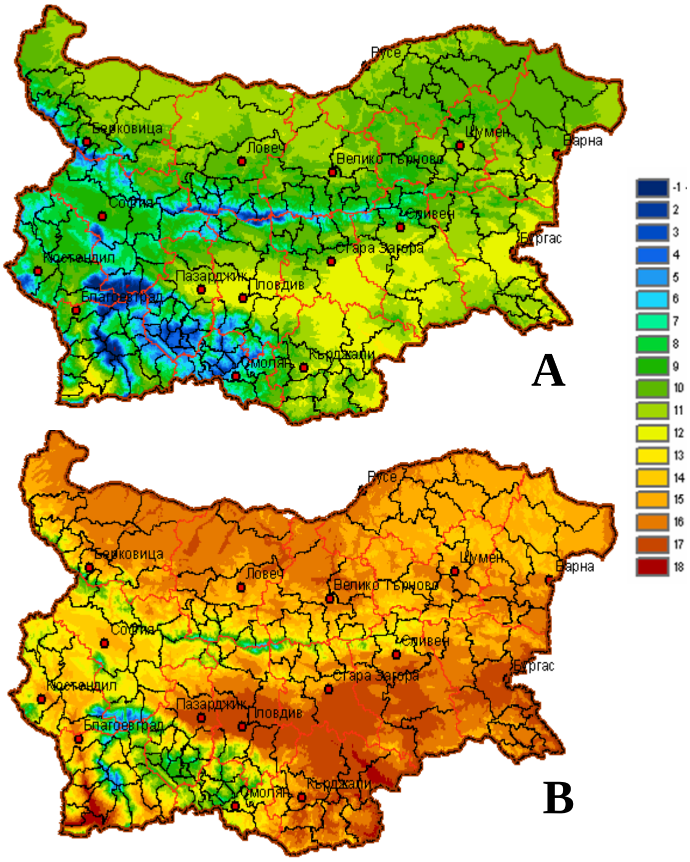
Source: World Bank design.

Introduction - Climate Change in Bulgaria

12. Bulgaria is situated in one of the regions that are 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 at the national and transboundary levels.

13. 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 3. Average year temperature for 1961–1990 (A); Pessimistic climate scenario for average year temperature for 2080 (B)



Source: NIMH-BAS.

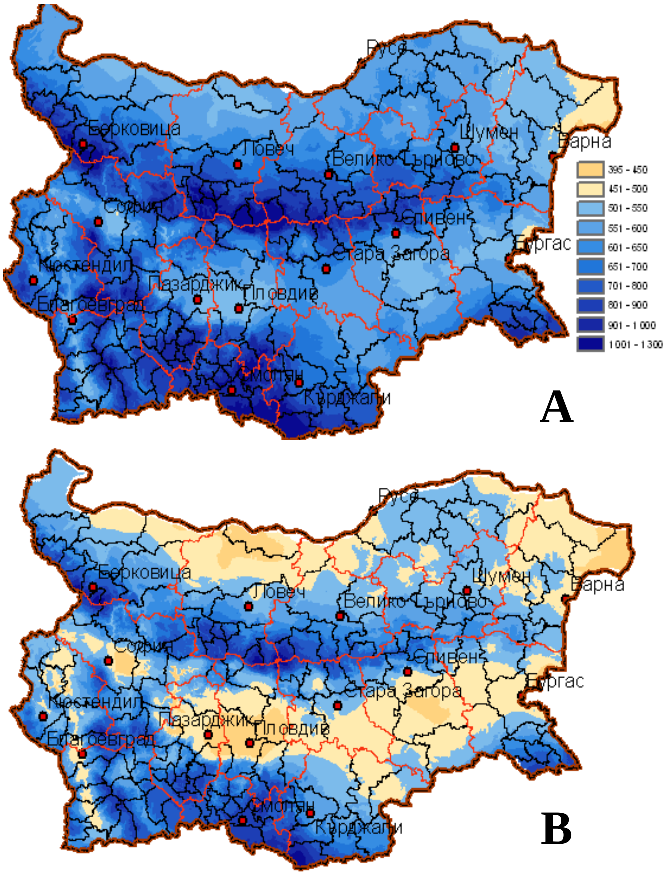
14. Scientific projections indicate that global temperature will rise between 1.8°C and 4°C by 2100, with the temperature increase in Europe expected to be even higher than the estimated global average.

15. 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).

16. 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 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.

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

Figure 4. Precipitation per year for 1961–1990 (A); Precipitation per year for 2080, according to the pessimistic scenario (B)



Source: NIMH-BAS.

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

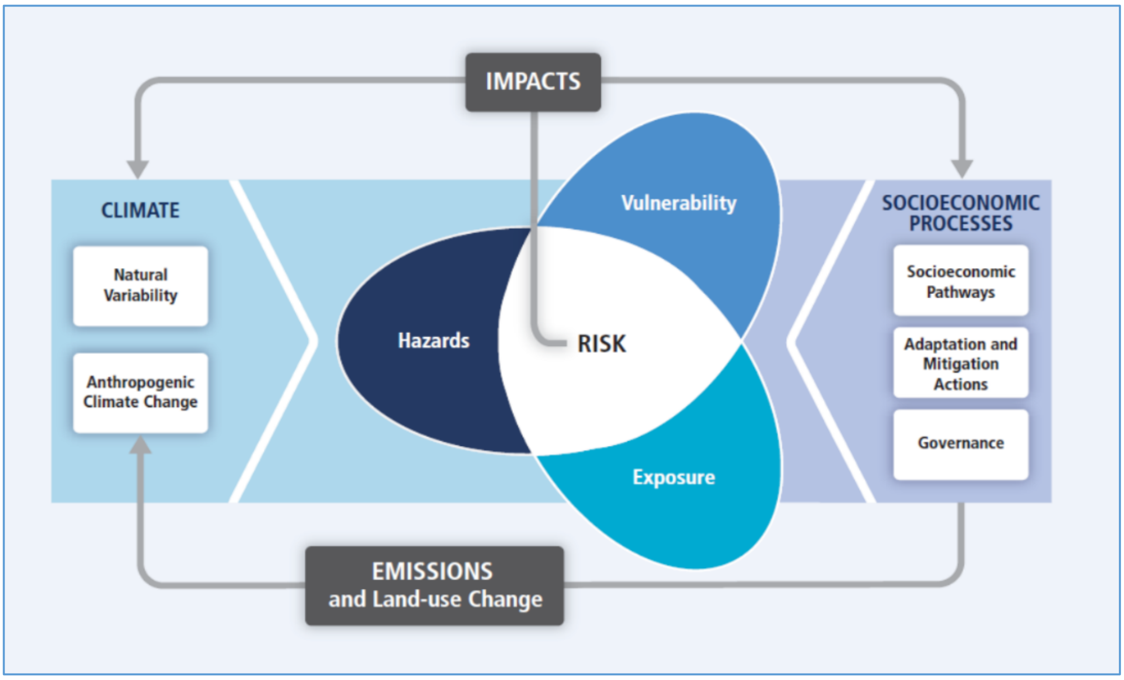
19. Climate change impacts do not affect all people and territories equally due to different levels of exposure, existing vulnerabilities, and adaptive capacities to cope. The risk is greater for the segments of the society and businesses that are less prepared and more vulnerable.

20. This report aims to inform on vulnerabilities to the Bulgarian biodiversity and ecosystems (BD&ES) sector and identify adequate climate change adaptation (CCA) options. It 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 and Action Plan. The report follows the general logic and structure as proposed for all sectors and is divided into three parts: (a) part one of the report (Chapter 1) focuses on the climate change risk and vulnerability assessment; (b) part two (Chapter 2) comprises a gap analysis of the policy, legal, and institutional context; and (c) part three (Chapter 3) focuses on the identification and prioritization of adaptation options. This sector assessment was carried out during March–November 2017, as a combination of quantitative

and, especially, qualitative analysis. Several workshops have been organized as part of an ongoing consultation process, bringing in the wealth of expertise of various stakeholders.

21. The report uses the terms and definitions of risk, vulnerability, and adaptation options as introduced by IPCC Working Group II contribution to Assessment Report 5 (WGII AR5 - IPCC 2014). Risk of climate-related impacts results from the interaction of climate-related hazards with the vulnerability and exposure. Changes in both the climate system (left side in ***Figure 5***) and socioeconomic processes including adaptation and mitigation (right side of ***Figure 5***) are drivers of hazards, exposure, and vulnerability. This understanding reveals the importance of the adaptation options. When they are properly identified and timely implemented, vulnerability, hazard, and/or exposure will be reduced, and thus the risk will be mitigated.

Figure 5. General concept of WGII AR5



Source: IPCC 2014.

Chapter 1. Risk and Vulnerability Assessment

Introduction

Purpose and extent of this report

22. Human existence, economy, and well-being in general depend on natural capital, which provides ecosystem services, including fertile soil, fresh water, pollination, natural flood protection, and climate regulation. However, the ecosystems, habitats, and species that provide this natural capital are being degraded or lost due to human activity (Newbold et al. 2015). It is therefore important to protect and enhance this natural capital, as recognized in the European Union's (EU's) Seventh Environment Action Programme (EAP), and Horizon 2020 (H2020), which sets out the priorities for environmental policy until 2020 and includes an outlook to 2050[2] (EC 2013).

23. Both on the global level and on the very tangible level of national and local communities, the loss of biodiversity can have severe impacts. Biodiversity is a very efficient and cost-effective way of regulating the microclimate and protecting from the effects of severe weather events—tasks that would otherwise require significantly more resources and energy, making such facilities untenable for poorer, socially vulnerable population groups. On the other hand, combining CCA measures in other vital sectors (such as water, agriculture, forestry, and health) with green infrastructure providing ecosystem services can not only cut costs but also create new business for green tourism enterprises, pharmacy, green industry companies, insurance, and other sectors.

24. This report presents the use of an ecosystems-based approach in CCA in Bulgaria. The ecosystems-based approach is one of the main pillars of the holistic, interlinked priority objectives agreed on by the EU member states in the General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' (also referred to as 'the 7th EAP') in response to global challenges that affect environment protection such as population dynamics, urbanization, disease and pandemics, accelerating technological change, and unsustainable economic growth. The 7th EAP creates a framework for environmental action with links to other related EU strategies and legislation.

25. This chapter introduces the expected climate change impacts on Bulgaria and discusses their influence on BD&ES sector and other sectors that use ecosystem services. Chapter 2 presents the EU legal framework and its links to the Bulgarian legislation, institutions, and practical implementation of CCA in the BD&ES sector and related sectors. Finally, Chapter 3 presents specific adaptation options and discusses their prioritization, links, and possible synergies with other sectors' adaptation options, expected costs, and benefits. All sections of the report also aim at presenting relevant international experience.

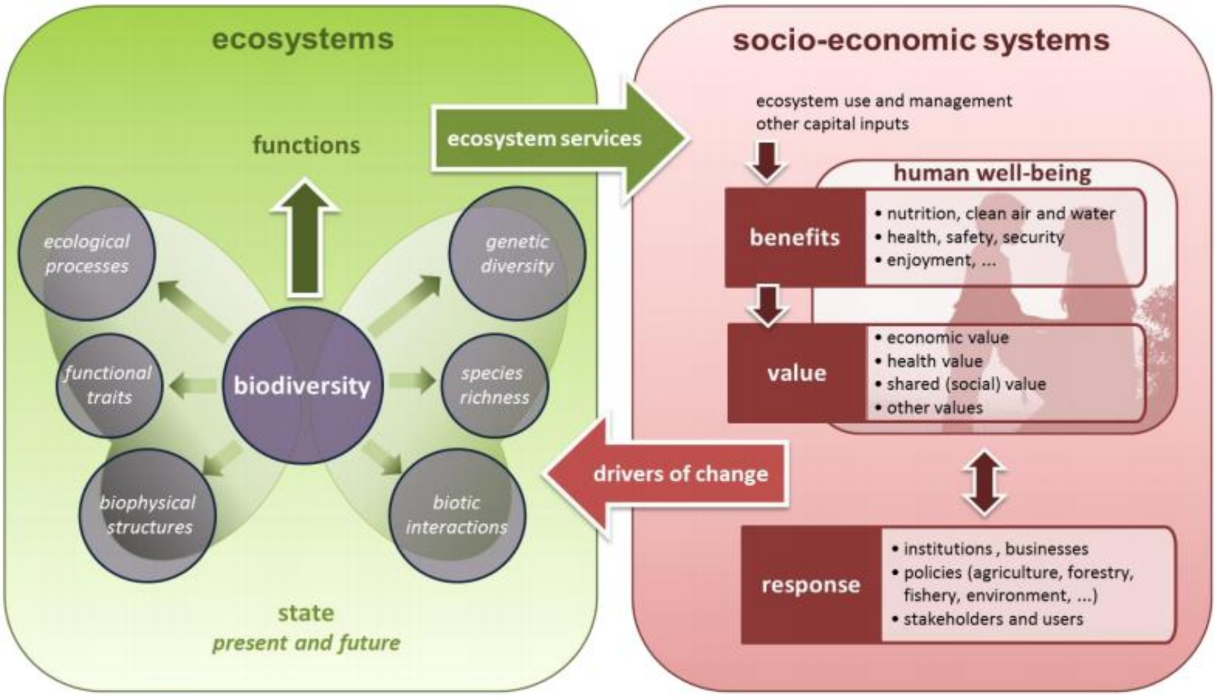
BD&ES and links to CCA

26. The relationship between the BD&ES' functions and the socioeconomic systems is presented in the Conceptual Framework developed by the EU and national experts within the

[2] General Union Environment Action Programme to 2020 'Living well, within the limits of our planet - No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013, http://eur-lex.europa.eu/legal-content/EN-BG/TXT/?uri=CELEX:32013D1386&from=EN

Mapping and Assessment of Ecosystems and their Services (MAES) process (2014) (see ***Figure 6***).

Figure 6. Biodiversity and ecosystem services as components of the socio-ecological system



Source: MAES 2014.

27. In the context of climate change policies, adaptation in BD&ES is defined as "the process of adjustment to actual or expected climate and its effects. 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."[3] The importance of biodiversity is widely acknowledged even in heavily modified ecosystems such as the urban environment. Therefore, CCA offers the opportunity to influence both the human systems and the natural systems. More specific implications are outlined in Chapter 3.

28. Adaptation to climate change in BD&ES refers to an array of approaches that range from natural adaptation at one end of the spectrum to sustainability in coupled human and natural systems at the other (Brooke 2008). Adaptation to climate change is linked to the concept of vulnerability, the degree to which a system is likely to experience harm due to exposure to perturbations or stresses.

29. However, as highlighted in the recent European Environment Agency (EEA) report (EEA 2017), climate change is one of the major drivers of BD&ES change with 14 percent of habitats and 13 percent of species in Europe assessed as already under pressure because of climate change, and the number of habitats threatened by climate change is projected to more than double soon. Climate change is likely to exacerbate the problem of invasive species in Europe. In this assessment report, it is important to note that the BD&ES sector is an overarching area that influences other sectors such as industry, tourism, water management,

[3] IPCC WGII AR5 Summary for Policymakers 2014.

agriculture, forestry, and so on.

30. The various manifestations of climate change are expected to have different impacts on the different ecosystem types and affect their biodiversity and ecosystem services in different, sometimes abruptly changing and catastrophic, ways.[4] On the other hand, the use of ecosystem services can be instrumental in reducing the costs of CCA, creating new opportunities, and supporting mitigation. Healthier ecosystems with richer biodiversity are less vulnerable to climate change and at the same time produce more ecosystem services, including carbon sequestration. This is especially important for Bulgaria—a country of rich biodiversity but low gross domestic product (GDP) and limited resources for CCA.

Box 1. Example of the relationship between ecosystem resilience and CCA, as illustrated by the concept of ecosystem services and disservices

Wetland ecosystems are among the most important nurseries for biodiversity. They provide invaluable resources for the survival of many species, such as migrating birds. For example, the Poda protected area near Burgas, naturally regenerated and currently managed by the Bulgarian Society for Bird Protection, is located along the Via Pontica bird migration route. The three lakes—freshwater, saline, and super saline—on a very small territory of only 100.7 ha are home to nearly 400 plant and over 480 animal species, including 273 bird species, and a favorite destination for birdwatching tourism.

Wetlands are also known to provide the ecosystem service Carbon sequestration and storage. This is due to the absorption of carbon for the active production of plant, animal, and microorganism biomass, followed by the collection of dead organisms' biomass and its anaerobic storage of carbon-rich organic matter at the bottom. This function, however, is only in place as long as the wetland exists, is in a good condition, and is regularly inundated. Should it be dried, for example, for use as arable land, the organic matter decomposes, and stored carbon is quickly released back to the atmosphere—a process known and approached as ecosystem disservice because of the additional investment needed for capturing the additional carbon.

In addition, constructed wetlands of different flow types and dimensions are used for nearly 60 years as an inexpensive way to treat wastewater from a number of industries and urban areas, that is, wastewater from refineries, pulp/paper, mines, landfills, chemical and textile industries, pigsties, dairies, explosives, airport and urban runoff, and so on (Vymazal 2011), providing a complex of purification ecosystem services that may be the only viable option for remote and sparsely populated areas (UN-HABITAT 2008). Wetlands can also be used as retention volumes in case of floods and provide recreation and many other ecosystem services.

There is a growing body of scientific and economic evidence on synergies between the preservation of wetland biodiversity, the benefits of wetlands for climate change mitigation, CCA, and their use as the source of many other benefits to humans. Nevertheless, wetlands outside NATURA 2000 are often viewed mainly as an obstacle to intensive agriculture and mosquito-breeding areas and many incentives exist to remove them. Finding the trade-off between the use of wetland ecosystem services and modification of wetlands to other ecosystem types is additionally complicated by the fact that global benefits (such as wildlife preservation and carbon sequestration) do not weigh heavily in the decision-making process of local communities when they must bear the negative local consequences, costs, and decrease of benefits (that is, disrupted cropland, mosquito repellents, health consequences). In case of poor local communities, short-term financial considerations such as lack of funds

[4] When Ecosystem Services Crash: Preparing for Big, Fast, Patchy Climate Change, Springer, 2011.

for managing a wetland can even outweigh the much higher future costs of ecosystem disservices, such as erosion and floods once it is removed. With ecosystem services not yet incorporated into business and national accounts, the decision makers have insufficient information to implement optimal, informed policy decisions.

1.1. Sector Characteristics and Trends

31. BD&ES is not a typical sector due to the combination of tradeable and non-tradeable benefits (ecosystem services) that humans derive from the ecosystems.[5] While some of the ecosystem services (mostly provisioning services such as food, timber, and linen production) are subject to economic activities, many other services are not traded or included in the company accounts and national statistics. This group includes, among others, some of the 'invisible' services that are core to CCA, such as erosion, flood, wind and avalanche protection, carbon sequestration, and water purification and provision. Therefore, no monetary trends can be described at this stage. However, understanding that overexploitation of non-valued ecosystem services can drastically reduce the protection provided, especially to the most vulnerable people whose migration is limited, is essential and a focus of this report. A comprehensive valuation of Bulgaria's natural capital could contribute to significant value added to the country's national accounts or possible future Green GDP.

32. The share of 'invisible' ecosystem services that are not being traded in traditional markets can be very significant and arguably exceed the value of provisioning services by orders of magnitude. While Bulgarian Natural Capital Accounts are not yet developed, the United Kingdom natural capital stock account assessment[6] shows that in 2012 the value of carbon sequestration alone (assessed at GBP 57.86 billion) constitutes 96.4 percent of the sum of stocks for provisioning service from agriculture, fishing and aquaculture, timber, and water provisioning services (totaling GBP 60.02 billion). In addition, pollution removal services for the same year (assessed at a stock of GBP 114.23 billion) were valued at 190 percent, and the recreation services (assessed at a stock of GBP 223.73 billion) at over 372 percent of the provisioning service stocks. Recreation service stocks were assessed to exceed even the U.K. oil and gas stocks (valued at GBP 148.33 billion). In countries with severe ecosystem degradation such as China, large scale restoration projects such as the Chinese restoration projects covering 63 percent of the country[7] provide an insight on the multiparametric optimization of ecosystems to provide ecosystem services necessary for the human society. Here, too, regulation ecosystem services have been found to be the most valuable services forming 65 to 95 percent of the benefits out of a 'Gross Ecosystem Product' of 2,162.32 billion Yuan (over US$337.69 billion) in four pilot areas.[8] These figures illustrate the great, still unrealized economic potential in the use of regulating and cultural ecosystem services.

33. At the time of development of this report, no official climate projections are published about expected changes in the living parameters of biodiversity: average, minimum,

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[5] For a concise short introduction, see https://www.ted.com/talks/pavan_sukhdev_what_s_the_price_of_nature

[6] https://www.ons.gov.uk/economy/environmentalaccounts/datasets/assetandserviceflowvaluesforallcomponentsofnaturalcapitalcurrentlymeasured2007to2014.

[7] Keynote "Ecological Restoration and Eco-civilization in China" https://www.aanmelder.nl/i/doc/bfe10fd4ef27f1e890f9bcd1418e7d06?forcedownload=True

[8] Keynote "Mainstreaming Ecosystem Services into Policy Making in China" https://www.aanmelder.nl/i/doc/5865336cc0d9c96589a8de8cd863c055?forcedownload=True

and maximum temperatures, precipitation, extreme weather events, floods, and fires for different regions of the country, at the biogeographical zone level or smaller scale. This is a significant knowledge gap that should be filled with priority because areas with similar biogeographic conditions are more likely to be affected in a similar manner and to require similar adaptation measures. Having in mind that the same climatic events may influence different ecosystems in different manner (for example, inundation may be beneficial for wetlands and detrimental for sparsely vegetated areas), detailed projections are important for informing the local and national policy makers on the type, extent, and location of necessary adaptation measures. The need for acquisition of additional knowledge is especially severe for the marine ecosystems whose study is both more costly than other ecosystem data collection and prone to some theoretical and methodological challenges, unique to water ecosystems. Current efforts at scientific and policy levels to share and systematize information for incremental modeling using existing and new data to forecast time series (such as changes of seasonal precipitation, sea water temperature, and acidification) at a regional level may be of use for bridging this gap. The scope and scale of such regional studies is usually necessitated by other needs, such as urban development and spatial planning, that are not primarily related to the ecosystems. They, therefore, are likely to go beyond the single ecosystem, and the concepts of the relatively new direction of landscape ecology (studying the interaction of ‘patches’ of different ecosystems on a territory) as well as the study of complex maritime ecosystem processes are likely to grow in importance.

1.1.1. Topography, biogeographic zoning, and main ecosystems in Bulgaria

34. One of the main factors determining Bulgaria’s rich biodiversity is its topographic diversity. Within only 111,000 square kilometers, the country has a highly variable terrain. Elevation ranges between sea level and the highest peak on the Balkan Peninsula—Musala (2,925 m). Mountains in Bulgaria vary between the higher, geologically younger Balkan chain, Rila and Pirin and the older, less steep Rhodope Mountains, Strandzha, and other smaller mountain ranges. The higher mountain ranges are home of unique biodiversity—glacial relics surviving from the last ice epoch, whereas the lower mountains host a diversity of wide leaf forest habitats. The temperate continental climate is typical for north and part of southwestern Bulgaria. The rest of Bulgaria, south of Stara Planina, has a climate which is transitional between temperate and subtropical. Several major rivers—Danube, Maritsa, Struma, and Iskar, with multiple tributaries and unique wetlands, as well as the Black Sea in the east, complete the picture of varied wildlife habitats. The lower regions of the Danube and Thracian plains with their respective climatic and biogeographical specifics are separated by the Balkan mountain ridge that provide a barrier for atmospheric flows and species migration and contribute to the evolution of many different species in each region or microregion and the provision of high-value ecosystem services on the country’s limited territory. For example, the unique Rose Valley climate supports the production of specific ecosystem services, essential oils from roses and lavender in a small but economically and culturally very important area between the Balkan mountain and Sredna Gora, and the related ecosystem services of aesthetic enjoyment through a festival and specialized tourism; through the use of the ecosystem service, Genetic materials from all biota, the yoghurt bacteria *Lactobacillus Bulgaricus*, endemic to the Balkans, has gained worldwide popularity as a healthy food.

35. In line with the topological diversity, the country has a variety of different biogeographic zones. The biogeographical zoning efforts starting in the 1930s led to several classifications over the years. The most widely acknowledged are the geobotanical zoning of Bondev (1988) with 3 areas consisting of 5 'provinces' and 28 districts, the zoogeographical zoning of Georgiev (1984) with 7 areas, and the biogeographical zoning of Gruev and Kuzmanov (1994) with 5 main regions and 19 sub-regions.

36. With the EU accession, Bulgaria has adapted also the biogeographical zoning to the EU classifications of Directive 92/43/EEC (Habitats Directive), and the currently notified biogeographical zoning consists of three regions containing a total of 61 habitats in the alpine, 75 habitats in the continental, and 55 habitats in the Black Sea region of the ecological network.[9]

37. Apart from the relatively finer-grained habitats division,[10] in recent years a more general classification by ecosystem type is adopted on the EU level and in Bulgaria. According to this classification, the country has nine main ecosystem types—cropland ecosystems; grassland ecosystems; heathland and shrubs; marine ecosystems; sparsely vegetated ecosystems; rivers and lakes; wetlands; woodland and forest ecosystems; urban ecosystems. However, to accommodate the rich biodiversity, it was deemed necessary to explore ecosystems at a deeper level of detail, leading to the inclusion of ecosystem subtypes in the National Methodological Framework for mapping and assessment of ecosystems and ecosystems services.[11] Each subtype is aligned both to the European Nature Information System (EUNIS) habitat classification and to other relevant sectoral classifications, for example, the urban ecosystem subtypes relate to the National Concept for Spatial Development, the freshwater and marine subtypes' indicators are correlated with the Water Framework Directive and the Marine Framework Strategy Directive, respectively, forest and agriculture subtypes are synchronized with relevant sectoral legislation, and so on. More on the ecosystem typology is presented in Section 1.1.3.

38. When studied in detail, ecosystems function in very different ways and changes in living environment (including the higher average temperatures, dry and cold spells, and extreme weather events that may be caused by climate change) may cause them to react in an opposite manner; for example, dry spells may negatively affect most ecosystem types but be beneficial for sparsely vegetated lands and some subtypes of the grassland ecosystems. To simplify the exposition, this report does not delve in such detail but rather focuses on climate changes' impact on significant levels of structure and functioning that are common to all ecosystems—genes, population, habitat, and ecosystem-level. Additional scientific efforts are necessary for any modeling on a finer level of detail (such as on a biogeographical zone level), while official climate projections are not published yet.

[9] The Bulgarian Red Book, online edition: http://e-ecodb.bas.bg/rdb/bg/vol3/07natura2000.html.
[10] Found in https://eunis.eea.europa.eu/.
[11] Available online at http://bg03.moew.government.bg/node/296.

1.1.2. Biodiversity and conservation activities in Bulgaria

39. Bulgaria hosts a significant proportion of the species that are threatened at the European level[12] and has the responsibility for protection of these species within its territory. Species require enhanced attention to maintain and improve their status. While many species already receive some conservation attention, others do not and remain vulnerable to climate change. As an EU Member State, Bulgaria has committed to halting biodiversity loss by 2020, but urgent action is needed to meet this target and improved monitoring capacity is required to confirm progress.[13] Considerable conservation investment is needed from Bulgaria to ensure that the status of European species improves in the long term.

40. Bulgaria is host to an estimated 41,493 species of animals and plants. This diversity is in part due to the range of elevation in Bulgaria (from sea level up to almost 3,000 m above sea level) and the country's transitional position between different climate types and vegetation regions. The Balkan Peninsula was one of the most important refugia for species in Europe during the large glaciations contributing to very high ecosystem diversity and number of species. Bulgaria also has an important role in the region as one of Europe's most forested countries.

41. The figure of 41,493 species represents 26 percent of the total species described for Europe and could represent more than 2 percent of the species in the world. A total of 25 percent of the species assessed by the European Red List of Species are present in Bulgaria.[14] For some of the taxonomic groups, the percentages of European species that occur in Bulgaria are particularly high, such as saproxylic beetles, dragonflies, and butterflies. The NATURA 2000 sites occupy 34.4 percent of the territory. Protected areas cover a total of 584,563.19 ha or 5.3 percent of the country. Among these areas are small in area but highly valuable biodiversity sites, such as the United Nations Educational, Scientific, and Cultural Organization (UNESCO) biosphere reserves and Ramsar wetland sites. Forest ecosystems in Bulgaria constitute more than 37 percent of the total area and contain 192 NATURA 2000 sites hosting 27 habitats. Species that are considered threatened at the European level and occur in Bulgaria are found mostly in wetlands, forests, and grasslands. These ecosystems require specific attention to ensure the habitats of these sensitive species remain. For more information on Bulgaria's biodiversity and its conservation, see ***Annex 3***.

1.1.3. Ecosystems in Bulgaria - the ecosystem services concept

42. Since climate change can have effects both on single species and their communities, as well as the ecosystems they inhabit, the concept of ecosystem integrity is key to understanding climate change impact on biodiversity. Ecosystem integrity is as important for the system's resilience as a person's good health is important for immunity to diseases. In the same manner health can affect work productivity, ecosystem integrity is closely related to the ecosystem services provision (Bratanova-Doncheva et al. 2017a), which, in turn, is key to assessing the links between biodiversity and human activities in CCA.

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[12] http://ec.europa.eu/environment/nature/pdf/state_of_nature_en.pdf.
[13] http://ec.europa.eu/environment/nature/pdf/state_of_nature_en.pdf.
[14] http://e-ecodb.bas.bg/rdb/bg/

43. Ecosystems are defined in the Convention on Biological Diversity (CBD) as ‘a dynamic complex of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit.’ Biodiversity, defined as the variability among living organisms,[15] is one of the two major traits of the ecosystems, closely interlinked with their second major trait—the abiotic heterogeneity. A study of the BD&ES is conducted on several levels of their structure and functioning—diversity at genetic, species, habitat, and population levels and the mass, energy, and information flows within and between ecosystems. These levels are important both socially and economically. Ecosystems’ structure and functions that are essential to humans are provided on these levels. For example, **genetic diversity** is at the core of important industries such as food,[16] pharmacy, and cosmetics and affects the climate change resilience of agricultural crops by crossing with wild relatives; **species diversity** is key for a high margin niche tourism; and long-term **ecosystem-level processes** provide natural products such as amber and corals (which are sources of handicraft materials for low-income population). Therefore, disruptions at any level of ecosystem functioning caused by climate change or other pressures may significantly affect human well-being.

44. The first assessment of Bulgarian ecosystems on a national scale was provided by cameral work during the preparation of the National Prioritized Action Framework for NATURA 2000 (NPAF). According to mapping and assessment of ecosystems (MAES) typology, there are three major types of ecosystems at level 1 in Bulgaria: terrestrial, freshwater, and marine ecosystems. At level 2, the major ecosystem types are further subdivided into a total of nine Class 2 types – urban, cropland, grassland, woodland and forest, heathland and shrub, sparsely vegetated land, wetland, rivers and lakes, and marine ecosystems. Details on their distribution are given in ***Annex 4***.

45. The National Methodological Framework produced in the scope of the Methodological Support for Ecosystem Services Mapping and Biophysical Valuation (MetEcoSMap) Project (2015–2017) provides a national typology of ecosystems that combines the CORINE Land Cover (CLC) classes[17] with the European Nature Information System (EUNIS) habitat classification types.[18] In addition, water ecosystem indicators (freshwater and marine) are also structured to be as close as possible to indicators for the Water Framework Directive and Marine Strategy Framework Directive. In this manner, compatibility is ensured between the EU-level classifications used in different types of legislation (Bratanova-Doncheva et al. 2017a).

46. As a subsystem of ecosystem structure and functions used by humans, the ecosystem services concept emphasizes the multiple benefits of ecosystems (MA 2005). Since it brings the (often intangible) benefits into the spotlight, the use of the ecosystem services concept can

[15] See Article 2 of the Convention on Biological Diversity, 1992.
[16] Export of specific food products has both the potential of worldwide brand recognition but also for generating significant income, as exemplified by Lactobacillus Bulgaricus and the success story of Bulgarian Yoghurt as export and licensing commodity, see https://www.vesti.bg/pari/stoki-i-ceni/2-mlrd.-po-sveta-iadat-kiselo-mliako-po-bylgarska-recepta-5973751 , http://www.novinite.bg/articles/118924/Yaponskata-Mejdji-Holdings-s-patent-za-imeto-Balgariya-za-kiseloto-mlyako, http://rodopi24.blogspot.bg/2017/09/blog-post_39.html , http://paper.standartnews.com/bg/article.php?d=2017-09-18&article=289100.
[17] https://www.eea.europa.eu/publications/COR0-landcover.
[18] http://eunis.eea.europa.eu/; *MetEcoSMap Project, 2017,* www.metecosmap-sofia.org.

facilitate collaboration between scientists, professionals, decision makers, and other stakeholders. People benefit from ecosystem (goods and) services. These benefits are, among others, nutrition, access to clean air and water, health, safety, and enjoyment, and they increase human well-being—which is the key target of managing the socioeconomic systems. Ecosystem services are grouped into three categories—provisioning, regulating, and cultural (CICES 2015) (***Annex 4***).

47. Ecosystem services provision potential in Bulgaria is being assessed in two stages. The first assessment stage, covering ecosystems outside NATURA 2000, was concluded in April 2017 and the results are being finalized (published at the website of the Executive Environment Agency (ExEA)[19]). The assessment of ecosystem services within NATURA 2000 is forthcoming (supported by the Operational Programme (OP) Environment 2014–2020). Additional details on the mapping and assessment are provided in ***Annex 4***. These biophysical assessments are intended to form the basis for national capital accounting, planned to be in place by 2020.

1.1.4. Major threats to BD&ES

48. Climate change can have both direct and indirect impacts at all levels of biodiversity—species, communities, their habitats, and ecosystems. Examples of direct impacts on species include potential phenological changes,[20] physiological changes of organisms' growth, and life cycle of plants, insects, and animals, because of changes in the length of growing season. Mismatch in these living cycles (such as pollinators awakening before the bloom of their honey source plants) can lead to changes in the trophic chains and species interactions, resulting in diminished production of ecosystem services (in the above example, less pollination leads to less crops and smaller quantity/lesser quality honey). Rising temperatures and carbon dioxide levels may lead to a change in the physiology of the plant species by increasing the intensity of photosynthesis (European Commission 2013). Indirect effects are expressed as a change of abiotic conditions, such as the level of surface and underground waters, amplification of erosion, floods, fires, and so on. These changes drive alteration of conditions in habitats that can lead to reduction or loss of biodiversity and changes in ecosystem functioning. Additional details on the mechanism of drivers, pressures, state, impact, and response (DPSIR) in the context of climate change are provided in ***Annex 5***.

49. The most significant threats, at the European level, to species that occur in Bulgaria include natural system modification; habitat loss, fragmentation and degradation by human activities; climate change; and invasive species. For freshwater species, major threats include the over-extraction of water, often further exacerbated by increasing water scarcity due to climate change, pollution, and the introduction of alien species.

50. In terms of sectoral pressures, major threats come from farming and ranching as a result of agricultural expansion and intensification, urbanization (including transport, water, and infrastructure), and tourism.[21] The ranking of pressures on biodiversity is provided in the

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[19] http://www5.moew.government.bg/ , http://bg03.moew.government.bg/bg/.

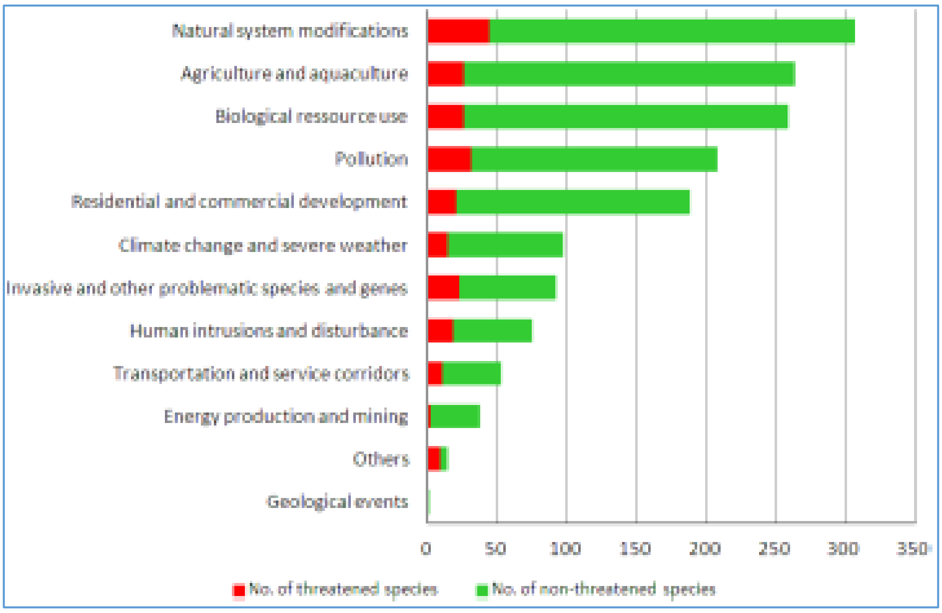
[20] Phenology is the study of changes in the timing of seasonal events such as budburst, flowering, dormancy, migration, and hibernation. Some phenological responses are triggered principally by temperature, while others are more responsive to day length (Menzel et al. 2006)

[21] The European Red List, International Union for Conservation of Nature © May 2013.

European Red List.

51. ***Figure 7*** shows that the major threats to biodiversity result from human activity not immediately related to climate change. For example, road infrastructure modifies habitats by fragmenting them, thereby limiting exchanges between populations and making species more isolated and vulnerable; agriculture and aquaculture result in excising land/sea space from natural habitats to create strongly modified habitats with very limited biodiversity; and intensive agriculture is a source of threats to other adjacent ecosystems; for example, pesticides and repellents weaken and kill the pollinator populations, and nitrate enrichment of water resources results in their eutrophication and degradation.

Figure 7. Major threats at the European level to species occurring in Bulgaria



Source: European Red List.

52. While not always directly related to climate change, some of these impacts coincide with climate change triggering (for example, release of methane greenhouse gas (GHG) from intensive livestock breeding) or reducing the ecosystems' resilience to climate change impact (that is, the smaller size of habitats reduces the migration ability of specialist (stenobiont) species that require a narrow range of temperature and moisture and, if disturbed, are in danger of extinction).

53. Conversely, preserving biodiversity can have positive correlation with climate change mitigation, for example, through carbon sequestration in forests or wetlands. It can have significant monetary impact by cutting costs for promoting human health and better environment. For example, a U.K. assessment[22] values the annual pollution capture by ecosystems at GBP 1,005 million, with 88.4 percent of the value attributable to the capture of $PM_{2.5}$ particles. With air pollution constituting a major problem in Bulgaria as well, the economic potential of ecosystems to fight the problem is still underutilized. Therefore, CCA is closely related to removing other pressures on the ecosystems and biodiversity.

[22]https://www.ons.gov.uk/economy/environmentalaccounts/articles/theukenvironmentfightingpollutionimprovingourhealthandsavingusmoney/2017-10-02.

54. It is to be noted that the simplifications made by any classification, including the one in ***Figure 7***, lead to pooling of several important aspects (such as climate change and severe weather) within one indicator and the implicit or indirect inclusion of many relations (such as the fact that climate change may exacerbate some of the other categories in ***Figure 7***; that is, the development of transportation and service corridors may lead to fragmentation, but they are also one of the pathways for spreading invasive alien species (IAS) that may migrate from the south as temperatures grow due to climate change). Therefore, the complete understanding of these phenomena requires a holistic approach and careful consideration to cross-sector impacts.

1.2. Past and Present Weather Events and Their Consequences and Response Actions in the BD&ES Sector in Bulgaria

1.2.1. Climate trends, extreme events, and their impact on BD&ES

55. The trends of climate elements in Bulgaria from the end of the 19th century show increasing temperatures in the last decades (compared to the basic climatic period between 1961 and 1990). This trend is most clear in the mountain areas. However, over the same period, long periods of low temperatures have periodically occurred in Bulgaria during the winter. The climate of Bulgaria is characterized by high temperature amplitudes not only seasonally but also daily (from 1˚C overnight to 25˚C during the day). These weather events may, in the long term, affect the species and ecosystem functioning and adaptation more than gradual temperature increases.

56. Droughts are projected to be the most common impact due to climate change in Southern Europe, including Bulgaria.[23] The adverse effects of droughts on BD&ES are very serious because of the potential for regime shifts; for example, during these periods Bulgarian forests experienced higher mortality rates. Indirect effects include pest and insect outbreaks due to the ecosystem deterioration and degradation. Changes in the water habitats of the lowlands can be disastrous—the water bodies are completely or largely dry, the river beds have been changed, and many riverside habitats destroyed. Many new artificial water bodies and irrigation systems have been built and some plant communities together with their accompanying fauna have colonized them. At the same time, floods caused by short-term, heavy precipitations are happening more frequently. This very high dynamic between drought and wet periods with heavy precipitations also has adverse effects on wider BD&ES.

57. In addition to temperature extremes, other weather-related events are projected to be increasingly frequent. These include floods, storms, and forest fires. The highest environmental risks for BD&ES services that may be related to climate change were posed by the increased incidence and severity of floods and dry periods, storms, and forest fires.

58. Key impacts of climatic trends in Bulgaria and the effects on BD&ES services include the following:

[23] IPCC 5 report, https://www.ipcc.ch/report/ar5/.

- There is a strong tendency towards increasing the **maximum summer air temperatures** and the number of tropical nights (with a minimum temperature above 20˚C), as well as increase in the length of the dry periods.[24]
- **Seasonal increase** in **air temperature** in the country by 2025, according to the model HadCM2, will have increased 1.0˚C (winter), 1.1˚C (spring), 1.4˚C (summer), and 1.2˚C (autumn) (Alexandrov 2011).
- **Large seasonal and diurnal temperature fluctuations** are observed,[25] and this does not act favorably for adaptation of different levels of biodiversity in the long term.
- The **largest decrease in rainfall** is expected in the summer (10 to 30 percent) and winter precipitation is expected to be up to 10 percent higher than in the reference period.
- The climate extreme indices, as introduced by Sillman et al. (2014), of the annual maximum number of consecutive days with **precipitation** < 1 mm and the annual maximum number of consecutive days with rainfall ≥ 1 mm tend to longer **dry periods** and shorter periods of consecutive days of rainfall over the year. In the RCP2.6 scenario, the first index values show an increase for Bulgaria during both future periods (2016–2035 and 2081–2100) with up to 2–4 days. According to the RCP8.5 scenario at the end of the 21st century, these values are expected to increase by more than 10 days compared to the baseline climatic period.
- From the mid-1990s, **annual rainfall** tends to rise in most regions of the country, with the trend of increasing the number of cases with typical spring-summer convective clouds with rainfall and thunderstorms (Alexandrov 2010).
- The results obtained for the analyzed expected changes in the temperature values during the **growing period** (average daily temperature > 5.0˚C) show an increase in the values of the indicator for all scenarios and for all future periods. During 2016–2030, the growing period is expected to increase from 10 to 20 days in Northeastern and Southern Bulgaria compared to the reference period and from 20 to 30 days in the rest of the country. Under the RCP8.5 scenario, this increase is expected to be over 50 days for most of the country.

Extreme weather events

59. Three Southeastern European states are among the six countries in the world most affected by extreme weather events last year with 'absolute losses' estimated at US$2.383 billion.

- In the early 21st century, Bulgaria was not considered as a country with frequent flood damage, but since 2005 the situation has changed. For two years, 2005 and 2006, there were several significant floods caused by increased local rainfall and precipitation across Europe. Bulgaria's east was hit by **heavy floods** early in the summer of 2014, claiming the lives of 12 people, and was followed by a hailstorm that **caused damage worth millions** in the capital Sofia. Flood regulation

[24] CLAVIER, 6FP, (www.clavier-eu.org).
[25] CLAVIER, 6FP, (www.clavier-eu.org).

is one of the most important ecosystem services and for Bulgarian forests and forest ecosystems is one of the main management goals. About 250,000 ha of the Bulgarian forests have special water protection functions and another 220,000 ha have protection from soil erosion as their main goal (EFA 2017). The number of events with overnight rainfall above 100 mm, which are the main reason for floods, increased by 30 percent in 1991–2007 compared to 1961–1990. This underlines erosion control and regulation of water runoff as one of the most important future regulating ecosystem services.

- **Storms** with strong winds cause catastrophic windthrows mostly in coniferous forests usually dominated by *Picea abies*. The data analysis by Panayotov et al. (2017) showed that there were at least 59 windthrows that caused mortality of all trees on areas more than 1 ha for the last century. In Bulgaria, there is an increasing trend of this disturbance after the 1960s, similar to European experience. Litterature sources (Seidl et al. 2014.) and expert analysis of this kind of events represent one of the main risks for coniferous forests in Europe and Bulgaria and a challenge for forest management in the future. Storms could provoke changes in the structure mainly of forest ecosystems, degradation of ecosystem functioning and, after windthrows, the potential for bark beetle outbreaks.
- **Forest fires** affect not only forest, but also shrub and grassland ecosystems, causing degradation of ecosystem structure and destruction of ecosystem integrity; however, they could also stimulate increased regeneration, accommodating new species and regime shifts. In 2016, there were 583 registered forest fires in Bulgaria (EFA 2017) affecting 6,338.9 hectares of forest land. The area of the affected coniferous forests is 935.9 hectares, the affected areas with deciduous forests are 4,193 hectares, the mixed forests are 221.3 hectares, and the 988.7 hectares are burned grasses and non-wooded forest territories. Occurrences of forest fires due to natural reasons (and possibly climate change) represent only 4 percent of the overall number of forest fires. Therefore, the vulnerability due to direct climate change impact remains low as compared to the indirect effects of climate change.

60. Considering the projections of extreme events and their frequency, it can be expected that Bulgaria faces the greatest threat from floods that have the largest share of the total number of casualties and economic losses. The slow onset effect of drought is another climatic extreme, which is observed in Bulgaria. Over the past 13 years, droughts have become more frequent and more intense in many member states of the EU, including Bulgaria.

1.2.2. Ecosystem services most relevant to CCA and BD&ES

61. As mentioned earlier, healthy BD&ES may play a powerful adaptation role. Considering the types of projected hazards, the regulating ecosystem services are likely to have a growing importance for CCA across all ecosystem types, along with some of the provisioning services related to the provision of surface and groundwater. The Common International Classification of Ecosystem Services (CICES)[26] distinguishes a total of 48

[26] http://www.cices.eu

ecosystem service classes. The provision of these services by classes is detailed in ***Annex 4***. ***Table 1*** presents the importance of different ecosystem services for each ecosystem type—from very important (+++) to not important ( ).

Table 1. Importance of ecosystem services for each ecosystem type

CICES division, group	CICES class	Examples of key services	Urban	Cropland	Grassland	Marine	Freshwater	Woodland and forest	Sparsely vegetated land	Wetland	Heathland and Shrub
Provisioning - Water	Surface water for drinking	Collected precipitation, abstracted surface water from rivers, lakes, and other open water bodies for drinking	+++	++	+	+	+	++		+	+
	Groundwater for drinking	Freshwater abstracted from (non-fossil) groundwater layers or through groundwater desalination for drinking	+++	++	+	+	+	+++		+	+
Regulating - Mediation of waste, toxics, and other nuisances	Mediation of smell/noise/visual impacts	Visual screening of transport corridors, for example, by trees; green infrastructure to reduce noise and odor	+++	++	+	+	+	+++	+	+	+
Regulating - Mediation of flows	Mass stabilization and control of erosion rates	Erosion/landslide/gravity flow protection; vegetation cover protecting/stabilizing terrestrial, coastal, and marine ecosystems, coastal wetlands, and dunes; vegetation on slopes also preventing avalanches (snow, rock), erosion protection of coasts and sediments by mangroves, sea grass, macro algae, and so on	+++	++	++	++	+	+++	++	++	++
	Buffering and attenuation of mass flows	Transport and storage of sediment by rivers, lakes, and sea	+	+	+	+++	+++	+	+	++	+
	Hydrological cycle and water flow maintenance	Capacity of maintaining baseline flows for water supply and discharge; for example, fostering groundwater; recharge by appropriate land coverage that captures effective rainfall; includes drought and water scarcity aspects.	+	++	++	+	++	+++	+	++	+
	Flood protection	Flood protection by appropriate land coverage; coastal flood prevention by mangroves, sea grass,	+++	++	++	+	+	+++	+++	+++	++

CICES division, group	CICES class	Examples of key services	Urban	Cropland	Grassland	Marine	Freshwater	Woodland and forest	Sparsely vegetated land	Wetland	Heathland and Shrub
		microalgae, and so on (supplementary to coastal protection by wetlands and dunes)									
	Storm protection	Natural or planted vegetation that serves as shelter belts	++	++	+	+	+	+++	+	+	+
	Ventilation and transpiration	Natural or planted vegetation that enables air ventilation	++	+	+	+	+	+++	+	+	++
Regulating - Maintenance of physical, chemical, and biological conditions	Pest control	Pest and disease control including IAS	+++	++	+	++	+	+++	+	++	+
	Disease control	In cultivated and natural ecosystems and human populations	+++	++	+	++	+	+++		++	+
	Global climate regulation by reduction of GHG concentrations	Global climate regulation by GHG/carbon sequestration by terrestrial ecosystems, water columns and sediments and their biota; transport of carbon into oceans (DOCs) and so on	+++	++	++	+++	++	+++		+++	++
	Micro and regional climate regulation	Modifying temperature, humidity, wind fields; maintenance of rural and urban climate and air quality; and regional precipitation/temperature patterns	+++	++	++	+++	++	+++	+	++	+

Note: For better adaptation, each ecosystem type must be managed to better provide the important ecosystem services on a case-by-case basis.

1.2.3. Major threats to other sectors from BD&ES loss

62. The loss of biodiversity should not be considered as something negligible and not related to the economy. On the contrary, both society and business rely heavily on ecosystems and their services for our everyday lives.

63. Systemic interdisciplinary research (Wu et al. 2016, Makarieva et al. 2018, and others) suggests that biodiversity is one of the major mitigating factors to climate change on a macro- to planetary scale as it influences the abiotic environment at these scales as well. Therefore, the relation between biodiversity and climate change is two-way. Both climate projections and vulnerability and risk assessments in other sectors need to take into account the loss of biodiversity as a factor that could exacerbate the consequences of climate change and impact the adaptation planning and costs.

64. Once an ecosystem deteriorates or is destroyed, the reduction or loss of ecosystem services that it used to provide must be compensated with technologies, which may not

always be possible. Where feasible, such replacement of ecosystem services causes additional costs and may deepen social inequalities since not all technologies are accessible and affordable for everyone in society.

65. Some of the threats in other sectors due to the loss of biodiversity include the following:

- **Agriculture** is affected by loss of crop yield, due to declines in pollination, reduced pest and disease control and soil formation, lesser genetic diversity of sorts and breeds, and loss of regulating ecosystem services (local microclimate regulation, water production and water quality regulation, erosion and wind protection, and so on). The decline or loss of these services is likely to result in additional costs for irrigation infrastructure, fertilization of depleting soils, as well as possibly more expensive self-pollinating crop and/or cultivated tree sorts. With reduced genetic diversity, these introduced sorts may be less well adapted to local conditions and more susceptible to pests and diseases and cause additional costs for herbicide and insecticide threats. In animal breeding, additional costs may be incurred for water supply and wastewater treatment across longer distances and due to threats to animal health.

- **Disaster risk management and Transport** are mostly affected by the loss of regulating ecosystem services, which leads do reduced disaster resilience. Depending on location, the services whose loss may cause additional costs include protection from wind, avalanches, landslides, floods, and other extreme events and may be very high relatively to metrics such as population numbers or density.[27] While the lack of detailed modeling makes it difficult to estimate the exact proportion of ecosystem services loss in the total costs of disaster prevention and risk management, the magnitude of such costs allows the conclusion that cost savings can be significant in absolute monetary terms. An in-depth analysis may use as a comparison basis costs of relevant prevention and protection measures by aggregated by funding source (for example, flood risk and landslide prevention measures for 2014–2020 are to be funded by OP Environment) and/or use single projects for reference to calculate unit prices of infrastructure.

- The **Water** and **Energy** sectors are likely to be mainly affected by the decline or loss in provisioning services related to water production and purification. Water production ecosystem services are mainly affected by the decline in forest ecosystems, whereas water purification services are provided mainly by wetlands, freshwater ecosystems, and forests (tree belts along riverbeds). In parallel to the decline or loss of regulating services, the demand for water is likely to grow for urban areas and agriculture, and the energy supply from hydropower may need to be partially replaced from other sources. In addition, if food production of cropland ecosystems is affected negatively,

[27] As an example, the dyke and channel reconstruction near Krushovene (a village of just over 1,000 inhabitants close to the Danube River with an important transport crossing) and river and coastal protection of several small settlements in the Aytos area near Burgas were funded with 292,000 each by OP Regional Development. http://umispublic.government.bg/srchProjectInfo.aspx?menu=search&id=48826 , http://umispublic.government.bg/srchProjectInfo.aspx?menu=search&id=48836.

the land allocated to biomass production may be reduced and this will also influence renewable energy production.

- Since forests are an important ecosystem type, the **Forestry** sector faces adaptation challenges that are essentially the same as the ones for Biodiversity in general. Apart from the losses of forests themselves (detailed in the Forestry report), loss of biodiversity in other related ecosystems may also negatively affect the forests. The closest correlation exists with freshwater ecosystems (with respect to decline of filtration, water production, and purification), sparsely vegetated areas with unique biodiversity around meadows and cliffs, and wetlands where some trees types are not subject to forestry regulations but provide important regulating services.
- **Tourism** may be negatively influenced by the loss of cultural ecosystem services. Such loss is likely to affect all alternative types of tourism, including the higher-margin segments rural tourism, for example, in the business of preparing food from local sorts, care for local breeds, and so on, botanical, birdwatching and hunting tourism.
- The **Urban Environment** and **Human Health** sectors are likely to be affected by the loss of a wide range of regulating ecosystem services and the recreational cultural services. Particularly the decline in microclimate regulation to mitigate heat waves and alleviate smog and the reduced recreation options are likely to negatively affect both the general well-being and the health of urban population. In addition, the regulating services related to protection from flash floods and generally disaster protection are likely to be relevant for the urban sector, whereas the health impacts will also be extended in a similar manner to rural population.

66. These relations are systematized in Chapter 3, which also contains a discussion on adaptation options, their costs, and principles of applying a cost-benefit analysis (CBA) on a case-by-case basis in local strategies and/or single projects.

1.3. Climate Change Risks and Vulnerabilities Related to BD&ES

1.3.1. Vulnerabilities of BD&ES

67. It is widely accepted that at global levels, climate change is a driver of significant changes on BD&ES. The main conclusions made at the European level could be summarized as follows:[28]

- Climate change significantly affects ecosystems, their constituent biodiversity, and consequently their capacity to provide services for human well-being. Climate change may have already provoked ecosystem regime shifts, for example, in higher mountain areas where the upward shift of the tree line can be attributed to the combination of climate change and succession after the abandoning of highland pasture.
- There is a still limited but improving[28] knowledge base about the combined effects of climate change in association with other pressures on ecosystems, and the ways in which these combined effects affect the ecosystems' capacity to provide services.

[28] Climate change, impacts, and vulnerability in Europe 2016, an indicator-based report.

However, climate change is increasingly exacerbating the impact of other human stressors, especially in natural and semi-natural ecosystems.

- The relative importance of climate change compared with other pressures depends on the ecosystem type (terrestrial, freshwater, marine) and geographical region. Europe's marine and alpine ecosystems are assessed as being most sensitive to climate change.
- Climate change can facilitate the spread of IAS, which provoke changes of local flora and fauna and biodiversity loss.

68. The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as a function of the sensitivity of the different systems to climate change, its exposure to those changes, and its potential to adapt to them. **Sensitivity** is the degree to which a system is affected, either adversely or beneficially, by climate variability or change (IPCC 2007a, 2014). **Exposure** describes the nature, magnitude, and rate of climatic and associated environmental (incl. anthropogenic) changes experienced by a species (Dawson et al. 2011, Foden et al. 2013, Stein et al. 2014, not defined in IPCC 2007). **Adaptive capacity** is the potential, capability, or ability of a species, ecosystem, or social system to adjust to climate change, to moderate potential damage, to take advantage of opportunities, or to respond to the consequences (IPCC 2007, 2014).

69. Climate change vulnerability may be described at a range of **different biological hierarchy levels or entities** (from gene, species, subpopulations to ecosystems) and at different **spatial scales** (from sites to globally), considering different **biodiversity impact types** (from extinction risk to declines in ecosystem function or evolutionary diversity), considering different **aspects of climate change** (impacts from direct climate change to indirect impacts from humans and biodiversity responding to climate change), and covering considerably different **time frames** (IPCC 2007, 2014).

70. The recently developed ‘biodiversity ecosystem functioning’ (BEF) and ‘biodiversity ecosystem services’ (BES) theories[29] consider biodiversity as a causal factor affecting ecosystem functioning, environmental characteristics, and ecosystem services, extending the classical ecological theory that biodiversity is affected by different drivers but is not considered a driver itself. BEF identifies two main classes of mechanisms by which biodiversity can positively affect productivity and other ecosystem processes: the functional complementarity effect and the selection effect of diversity. According to the BEF theory, diversity makes ecosystem functioning more sustainable and ecosystems more resilient. Levels of ecosystem functioning and stability over time depend on biological diversity at different hierarchical levels: intrapopulation diversity (genetic and phenotypic), intraspecific (populations and ecological/morphological forms composing species), species diversity within communities, and diversity of communities and ecosystems. All these levels of biodiversity are important for maintaining ecosystem functioning and providing ecosystem services.

71. The main vulnerabilities concerning climate change are addressed at the different levels of biodiversity in Bulgaria, as described in the following paragraphs.

[29] doi:10.1038/nature11148

Genetic diversity

72. Genetic diversity is fundamental to biological diversity and helps populations to respond to changes in environmental conditions in short and long-term scales. As the trend of projected climate change increases, putting pressure on populations, the natural selection will favor genes that increase species survival in new environments and may lead to the decline of genes that were dominant under previous conditions (Staudinger, Grimm et al. 2012 [Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment. Cooperative Report p. 296[30]]). Evolutionary responses to climate change are less likely when genetic diversity is absent or beneficial alleles occur at a low frequency within a population.[31] In those cases, evolution will depend on new genes arising from mutation or gene shuffling. Under strong selection pressure (for example, rapid climate change) such populations risk going extinct before beneficial genes have a chance to increase population fitness. Genetic diversity forms the foundation of ecosystems' resilience to change (including climate change). Resilient ecosystems can better tolerate disturbances caused by warmer and drier environments. For most of the ecosystem types, increasing resilience and reducing other pressures will likely be the adaptation measures of choice. Genetic diversity is subject to threats posed directly by climate change on vulnerable species that may be lost forever, or indirect climate change induced effects due to competition for resources between biodiversity and human activities that cause an increase of other pressures in the CCA context (such as water extraction, overexploitation of rare species by vulnerable population groups, land use change, and fragmentation by infrastructure).

73. Genetic diversity in the context of CCA includes the protection of particularly vulnerable genetic resources, for example, from mountain habitats hosting rare and endangered species with low migration capability may Specific protection measures include ex situ preservation of species in gene banks. Genetic resources are subject to increased applied research in the areas of pharmacy, synthetic biology, and so on. Another CCA aspect of genetic resource use is the utilization of specific provisioning ecosystem service 'genetic materials from all biota' to improve climate change resilience in agriculture (restoring the genetic lines of local varieties and research into their wild relatives to improve climate resilience). Genetic diversity is being supported by the work of the National Gene Bank[32] in Sadovo that hosts over 60,000 gene samples from 600 plant species.

Species

74. Species of plants, wildlife, and fish are the target of conservation policy. Their sensitivity relates to their physiological characteristics and reproductive rates. Their exposure depends on geographic location and climatic characteristics. Temperature-sensitive species or moisture-sensitive species could be affected by temperature increasing and moisture decreasing, especially in the south of the country. The phenological changes in are a reliable indicator for this kind of response on species level. For example, if the living cycles of plants and their pollinators become asynchronous due to climate induced changes in phenology cycles, this could lead to damage for both the plants and the pollinating insects and result in a

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[30] Available at: http://assessment.globalchange.gov
[31] The same
[32] http://ipgrbg.com/.

decline in the provision of pollination ecosystem service. In Bulgaria, phenological observations of the National Institute of Hydrology and Meteorology (NIMH) show that the phenology cycles have shifted by 10 to 15 days (Alexandrov 2010b).

75. According to the assessment of the conservation status in Bulgaria[33] with respect to the species of Annex II of Directive 92/43/EEA as transposed in Annex 2 to the Biodiversity Act, the conservation status of 47.9 percent of all species in the continental region is 'favorable', 40.2 percent is 'unfavorable-inadequate', 4 percent is 'unfavorable-bad', 4 percent are rated 'unknown', and 5.1 percent are not reported. In the Alpine region, 57.3 percent of the species have 'favorable' conservation status, 32 percent have 'unfavorable-inadequate' status, 2.7 percent have 'unfavorable-bad' status, and for 8 percent of all species the conservation status is not reported. In the Black Sea region, 58 percent of the species have 'favorable' conservation status, 23.2 percent have 'unfavorable-inadequate' status, 7.3 percent have 'unfavorable-bad' status, 4.3 percent are rated 'unknown', and for 8.7 percent of all species the conservation status is not reported. In the Marine Black Sea region (MBLS), four species from Annex II are rated 'unknown'.[34] Most of these species are specialists (stenobionts)—they could exist in a narrow interval of restricted ecological conditions—unlike the generalists (euribionts)—that survive in a range of conditions. Some species are more sensitive to the new climate conditions that lead to locally extinction or deterioration or move in altitudinal and latitudinal direction. Bulgaria has a high number of endemic species and rich biodiversity. It will be a significant challenge to manage this process in the future to maintain rare habitats and species and at the same time to maintain the other ecosystem services.

76. The impact of climate change on biodiversity can be demonstrated by changes in the wintering water birds in Bulgaria. This number has varied considerably in the past five years, with numbers in 2012 being 46.87 percent less than in 2011. This variation depends mainly on the meteorological conditions in Bulgaria and northwards. Recently, the shifting of peaks in the number of some water birds (mainly geese, ducks, and so on) has occurred.[35]

- Most vulnerable species

77. Most vulnerable species are rare (endemics), specialists, and endangered species with already limited distribution, especially when migration options are not possible. The Red Lists and Annexes to the Biodiversity Protection Act are available.

- Impact of invasive species - beyond vulnerability

78. Invasive species are one of the main threats to BD&ES and one of the main pressures in Europe. They compete with the native species and replace them from traditional niches, therefore changing the ecosystem integrity. They could provoke biodiversity loss, especially for rare and endangered species. For example, there are many European and global examples demonstrating mass mortality in forests caused by invasive species, mostly fungi and insects. Many of these invasive species prefer warmer climate zones and with predicted increased average temperatures pressure will increase in the future. For rare habitats, this is a

[33] NPAF.
[34] https://circabc.europa.eu/sd/a/c3d5d7f4.../BG_20140528.pdf.
[35] CBD Fifth National Report 2009–2013.

real risk, for example, *Castanea sativa Mill.* infestation by the invasive fungus *Cryphonectria parasitica* can endanger the chestnut species. Other types of diseases, such as the crab pest, are transmitted by immune invasive species to nonimmune local species. Yet, another mechanism of invasion is the physical and/or chemical transformation of ecosystems by invasive species (ecosystem engineers), as is the case with sparsely vegetated areas being affected by strong growing invasive grass species. Some of the species are likely to spread wider in a warming climate—examples include invasive Opuntia cacti and invasive parrot species.

79. In Bulgaria,[36] about 60 species of flowering plants are considered invasive or potentially invasive. Among the most problematic for local biodiversity are *Ailanthus altissima*, *Amorpha fruticosa*, *Fallopia bohemica*, and, recently, *Opuntia humifusa*. The impact of these species is caused by their competition with native plants, changes in the composition and structure of plant communities and habitats, and parasitism. Of all 347 alien terrestrial arthropods, 52 species are widespread crop pests with potential negative impact on forestry, agriculture, horticulture, and greenhouse production. The greatest threat to biodiversity in Bulgaria are two species: the Asian ladybeetle *Harmonia axyridis* and chestnut leaf miner moth *Cameraria ohridella*.

80. From a total of 29 alien species of marine invertebrates found along the Bulgarian Black Sea coast, 9 species are considered invasive. The introduction of some of them has entirely changed the ecosystem of the Black Sea, such as *Ficopomatus enigmaticus*, *Rapana venosa*, *Mya arenaria*, and *Anadara inaequivalvis*, *Mnemiopsis leidyi*, and *Beroe ovata*. Their impact is due to predation, competition, and habitat change. For example, the highly invasive *Rapana* is considered the major cause of the destruction of the populations of the oyster *Ostrea edulis* and *Flexopecten glabrar*, the reduction in the population of *Chamelea gallina*, and a widespread deterioration of the mussel fields of the Mediterranean mussel (*Mytilus galloprovincialis*), including during 2009–2012.

81. The project (ESSENIAS-Tools) provided data for invasive species in Bulgaria and southeastern Europe. Limited data and analysis are available to allow a clear definition of the additional climate change risks associated with IAS.

The multiple manifestations of invasive species spread is bringing them apart from other vulnerability factors as they may also bring opportunities for CCA. Their spread, if monitored on a regular basis and linked to climate change, can be used as an indicator in an early warning mechanism. Some IAS are commercially important and contribute to providing ecosystem services. For example, *Rapana venosa* is subject to fishing and the shells are used for the production of tourist souvenirs. In addition, the spread of invasive species in ecosystems degraded beyond conservation may contribute to increasing the genetic diversity and biodiversity within designer ecosystems, optimized for ecosystem service provision.

[36] CBD Fifth National Report 2009–2013.

Populations and communities

82. Most important is the interaction between species, competition for resources, the mismatch of their life cycles, and loss of synchrony between species, resulting in affected species in abundance and balance in the communities. It is highly probable that some species will be more competitive than others and modify community composition. The limited data and research so far in Bulgaria highlight the need for further research.

Habitats

83. According Volume 3 of the Red Data Book of the Republic of Bulgaria, Habitats,[37] the country is one of the richest in Europe. Five categories (extinct, critically endangered, endangered, vulnerable, nearly threatened) of conservation status have been identified, and these are based on criteria related to the main characteristics of the habitats, that is, areas of distribution, structure, functions, sustainability, restoration capacities, and resilience rehabilitation under pressure; and the conservation status of Bulgaria's **166 habitats** of conservation importance has been identified. They are included in the Red Data Book and need specific conservation measures. They belong to the following groups: marine habitats - 11; coastal habitats - 8; inland waters - 21; mires, bogs, and fens - 6; herbaceous communities and communities of lichens and mosses - 32; shrub communities - 32; forests - 40; and inland rock habitats - 16. The habitats belong to four threat categories:

- Critically endangered - 28 habitats
- Endangered - 71 habitats
- Vulnerable - 47 habitats
- Nearly threatened - 20 habitats

84. According to the assessment of the conservation status of the habitat types of Annex I of the Habitats Directive in the Continental region, 86.3 percent of the habitats are in an 'unfavorable-inadequate' conservation status, 11 percent are 'favorable', and 2.7 percent are rated 'unknown'. In the Alpine region, 83.6 percent of the habitats are 'unfavorable-inadequate' and 14.8 percent are 'favorable' In the Black Sea region, 93.6 percent of the natural habitats are 'unfavorable-inadequate', and 6.4 percent are 'favorable'. In the MBLS region, five types of natural habitats are 'unfavorable-inadequate' and one is rated 'unknown'.

- Most vulnerable habitats

85. The possible consequence of climate change is the deterioration of habitats in the four categories and these that are 'unfavorable-inadequate' or moving in altitudinal and latitudinal direction. The response could be adjustment of the protected area according to the new conditions due to the climate change. The high-altitude habitats have this kind of vulnerability.

86. It should be noted that shortage of funds for monitoring the biodiversity outside NATURA 2000 has led to significant bias of data collection to the areas that already have more natural and resilient ecosystems and better-preserved habitats. At the same time, nonprotected areas are subject to higher anthropogenic pressures and in some cases harmful

[37] Red Data Book of the Republic of Bulgaria 2011.

subsidies or targeted practices that reduce biodiversity (such as removal of old trees and natural refugium strips to create level fields for heavy agricultural machinery).

87. This bias is not likely to change soon since the EU funding is explicitly limited to activities within NATURA 2000. The situation was partially amended by the MAES outside NATURA 2000 within program BG03 Biodiversity and ecosystem services since biodiversity is part of the indicator framework for ecosystem assessment. However, the lack of data for nonprotected areas is likely to continue if funding for long-term national-scale monitoring is not secured.

Ecosystems

88. The ecosystem is a functional unit, so the most important risk here is the regime shifts in the long-term that also occur in the provision of ecosystem services. Regime shifts could be in both directions—the increased length of the growing period could lead to increasing of productivity of terrestrial ecosystems. The increasing of temperature could change the water condition of lakes, resulting in changes in fish composition and productivity. Periods of drought could change the composition of producers[38] in the terrestrial ecosystems causing changes in their functioning and resulting in changes in the provision of ecosystem services. Similar consequences are expected from natural disturbances on ecosystems. The floods, fires, windthrows, and bark beetle outbreaks in forests cause tree mortality and subsequently, species more adaptive to the new climate conditions could replace the formerly dominant species, changing the ecosystem integrity and provision of ecosystem services. Decreasing ecosystem services quality will directly affect many other economic sectors in the country—provisioning ecosystem services in agriculture, forestry, water sector, industry, health, regulating ecosystem services in all sectors, cultural in recreation and tourism, urban, and education sectors.

89. In the Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change, produced in 2014,[39] the sensitivity of ecosystems to climate change in Bulgaria is estimated for 2016–2035, based on Representative Concentration Pathway (RCP) scenarios for changes in temperature, rainfall, and extreme events. Estimates are determined based on the analysis of the expected impacts of climate change. For ecosystems with low sensitivity for 2016–2035, it is assumed that the expected changes in the capacity to provide ecosystem services will not be substantial. In moderately sensitive ecosystems, it is assumed that the impact of climate change will reduce capacity by 10 percent. In highly sensitive ecosystems, it is assumed that the impact of climate change will lead to a change in capacity to deliver ecosystem services of up to 20 percent.

[38] Organisms that secure the primary production of biomass, such as terrestrial plants and algae.

[39] Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change, 2014, http://www.moew.government.bg/bg/proekt-na-ramkov-dokument-analiz-i-ocenka-na-riska-i-uyazvimostta-na-sektorite-v-bulgarskata-ikonomika-ot-klimatichnite-promeni/

Table 2. Ecosystem sensitivity to climate change and the potential to provide ecosystem services

Ecosystem type		Vulnerability			Possible change in ecosystem services potential		
		ΔT°C	ΔEx	ΔP%	ΔT°C	ΔEx	ΔP%
Terrestrial	Urban	1	1	2	0.0	0.0	0.0
	Cropland	2	3	3	−0.1	−0.2	−0.2
	Grassland	3	2	3	−0.3	−0.2	−0.3
	Woodland and forest	2	1	2	−0.3	0.0	−0.3
	Heathland and scrub	3	3	3	−0.5	−0.5	−0.5
	Sparsely vegetated land	2	1	3	−0.1	0.0	−0.2
	Wetlands	3	3	3	−0.4	-0.4	−0.4
Fresh water	Rivers and lakes	3	2	3	−0.5	-0.3	−0.5
Marine	Marine inlets and transitional waters Coastal areas Open sea	3	1	1	−0.4	0.0	0.0

Note: The estimates are not aligned with the latest ecosystem services valuations that are not yet complete for the entire territory of Bulgaria and not yet verified across ecosystem types as of this report's date.

Sensitivities: 1 – low, 2 – moderate, 3 – high; T - temperature, P - precipitation, and Ex - extreme events.

90. Within forest ecosystems, Bulgaria has identified and characterized vulnerability zones on a three-level scale (high, medium, and low) in scenarios for 2020 and 2050 (Raev et al. 2011). The loss of biodiversity is also graded in three stages (high, medium, and low).

➢ Vulnerability zones according to a realistic scenario for 2020

- **High degree of vulnerability** (**Zone A**) outlines the regions of North-East Bulgaria (Dobrudja) and the floodplains along the Danube River. The degree of biodiversity loss is expected to be low.
- **Moderate degree of vulnerability** (**Zone B**) includes the northern part of the Strandzha Mountain, part of the Eastern Stara Planina, the Ludogorie, the Eastern Rhodopes, and the Sandanski-Petrich valley. The degree of biodiversity loss for Zone B is expected to be low.
- **Low degree of vulnerability (Zones C and D)** covers all other areas that are expected to be affected insignificantly by biodiversity loss. The majority of these are typical xerophytic communities or those with local or intrazonal distribution.

➢ Vulnerability zones according to a realistic 2050 scenario

91. The differences for 2020 are basically the size of the zones where the climate is expected to become drier and warmer.

- **High vulnerability (Zone A**). It includes areas along the Danube River, Tundzha Hilly Plain, and Upper **Thracian** Lowland (parts). The extent of biodiversity loss for this area is estimated to be medium.
- **Moderate vulnerability (Zone B).** The extent of biodiversity loss for this area is estimated to be medium, **except for** the high fields of Western Bulgaria, where the degree is assessed as low.

- **Low vulnerability** (**Zones C and D**). Areas with low vulnerability will also have some changes. For vulnerable zones, the **degree** of biodiversity loss is assessed as insignificant.

92. There are also some BD&ES for which the climate change will provide good opportunities (for example, by increasing growing period), as presented in ***Annex 1***.

➢ Most vulnerable ecosystems

93. The most vulnerable and potentially most affected ecosystem will be the southern border forestry area as well as the other lowland areas of the country. While initially the expected level of biodiversity loss is low, the realistic scenario for 2050 identifies the rate of biodiversity loss as rising, ranging from medium in existing cases, and developing loss in previously unaffected locations. For more details, see the Forestry sector assessment report.

94. The inland **wetlands** ecosystems, **heathland and shrub** ecosystems (especially in the **alpine zone** in mountains), and **coastal zone** ecosystems are the most sensitive to climate change.[40] They are characterized by a high degree of sensitivity for all types of impacts of climate change and are further limited in area, making them particularly vulnerable. There are ongoing projects to assess the ecosystem conditions and ecosystem services in Bulgaria. In addition, a monitoring guide on ecosystem level is under development. One of the main aims of this monitoring is to follow, register, and analyze the long-term changes in ecosystems and their services[41].

1.3.2. Climate change risks for BD and society

95. The potential risks and opportunities that the BD&ES sector in Bulgaria faces because of the changing climate are outlined in ***Table 3.***

Table 3. CCA - potential direct risks and opportunities of the BD&ES sector

	Risks	Opportunities

Higher temperature (including heat spells and heat waves)	**Genetic diversity loss due to**
	• Loss of less resilient local sorts and breeds and/or their wild relatives, due to
	  ○ Mixing with introduced heat and drought-resistant sorts/breeds
	  ○ Stopped planting
	  ○ Lost local knowledge
	• Extinction of vulnerable stenobionts
	• Insufficient adaptability
	Species
	• Phenological changes
	• Physiological changes
	• Extinction of specialists - species (stenobionts)
	• Different diseases, new pests, viruses, and fungal diseases
	Population
	• Changes of population size
		• Longer growing season
		• Appearance of more heat resistant species

[40] Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change, 2014.
[41] MetEcoSMap Project 2017.

	Risks	Opportunities
	Habitats • Changes in geographical distribution • Species' distribution changes **Ecosystems** • Regime shifts • Increasing the primary productivity • Interaction changes between species – lifecycle changes • Increasing evaporation and transpiration in plants • Impact on environmental and water condition • Provisioning and regulating ecosystem services change • Increasing of fire risk • Higher potential for heat tolerant invasive species	• Increasing adaptive capacity by increasing biodiversity • Increasing adaptive capacity by internal heterogeneity and natural dynamics • Increased primary production from newly selected/introduced sorts and breeds • Increased biodiversity by ecosystem succession (wider spread of subtropical biodiversity) • Increasing of landscape heterogeneity

Lower temperatures (including cold spells and cold waves)	**Genetic diversity loss due to**
	• Loss of less resilient local varieties and breeds and/or their wild relatives, due to
	  ○ Mixing with introduced cold-resistant varieties/breeds
	  ○ Stopped planting
	  ○ Lost local knowledge
	• Extinction of vulnerable stenobionts
	• Insufficient adaptability
	Species
	• Phenological changes
	• Physiological changes
	• Extinction of specialists - species (stenobionts)
	• Damages on cold sensitive species
	Population and community and community
	• Changes of population size
	• Interaction changes between species – life-cycle changes
		• Mortality of pathogens demanding warmth

	Habitats • Changes in geographical distribution **Ecosystems** • Regime shifts • Decreasing the primary productivity under cold stress • Interaction changes between species – life cycle changes • Impact on environmental and water condition • Provisioning and regulating ecosystem services change	• Gain in primary productivity if cooler climate is stabilized

	Risks	Opportunities
More precipitation and humidity	**Species** • Phenological changes • Physiological changes • Damages on sensitive species • Extinction of specialists - species (stenobionts) • Improved conditions for different diseases, new pests, viruses, and fungal diseases **Population and community** • Changes in population size • Interaction changes between species – life cycle changes	• Increasing the abundance of moisture sensitive species • Improved growth of tree species, especially in drier environments
	Habitats • Changes in geographical distribution • Species distribution changes **Ecosystems** • Regime shifts • Increasing the primary productivity • impact on environmental and water condition • Provisioning and regulating ecosystem services change • Decrease of biodiversity in some ecosystem types, for example sparsely vegetated land	• Appearance of wetlands • Increasing adaptive capacity by increasing biodiversity • Increasing adaptive capacity by internal heterogeneity and natural dynamics • Increasing the biodiversity with moisture sensitive species
	• Increasing of flood risk • Increasing of erosion and landslides - degradation and deterioration of habitats • Higher potential for invasive species	• Decreasing fire risk
Droughts	**Species** • Drought stress on plants • Phenological changes • Physiological changes • Extinction of specialists - species (stenobionts) • Damages on moisture sensitive species **Population and community** • Changes in population size • Interaction changes between species – life cycle changes	• Decreasing of disservices of wetlands
	Habitats • Deterioration • Species distribution changes • Disappearance of wetland habitats **Ecosystems** • Regime shifts • Decreasing the primary productivity • Impact on environmental and water condition - soil moisture decreasing, decomposition of soil organic matter, soil salinization • Provisioning and regulating ecosystem services change	
	• Increasing of fire risk	• Decreasing of flood risk and landslides

	Risks	Opportunities
Floods	• Species distribution changes	• Improved inundation regime of wetlands
	• Habitat changes	
	• Improved conditions for pathogens	
	• Ecosystem deterioration • Provisioning and regulating ecosystem services change	
Fires	• Species distribution changes	• Increasing of landscape heterogeneity
	• Habitat changes	• Spread of new species via succession on fire sites
	• Improved conditions for pathogens	
	• Ecosystem deterioration • Provisioning and regulating ecosystem services change	
Pest and diseases	• Species' distribution changes	
	• Habitat changes	
	• Improved conditions for pathogens	
	• Ecosystem deterioration	
Invasive species	• Decreasing of local biodiversity	• Increasing of landscape heterogeneity
	• Species distribution changes	• Increased primary productivity and provisioning ecosystem services from fast-spreading invasive species
	• Habitat changes • Ecosystem regime shifts	

96. As noted earlier, climate change presents a number of threats and opportunities that may cause negative or positive externalities in various aspects of human activities, both economic and social. Understanding and handling these effects in the socioecological context is a significant societal challenge that needs to be addressed by institutional, scientific, and social capacity building to make the loss of biodiversity and climate change visible. Institutional capacity building is needed at national, regional, and local levels. This should be addressed through training staff at each of these three levels of administration. Scientific capacity has to do with overcoming barriers between research disciplines transitioning toward truly holistic, multidisciplinary science (Runting et al. 2016) and building an adequate research infrastructure. Finally, all stakeholders' capacity to communicate and share data, including the incorporation of citizen science and traditional knowledge, would contribute to the development of a shared vision and support well-informed research, based on modelling upon partial or topical research. The extent of such global-to-local decision-making alignment is illustrated, for example, by work focused on controversial impacts of different environmental policies, such as climate geoengineering that could harm biodiversity[42] or the negative impacts on alternative energy production on biodiversity (Bertzky et al. 2010), as

[42] See CBD decision from December 2016, available at: https://www.cbd.int/doc/decisions/cop-13/cop-13-dec-14-en.pdf

well as single ecosystem types or territories (Moor et al. 2015, Egan et al. 2016, Mina et al. 2017, and many other studies). The context of the specific societal risks is explained in more details in Chapter 3 and risks are listed in ***Annex 2***.

1.3.3. Uncertainty

97. Assessing the vulnerability and adaptive capacity of BD&ES to different threats and certainly to climate change is very complex and includes large levels of uncertainty within scientific information, system understanding, and expert knowledge. There are two major sources of uncertainty. First, local projections of climate change impacts can be unreliable and the spread of parameters between the single scenarios is in some cases wider than the projected intervals of change in the parameters. Furthermore, the impacts of any given level of change in environmental parameters on the ecosystems are insufficiently studied due to both lack of data time series and the complexity of interactions (Chipev et al. 2017). Therefore, current scientific knowledge is unable to predict with certainty how climate change could affect BD&ES services in any single location.

98. Like other countries, Bulgaria needs a better understanding about the impacts of climate change on BD&ES. Some of the main interdisciplinary research areas include the climate change effects on ecosystems by CICES 2 or CICES 3 type with respect to phenological cycles, single pressures such as drought or extreme weather phenomena, and combined effects of climate change and other major pressures on the ecosystems.[43] In addition, using modeling techniques to augment data series and include new data sources such as remote sensing data is an emerging area of data science, as related to ecosystems research.

99. Regardless of the knowledge gaps, it is still important to identify at an early stage the potential vulnerabilities given the uncertainties and to define what measures can be undertaken. These living systems have inherent resilience and adaptation potential to respond to the changes of environment. Practitioners of ecological sciences and decision makers face considerable challenges to understand and assess the capacity of natural systems to adapt. These uncertainties should not paralyze efforts to make decisions and to develop no-regrets strategies for adapting to climate change.

1.4. Conclusions

100. The expected climate change and extreme weather events are likely to affect all levels of biodiversity and ecosystems. Genetic diversity may be reduced due to the disappearance of endangered species—specialists and endemic species with a limited range of migration. Climate change can also affect and mismatch the life cycles of species, within ecosystems, and can affect habitats and functions of ecosystems, including by invasion of alien species (threats for local native species). But the IAS could be used as important indicators of climate change and as opportunities of ecosystems to adapt to the new conditions on the functional level.

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[43] A good example for such research is the MFORES Project promoted by the Forestry Institute at the Bulgarian Academy of Sciences (BAS) whose main deliverable is a prediction of the changes in forest ecosystems and the related ecosystem services under climate scenarios relevant for Bulgaria.

101. Species most vulnerable to climate change are rare (endemics), specialists, and endangered species with already limited distribution, especially when migration options are limited. At the community level the most important shifts are the changes in the interaction between species, competition for resources, the mismatch of their life cycles, and loss of synchrony between species, resulting in species abundance and imbalance. The possible consequence of climate change is the deterioration of habitats, particularly in the category 'unfavorable-inadequate', or moving in altitudinal and latitudinal direction. The inland wetland ecosystems, heathland, shrub ecosystems (especially in the alpine zone in the mountains), and coastal zone ecosystems are the most sensitive to climate change. They are characterized by a high degree of sensitivity for all types of impacts of climate change and are further limited in area, making them particularly vulnerable. As a result, the capacity of ecosystems to provide ecosystem services is also expected to change.

102. The vulnerability and adaptive capacity assessment of BD&ES to climate change is very complex and includes large levels of uncertainty within scientific information, system understanding, and expert knowledge.

103. Furthermore, the climate change impacts on ecosystem integrity characteristics are insufficiently studied due to a lack of data time series with suitable quality and the complexity of interactions in the system. Therefore, current scientific knowledge about Bulgaria is unable to predict with certainty how climate change could affect BD&ES services in any single location.

104. Facilitating and increasing the provision of ecosystem services allows for a nature based, sustainable way to use biodiversity and ecosystems for climate change adaptation. In this respect, regulating ecosystem services are especially important for win-win adaptation solutions across all sectors. According to assessments in the United Kingdom and China, the value of ecosystem services can be conservatively estimated to be about as high as the value of provisioning and cultural services; in some areas it may be as high as 90 or more percent of the total value of ecosystem services. Conversely, the loss of ecosystem services due to deterioration of biodiversity and ecosystems is likely to be extremely costly for society as a whole and the most vulnerable population in particular.

Chapter 2. Baseline - Policy Context

Introduction

105. Both BD&ES and climate change are rapidly developing, cross-cutting policy areas. They are characterized by an urgent need for action against the background of complex global and local developments. At the same time, the knowledge base used for traditional policy making is insufficient and collected weather and biodiversity data series are simply too short to see patterns with a sufficient degree of assurance. In addition, normal policy-making cycles can be too long (if a disastrous event threatens human life and health, or in the case of ecosystem destruction) or too short (against the background of long-term natural adaptation to disturbances or natural climate cycles when coherent action across several decades or centuries of different leadership is needed to produce desired results).

106. In addition, the progress in climate science and ecology causes shifts in policy objectives. In climate change, the initial focus on mitigation is being complemented by the growing understanding of CCA as another short- to midterm necessity. This is especially true for ecosystems whose natural adaptation is determined by evolution that may take thousands and millions of years. Through selection of domesticated varieties and breeds and more recently through gene engineering and large-scale, mechanized modification of natural ecosystems, human society can direct and accelerate the adaptation to some extent.

107. However, success on a planetary scale requires an in-depth understanding of the interactions within the ecosystem and between ecosystems in a landscape. The unprecedented growth of human populations and their connectivity also increases the scale of interlinking remote ecosystems and spreading global adverse effects. To preserve biodiversity, issues such as cross-border air, water, and soil pollution, or the accelerated spread of invasive species through international trade, are to be addressed in connection with climate change for humankind to retain its living space.

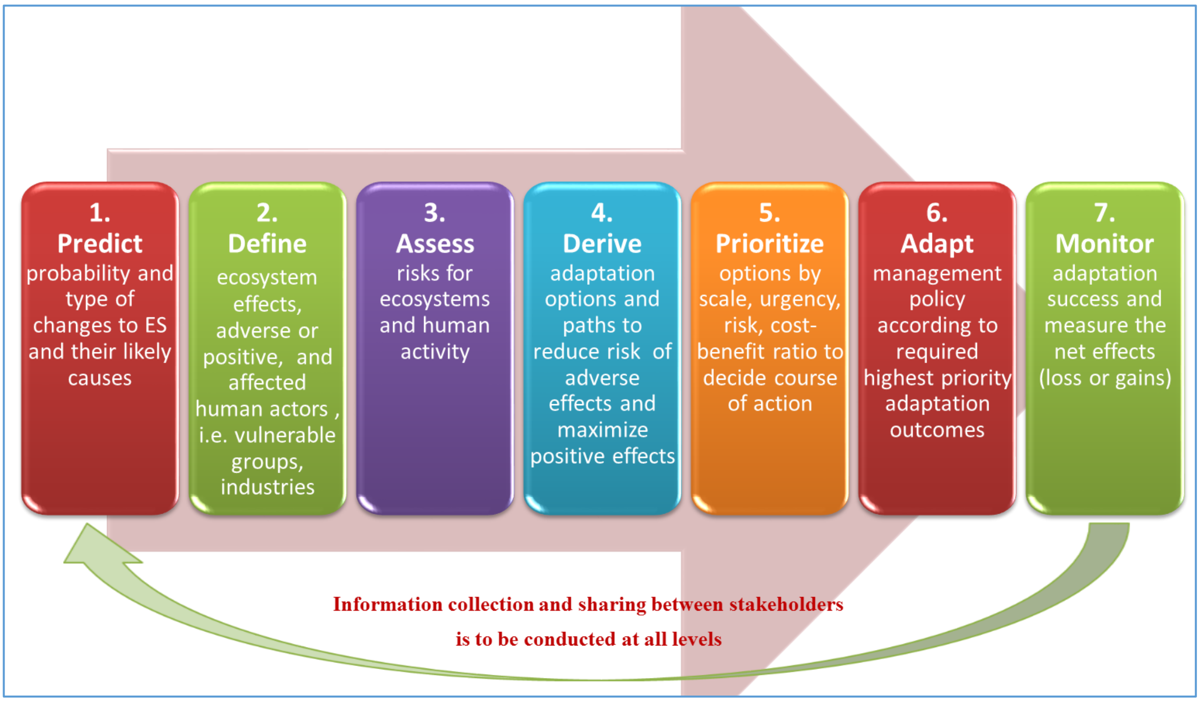
108. Therefore, in BD&ES, the observation and management focus is shifting from mechanistic conservation efforts on the species or habitats levels to a more holistic, ecosystems-based approach that considers all factors determining biodiversity's living environments. Interest is growing both in ecosystem management and in the management of landscape mosaics consisting of various ecosystems on a given territory.

109. Globally, at the national level, as well as increasingly at regional and local levels, there is a growing consensus toward adaptive, ecosystems-based management in which the importance of climate change as pressure is acknowledged and acted upon. An outline of possible steps for such management is presented in ***Figure 8***.

110. All its stages need to be underpinned by information collected and freely shared in such a manner that it (a) enables various economic sectors to initiate collecting and sharing of data and information that will establish ecosystems and biodiversity as the basis of their productivity and (b) tracks the changes in the regulating, provisioning, and cultural ecosystem services attributable to climate change, so that potential gains can be used for adaptation and adaptive measures can be devised for the vulnerable sectors leveraging BD&ES.

111. Against this background, both policy formulation and policy implementation need to be improved and upgraded to integrate CCA into the biodiversity policies, as well as to create positive loops between CCA, biodiversity, and other sectors using ecosystem services.

Figure 8. The main steps of ecosystems-based adaptive management in the BD&ES sector



Source: Authors' design.

112. Due to the rapid processes in our living environment, CCA and ecosystems-based management have gained international momentum and develop rapidly in a parallel, top-down manner while policy adoption cycles lag. With the development of the CCA strategy and Biodiversity strategy and the realignment of respective legislation, Bulgaria can formally align CCA and biodiversity conservation/ecosystem management objectives with the biodiversity, ecosystems, and climate-related aspects of the 7th EAP, EU strategies, and legislation.

113. Since this is an ongoing process, the current state of CCA legislation and biodiversity legislation is presented in parallel in this chapter. Environmental considerations are being mainstreamed into other policies both at the EU level and in national implementation; therefore, links to other sectors also need to be discussed. Such links may be two ways, as outlined in Chapter 1—the optimal use of ecosystem services can support adaptation options in other sectors, but the loss of ecosystem services, which the population and economy rely on, can become a source of additional costs to replace these services and ultimately increase the risk in other sectors.

114. Existing strategies and legislation in many cases provide a sound basis for adopting new policies, notably the effort to integrate CCA and ecosystems-based management. This raises the challenge of developing a new policy framework without a disruption from pursuing earlier policy and management objectives.

115. Bulgaria has been involved in international efforts to mitigate climate change as a party to the United Nations Framework Convention on Climate Change (UNFCCC) since 1995 and has been a party to the Kyoto Protocol (KP) since 2002. Since Bulgaria's accession to the EU on January 1, 2007, the context of climate policy in the country has changed substantially to accommodate the EU policies and practical climate change mitigation steps, such as the European Union Emissions Trading System (EU ETS) and the National Action Plan on Climate Change (NAPCC). The development of a CCA strategy is likely to trigger a series of additions to the Climate Change Mitigation Act (CCMA) (which is currently focused on mitigation and needs extension to flesh out the adaptation policies) and changes to other strategic and legal documents (in particular in biodiversity), as well as secondary legislation, to bring the CCA to the same policy level as climate change mitigation.

116. Against this background, the existing Biodiversity Strategy and Action Plan for 1999–2003 needs updating. These documents already refer to the key ecosystems-related elements of biodiversity conservation and ecosystems-based management, including even the need for integrated management, but lack both the direct relation to climate change, and the ecosystem services concept as a possible binding link to CCA in BD&ES and other sectors. Additions or modifications to explicitly incorporate CCA concerns are also needed in the sectoral biodiversity legislation to ensure a coherent institutional and stakeholder action.

2.1. State of Awareness, Understanding of Future Consequences of CC, Knowledge Gaps in the BD&ES Sector

2.1.1. State of awareness

117. The Ministry of Environment and Water (MoEW) together with its subsidiaries—the ExEA, National Park Directorates, RIEW, and BasD—has a dedicated policy to improve public awareness on environmental issues and ensure public participation in decision-making processes to promote sustainable and environmentally sound social behavior patterns, maintaining the ability of our natural environment for protecting biodiversity and delivering ecosystem services. Awareness on biodiversity, ecosystems, and the impact of climate change thereon is also promoted by the Nature Park Directorates under the Ministry of Agriculture, Food, and Forestry.

118. Furthermore, under the Aarhus Convention, Bulgaria has committed to sharing and applying the principles of open government and dialogue with stakeholders. The MoEW and its subsidiaries collect information on environmental matters and make it available for informing decisions and actions. Databases recording the status of environmental components[44] are being updated and new ones are being developed. The information system for national environmental monitoring maintained by the ExEA has recently been updated with an improved public interface to display ecosystem and ecosystem services data,[45] as well

[44] Under the current legislation, there is not yet a monitoring of ecosystems as a whole, but rather, single elements of the ecosystem are being monitored and data are collected about them.
[45] For data sets by ecosystem type, see http://eea.government.bg/flexviewers/ECOBUSH/
http://eea.government.bg/flexviewers/ECOCROPS/
http://eea.government.bg/flexviewers/ECOFOREST/
http://eea.government.bg/flexviewers/ECOGRASS/
http://eea.government.bg/flexviewers/ECOMARINE/
http://eea.government.bg/flexviewers/ECORIVERSLAKES/

as forestry data and the ESENIAS regional early-warning and IAS database that it can access through interfaces to the data owners.

119. In addition, support for citizen science is being encouraged by the development of new smartphone applications for volunteers wishing to submit species data, as well as new functionalities. In this manner, access is given to data on important biotic and abiotic factors influencing biodiversity and the state of environmental components, such as air, water, land and soils, forests and protected areas, biodiversity, noise and non-ionizing and ionizing radiation, use of water resources, and pollution. These elements are being reported in the State of the Environment reports and information is being provided through an increasing number of free online tools and public information centers in its regional structures.

120. For non-governmental organizations (NGOs), academia, business, and other stakeholders, there are several mechanisms for involvement and awareness raising, such as the Public Council to the Minister of Environment and Water created in March 2013. In addition to the legal option for access to public information, national campaigns, open door days, and competitions raise public awareness, including on the topic of climate change. MoEW subsidiaries such as the ExEA, BasD, and RIEW also provide topical information, including on biodiversity.

121. A number of initiatives have been developed to raise awareness and public participation during preparation of the National Adaptation Strategy (NAS), including workshops with public authorities, academia, NGOs, schools, and other stakeholders. However, CCA was not specifically addressed within the management of biodiversity.

122. The National Parks administration and management bodies in their visitor centers have organized different events on adaptation but focused more on biodiversity and, to a smaller extent, ecosystem services directly rather than on how these are affected by climate change. Hence, there is limited realization of the increasing environmental threats arising from biodiversity loss and the resulting decline in climate change resilience of ecosystems and societal systems relying on the ecosystem services.

2.1.2. Understanding of future consequences of climate change

123. Information about both climate change and ecosystems as a complex system is not communicated easily and sometimes simplistic messages fail to convey the importance of holistic views (see ***Box 2***).

Box 2. Importance of holistic views

The limitations of simplistic communication are illustrated by the public discussion on the infringement procedure against Bulgaria regarding protection of birds and habitats around Cape Kaliakra.[46] Public discussion focused on topics such as the correct delineation of the protected area (including responsibilities) and protests against restrictions of economic activities. At the same time, the EU Court's reference to the need for cumulative evaluation of the impacts of all projects was lacking from the public discussion.

http://eea.government.bg/flexviewers/ECOSPARSELY/
http://eea.government.bg/flexviewers/ECOURBAN/
http://eea.government.bg/flexviewers/ECOWETLAND/.
[46] Case C-141/14, judgement see http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:62014CJ0141&rid=1.

124. Historically, many NGOs with significant outreach and capacity focus on species, or small-scale pilots, involving single ecosystem services. Examples include the bird census actions of the Bulgarian Society for Protection of Birds, the voluntary payment for ecosystem services projects of the World Wildlife Fund (WWF), and species-related projects with excellent communication strategies, such as the projects for volunteer monitoring of dolphins, bats, and oaks funded by the Financial Mechanism of the European Economic Area (EEA FM).[47]

125. Similarly, CCA as a complex phenomenon is not a typical subject of awareness actions. General communication campaigns tend to highlight single aspects of environment protection. In this respect, the involvement of research bodies appears to provide stakeholders a more in-depth view of the complexities in nature. Evidence includes the publicity efforts of projects such as MFORES by the Forestry Institute at the Bulgarian Academy of Science (studying the climate change effects on forests),[48] the consultations with stakeholders during the socioeconomic study of heathland and shrubs ecosystems performed by the Sofia University[49] (that discussed important aspects such as the pollination ecosystem services), and the pilot exploration of grassland areas of interest by the 'Assessment and mapping of Grassland ecosystems condition and their services in Bulgaria (IBER-GRASS)' project[50] of the Institute for Biodiversity and Ecosystem Research at the Bulgarian Academy of Sciences (that uncovered a need to improve the value for money in agriculture subsidies for grassland use). An unexpectedly strong positive response was also given to the discovery of 'invisible ecosystems' through a travelling photo exhibition about sparsely vegetated areas (SPA-Ecoservices project) that by popular demand continued its tour beyond the planned locations.

126. Nevertheless, cooperation among stakeholders is necessary to highlight the complex systems and the socio-ecological win-win potential in their management, including in terms of cost savings for CCA. Such awareness action should also highlight the data and policy gaps and enable stakeholders to understand global objectives and be part of a more goal-oriented, participative management and adaptation at national and local levels.

Box 3. Sparsely vegetated land - the invisible ecosystems

Sparsely vegetated lands are specific, small-scale ecosystems with life forms that require dry conditions and poor soils. Such ecosystems include sand dunes that house rare species such as the sand lily and rocky inland landscapes of singular beauty and rich cultural ecosystem services.

Apart from being a nursery for biodiversity and therefore a prime location for botanic tourism, sparsely vegetated areas have been used for centuries for spiritual, religious, and aesthetic purposes. With the advance of new technologies, they also give the opportunity for extending the use of hitherto unusable cultural ecosystem services such as educational and scientific interactions. Inaccessible sparsely vegetated locations were mapped using drones in the SPA-Ecoservices project, discovering their potential to become a venue for high-tech scientific and citizen science exploration by modern tools, to bring nature to the classroom and lab, and to empower disabled people to access its beauty.

[47] http://bg03.moew.government.bg/Cetaceans , http://bg03.moew.government.bg/NBMS , http://bg03.moew.government.bg/OakC , http://time-foundation.org/kampaniya-za-dabovete/
[48] https://www.youtube.com/watch?v=vo5btfV7D9w.
[49] http://www.ekohrasti.eu/en/.
[50] http://grasslands-ecoservices-bg.eu/index.php/en/.

Sources: SPA-Ecoservices project, Wikimedia.

The above landscapes are vulnerable to coastal erosion that may ensue due to several reasons, including CCA-induced extreme storm events. They are also being infested by IAS such as Opuntia cactus and are subject to transformation due to increased demand for hotel space on the Black Sea coast.

127. It is to be noted that focusing on the big picture may prove more cost-effective in projects such as the ones mentioned earlier; this consideration is driving the shift in priorities on the EU level and similar objectives may improve the communication efficiency in Bulgaria as well. For example, LIFE-funded projects with comparable budgets from the previous and the current programming period show that ecosystems-based projects are bolder in scope[51] and result in the collection of knowledge better suited to create direct links to other sectors and facilitate CCA.

2.1.3. Knowledge gaps

128. As detailed in sub-chapter 2.3, the biodiversity legislation currently in force is mostly focused on managing biotic interdependencies and abiotic conditions up to the habitat level for biodiversity conservation and restoration purposes. With the notable exception of the Forestry Act, the ecosystem services concept is missing from the legislation. The management of important ecosystem types such as cropland, forests, freshwater and marine, or grassland

[51] For example, the LIFE08 NAT/BG/000278 Vultures' Return project with a budget of €1,332,328 was aimed at restoring the populations of three vulture species. While very successful and subject to several follow-up projects, it focused on ex situ breeding and reintroduction, resulting in the release of 210 birds and permanent settling of some 70. By comparison, the LIFE16 NAT/GR/000575 IGIC project with a budget of €1,246,704 aim to develop a demonstration network of green infrastructure components in 30 pilot fields across 10 areas surrounded by NATURA sites, improve the habitats and enhance the conservation status of 17 flora and 30 fauna target species, assess ecosystems and land use, establish sustainable farming in the pilot sites, support scaling up, and formulate policy proposals.

ecosystems is addressed in special legislation focusing on provisioning services and the social and business relationships in their production. Such legislation is not always conducive to improving the climate resilience of these ecosystems when focusing on monocultures with low biodiversity that increases vulnerability or allowing for the destruction of ecosystems with prevailing production of ecosystem services requiring non-use (regulating and cultural services).

129. Monitoring and data collection follow the legal framework and have historically not focused on systematic collection of ecosystems data that will allow for following trends in the production of regulating and cultural ecosystem services or estimating the ways in which they are influenced over time by climate change. Even for existing monitoring, data series are often short or incomplete due to fluctuations in funds availability, data incompatibility, or hoarding; this renders running models for assessing climate change impact on biodiversity a challenge. Thus, official climate and biodiversity models with sufficient granularity are not available to local and regional stakeholders while national projections are not sufficiently detailed. This data gap prevents making more specific recommendations in this report. As it is cross-sectoral in nature, concerted action is needed to set up consistent monitoring in all ecosystems, including the ones regulated by agricultural, fishery and aquaculture, and forestry legislation.

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

130. Most EU Member States and some other European countries have developed strategies and action plans related to the CCA. Many of them, including the aspect of BD&ES, could be used as good practices to develop a national adaptation strategy and action plan. The following examples illustrate strategic approaches, practices, and organization of the strategy development and subsequent implementation process that may be of relevance to Bulgaria's approach to BD&ES CCA.

Box 4. The United Kingdom - create space for nature, even in the cities

One of the many examples of best practice in the U.K. Biodiversity strategy is the coherent focus on providing green connectivity, corridors, and living spaces for wildlife. In response to climate change, communities of wild animals and plants will have to relocate from places that are becoming unsuitable for their survival to places where conditions are becoming more favorable. The way that open spaces and parklands are managed can have a significant impact on wildlife corridors and habitats and consequently on wildlife's ability to survive.

For rare species that cannot migrate easily (such as alpine species with no retreats), the only alternative to ex-situ preservation is creating space for biodiversity. The use of defragmentation and connectivity is important for all types of ecosystems and can be a key adaptation mechanism both for small valuable natural ecosystems such as sparsely vegetated areas and wetlands and for heavily modified ecosystems that form important parts of human habitats—urban and cropland ecosystems.

Box 5. Turkey - cross-sectoral CCA approach in the region

Turkey is a country that shares climatic and biodiversity traits with southern Bulgaria. Studying its CCA strategy related to biodiversity can be beneficial both methodologically and with specific shared ecosystems and biodiversity insights.

Turkey adopts a holistic approach based on ecosystem function principles. Synergies with other sectors are considered with a view to ecosystem conservation providing strategies that focus on sustaining the functions of ecosystems in a healthy and effective way. The management and conservation of water, land, and biological resources are important means for coping with the impacts of climate change. In terms of adapting to the impacts in urban and rural areas, even giving importance to physical infrastructure can be effective in adapting to climate change. 'Green infrastructure' as the EU expresses it "can play a vital role in efforts for adapting to climatic conditions within social and economic dimensions."

The strategy further considers the ecosystem services, particularly the regulating services of the 'Mediation of flows' group (such as flood protection; landslide, erosion, avalanche slope protection; storm protection; air ventilation and transpiration; water supply maintenance) as an important and cost-effective CCA resource. Raising awareness and creating capacity for the use of this resource is one of the strategy's objectives.

Unlike Bulgaria, Turkey does not regard forest as a stand-alone sector, and measures are identified by ecosystem type for forests along with other important ecosystem types, mountain, steppe, inland water, and marine ecosystems, with a view to maintaining/improving their condition and protecting the ecosystem services they provide.

Ecosystem services, biodiversity, and forest are also acknowledged as one of the five cross-cutting issues in the Strategy. Cross-sectoral measures such as review of legislation, monitoring that enables decision making, improved data collection, research and development (R&D) capacity building and infrastructure, awareness raising, institutional collaboration, and so on are set up for these cross-cutting subject areas.

Box 6. Austria - from strategy to specific interventions

The Austrian CCA strategy is very practice oriented. One of its key elements is setting up criteria for prioritizing adaptation measures. Based on this approach, measures from all sectors are treated uniformly and their grouping does not prevent the definition of very specific cross-sectoral measures.

For example, apart from large-scale tasks such as improving the knowledge base of climate change's impact on BD&ES and integrating climate change considerations in monitoring systems to provide early warning on species, habitats, and ecosystem levels, the strategy also defines tangible and easy-to-implement measures for improving the ecosystems condition while at the same time making optimal use of ecosystem services, such as perpetuation of extensive land use in mountain grassland ecosystems and management and adjustment of tourism activities for shifting from biodiversity harming to sustainable tourist activities.

The strategy is also very explicit in terms of tracking the CCA impact on ecosystem services and even contains a measure on conservation of ecosystem services in sustainable land use and nature conservation. It is complemented by a database outlining adaptation options and presenting case studies.

Box 7. Finland – system-based approach to BD&ES

The Finnish CCA strategy contains both a systemic approach to the CCA impacts on all sectors that rely on natural resources and an in-depth analysis of climate change impact on ecosystems and biodiversity. It includes measure definition that consider the capacity of species and habitats to adapt to climate change, that is, migratory ability of species.

Another important aspect of Finland's CCA approach to biodiversity is its granularity—measures are to be developed by biogeographic regions.

Ecosystems protection is placed in the greater scope of reducing other, non-CCA-related pressures and adverse factors caused by human activity and evaluating the integrity of the protected area network with a view to improving links between protected areas and allowing for species migration. The measures defined in such a manner are very coherent, and a good extension to in situ measures is provided by including ex situ conservation options. Measures clearly distinguish the actors in charge for their implementation, grouping them by public and private entity type.

2.3. EU CCA Legal Framework and Policies in the BD&ES Sector

131. The European legislative framework is undergoing a horizontal restructuring to include the ecosystems-based approach, in line with the overarching objectives set in the 7th EAP to 2020. This process is spread across many related policies, such as the Fitness Check and Action Plan of the EU Habitats and Birds directives,[52] the review of water policy instruments (freshwater including floods and nitrates, environmental quality standards, wastewater treatment, groundwater, and marine), forest, harmful emission ceilings, and sustainable use of pesticides. The EU-level review is under way with different deadlines, with some being very late into this planning period (for example, the water package has a review deadline of 2019) and others not yet adopted (soil framework directive was not adopted and is under review).

132. In addition, both the EU Biodiversity Strategy to 2020 and other related instruments (such as the Green Infrastructure Strategy) are not yet enacted at the EU legislation level and therefore not mandatory for implementation on a national level. Work is also ongoing on different levels of biodiversity; for example, the EU Habitats Red List was only released in 2016. Due to shortcomings found in the implementation of related legislation, there is also the danger of incompatible data, for example, between the 1st and 2nd river basin management plans in terms of reporting the environmental status of water ecosystems.

133. Unfortunately, this work goes in parallel with the actual implementation of the EU Biodiversity Strategy to 2020, making it virtually impossible for the MAES working group to deliver conclusive guidance to Member States in time for the implementation of Target 2 - mapping and assessment of ecosystems and biophysical assessment of their services by 2014, as well as monetary valuation and inclusion of ecosystem service value into national accounts by 2020. Once complete, however, such guidance is expected to contain indicators on climate change as pressure across all ecosystem types. These indicators will typically involve measuring the impact of climate change by ecosystem type, as well as in horizontal indicator sets (soil).

134. This circumstance is reflected in several issues in the policy-making and legislative process in the sector, as illustrated in ***Figure 9***.

[52] An Action Plan for nature, people and the economy, COM(2017) 198 final, see http://ec.europa.eu/environment/nature/legislation/fitness_check/action_plan/communication_en.pdf

Figure 9. Policy cycle and assessed issues in implementing the ecosystems approach to biodiversity

Note: For policies: green - adopted, orange - partially adopted or under revision, red - not adopted yet. For implementation: green - consistently implemented, orange - partially implemented, red - not implemented. Source: Authors' design.

135. Some relevant EU strategic, legislative, and implementation-related documents are summarized in the following paragraphs.

2.3.1. Strategic documents of the EU

General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'

136. The 7th EAP is an overarching document that creates the links between single environmental policies at the EU level. In particular, it explicitly links climate change by stating that *"...The Union's economic prosperity and well-being is underpinned by its natural capital, that is, its biodiversity, including ecosystems that provide essential goods and services, from fertile soil and multi-functional forests to productive land and seas, from good quality fresh water and clean air to pollination and climate regulation and protection against natural disasters. [...] the degradation and loss of natural capital is jeopardizing efforts to attain the Union's biodiversity and climate change objectives."* The Program further underlines the global socio-ecological processes by stating that *"...Environmental and climate change in the Union is increasingly caused by developments taking place at global level, including in relation to demographics, patterns of production and trade, and rapid technological progress. Such developments may offer significant opportunities for economic growth and societal well-being but pose challenges and uncertainties for the Union's economy and society and are causing environmental degradation worldwide." As necessary action, it states that "*…Ecosystem-based approaches to climate change mitigation and adaptation which also benefit biodiversity and the provision of other ecosystem services should be used more extensively as part of the Union's climate change policy..." Ecosystem restoration and green infrastructure are viewed as sources of important socioeconomic

benefits. These actions are viewed as pathways to enhancing ecological and climate resilience, as well as cost-effective options for climate change mitigation and adaptation and disaster risk management.

EU Biodiversity Strategy to 2020

137. On May 3, 2011, the European Commission adopted a new strategy to halt the loss of biodiversity and improve the state of Europe's species, habitats, ecosystems, and the services they provide over the next decade, while stepping up the EU's contribution to averting global biodiversity loss. It focuses on six major targets to address the main pressures on nature-and ecosystem services in the EU and beyond and lays down the policy foundations for EU-level action over the next 10 years.

138. The six targets covered by the EU strategy focus on (1) the full implementation of the EU nature legislation, (2) better protection and restoration of ecosystems and the services they provide, and greater use of green infrastructure, (3) more sustainable agriculture and forestry, (4) better management of EU fish stocks and more sustainable fisheries, (5) tighter controls on Invasive Alien Species, and (6) a greater EU contribution to averting global biodiversity loss.

139. Recognizing the need for a holistic approach and the shift toward ecosystem-level assessment, mapping, monitoring, and reporting, the European Biodiversity Strategy to 2020, required by the CBD,[53] includes Action 5 (Improve knowledge of ecosystems and their services in the EU). Action 5 requires the EU member states to assess the state of ecosystems in their national territories by 2014, as well as to assess the economic value of the ecosystem services and integrate these values into accounting and reporting systems on EU and national levels by 2020. To support this work, the MAES working group at the EU developed guidance documents—an analytical framework and indicators for ecosystem assessment.[54] These documents are mainly focused on biophysical valuation of ecosystem services since the work on their monetary valuation and inclusion into national accounts is still under way. Assessment of climate change impact on the ecosystems on the base of indicators will be done in the next years at the country level. The assessment of the climate change impact at the EU level was carried out recently (EEA 2017). Ecosystem restoration of at least 15 percent of the ecosystems is another priority of the EU Biodiversity Strategy to 2020, in particular Action 6 (Restore ecosystems, maintain their services and promote the use of green infrastructure) which creates the link between ecosystem conservation and restauration, as well as to the EU Green Infrastructure Strategy. The mid-term review of this target finds that increased efforts are needed to meet it against the background of strong or very strong pressures to most of the European ecosystems.

140. The concept and goals of environmental accounting have been discussed for over two decades at the international level and earlier than that in academic circles. The first global

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[53] https://www.cbd.int/convention/.

[54] Both documents are available as follows: An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020 (Discussion paper - Final, April 2013): http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf; Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020 (2nd Report - Final, February 2014: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf.

environmental-economic accounting standards (SEEA) were already published by the United Nations Statistics Commission (UNSC) in 1993 and revised in 2012/13. Natural capital accounting is also reflected in the 2012 Aichi targets under the CBD. Global goals of environmental accounting are also integrated into EU legislation (notably Regulation 691/2011, which introduced three modules into EU accounting systems: air emission accounts, accounts on environmental taxes, and material flow accounts). Bulgaria has applied for project funding granted through Eurostat to support the development of national accounts.

The EU Strategy on adaptation to climate change to 2020

141. The EU strategy on adaptation to climate change acknowledges that *"Ecosystem-based approaches are usually cost-effective under different scenarios. They are easily accessible and provide multiple benefits, such as reduced flood risk, less soil erosion, improved water and air quality and reduced heat-island effect"*. The Strategy further states that the Commission will provide guidance as needed to ensure the full mobilization of ecosystems-based approaches to adaptation; the LIFE financial instrument will encourage green infrastructure and ecosystems-based approaches to adaptation.

An Action plan for nature, people and the economy, Communication COM (2017) 198 final

142. This Communication summarizes the findings of the 'Fitness Check' evaluation of the Birds and Habitats Directives. It introduces an Action Plan consisting of 4 priorities and 15 actions. The report on Bulgaria specifically identifies the sound enforcement of Nature Protection Legislation as one of the challenges for the country. The opportunity is defined as 'Integrating the nature and biodiversity policy into other sectorial policies and defining conservation objectives and measures for the adequate protection and management of the NATURA 2000 sites.' The report identifies a number of sectoral improvements for Bulgaria, including delays in building environmental infrastructure due to appeals in relation to Environment Impact Assessment and NATURA 2000; the environmental friendliness of agriculture (including for intensive agriculture) may be considered by Bulgaria. The area of pastures is below the legally mandated 10 percent, and there are inconsistencies in determining environmentally sensitive pasture areas and the scope of subsidized cultures therein (a finding reinforced by the pilot within the grassland ecosystems mapping project IBER-GRASS).

EU Forest Strategy 2013

143. In this strategy,[55] an important part is also dedicated to biodiversity, especially in forest ecosystems. It is important to maintain and enhance the resilience and adaptive capacity of forest ecosystems, including through fire prevention and other adaptive solutions (for example, appropriate species, plant varieties, and so on). At the same time, forest management can mitigate climate change if forests' role as sinks in the carbon cycle is maintained, replacing carbon-intensive materials and fuels. Forests also mitigate the impact of extreme weather events by moderating temperatures and reducing wind speed and water runoff. The Strategy's Priority Area 4, which is also being implemented consequently in Bulgaria, outlines specific measures that are highly relevant to promoting the win-win aspects of CCA and mitigation.

[55] http://eur-lex.europa.eu/resource.html?uri=cellar:21b27c38-21fb-11e3-8d1c-01aa75ed71a1.0022.01/DOC_1&format=PDF.

Communication COM/2013/0249 final 'Green Infrastructure (GI) - Enhancing Europe's Natural Capital'

144. This is a document highly synergetic to both the EU Biodiversity Strategy to 2020 and the environmental aspects of the EU strategy on adaptation to climate change. Green infrastructure provides a way to enhance ecosystems' resilience by mitigating the effects of land use and ecosystem fragmentation while at the same time using ecosystem services to find cost-effective solutions for replacing gray infrastructure in the adaptation to extreme weather events caused by climate change.

2.3.2. EU legislation

145. To achieve the synergetic goals in different EU strategies outlined earlier, the CCA policy must be deeply integrated with many sectoral policies, as well as with the horizontal area of ecosystems and biodiversity.

146. Since the beginning of accession negotiations, the EU legislation has provided a framework for Bulgaria's policy development and environmental legislation. EU policies related to biodiversity span, with varying degrees of coherence, various aspects of biodiversity often referred to as 'elements of the environment', including specific targets for biodiversity conservation with legislative protection for key habitats and species, or other sectoral EU legislation, such as legislation on agriculture and forestry, fisheries, environment pollution, and climate change.

147. The EU and global biodiversity targets are partly delivered through legislative measures, which oblige the Member States to protect BD&ES. The EU and Member States have shared legal competence in implementing legislation for the environment—BD&ES.

In relation to wildlife and nature conservation, two key directives have been adopted:

- Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (Birds Directive)[56]
- Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)[57]

148. These directives provide for the protection of animal and plant species of European importance and the habitats that support them, particularly through the establishment of a network of protected sites—NATURA 2000.[58] The NATURA 2000 sites are designated to protect about 500 bird species and over 1,000 other species all over Europe.

149. Other EU legislations related to various aspects of the biodiversity include Council Directive 1999/22/EC of 29 March 1999 on the keeping of wild animals in zoos[59] (which also sets standards for the ex situ preservation of species and research in this area); the legislative package[60] implementing the Convention on the trade in endangered species of wild fauna and flora (CITES), prohibiting the trade in seal products and setting humane trapping standards; Regulation (EU) 1143/2014 of the European Parliament and of the Council of 22 October

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[56] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0147
[57] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992L0043
[58] http://ec.europa.eu/environment/nature/natura2000/index_en.htm
[59] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.1999.094.01.0024.01.ENG
[60] http://ec.europa.eu/environment/nature/legislation/wildlife/index_en.htm

2014 on the prevention and management of the introduction and spread of invasive alien species[61] (the IAS Regulation); the set of legislation on Genetically Modified Organisms; and Regulation (EU) No 511/2014 of the European Parliament and of the Council of 16 April 2014 on compliance measures for users from the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization in the Union (covering the equitable use of the ecosystem services on a genetic level).

150. The EU's environmental legislation is complemented by a variety of other nonbinding policy instruments[62] such as strategies, programs, and action plans to address the wider use of terrestrial and marine resources. By these means, the EU also aims to fulfill its international commitment under the CBD.

151. Some of this legislation currently needs better linking to CCA. Indications from the MAES process show that this is a priority area for the next planning period.

2.3.3. EU information and classification standards, guidelines and supporting tools

152. Apart from the strategic and legislative documents, the EU has worked over the years with Member States on practical guidance documents and policy implementation tools. Significant work has been done to develop unified indicators for biodiversity by targets used in the Biodiversity Information System for Europe (BISE) to measure the achievement of EU targets—the BISE indicators[63]—that underpin the entire EU strategic and legislative process in biodiversity and related areas such as agriculture, land use and landscapes, water biochemical parameters. The subset of BISE indicators related to biodiversity are the Streamlining European Biodiversity Indicators (SEBI) indicators,[64] created and reviewed within the EU's obligations under the Convention for Biodiversity and complementing another EU-level indicator sets. A set of ecosystems mapping and assessment indicators, and ecosystems services indicators is under development in the MAES working group.

153. The EU Commission and the EEA have released several key guidance documents and datasets related to biodiversity. Regarding climate change and NATURA 2000 management, a key document is the Guidelines on Climate Change and NATURA 2000.[65] For BD&ES both in and outside NATURA, a series of reports related to the mapping and assessment aspects are being published.[66] The Guide to Cost-Benefit Analysis of Investment Projects[67] is a more horizontal document, which is mandatory for large EU-funded projects and creates a local-level link between the investment, climate change, and environment impact assessment aspects when building different types of infrastructure.

154. A great number of information resources and case studies are available. Among the most relevant are the Climate Adapt platform[68] containing information and tools both on an EU level and from all Member States and the Biodiversity knowledge and data platform[69].

[61] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1417443504720&uri=CELEX:32014R1143
[62] http://jncc.defra.gov.uk/page-5324.
[63] http://biodiversity.europa.eu/policy/eu-biodiversity-indicators-and-related-eu-targets-simplified-overview.
[64] https://www.eea.europa.eu/themes/biodiversity/indicators#c7=all&c5=all&c10=SEBI&c13=20&b_start=0.
[65] http://ec.europa.eu/environment/nature/climatechange/pdf/Guidance%20document.pdf.
[66] http://biodiversity.europa.eu/maes.
[67] http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf.
[68] http://climate-adapt.eea.europa.eu/.
[69] http://ec.europa.eu/environment/nature/knowledge/index_en.htm.

2.3.4. Other documents affecting biodiversity in the climate change context

Sendai Framework for Disaster Risk Reduction 2015– 2030

155. This internationally agreed framework,[70] although not directly targeting biodiversity, has synergy-building potential between ecosystems-related management, building up resilience, and green infrastructure through the Build Back Better principle that could be used to rectify the consequences of previous management decisions.

Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire[71]

156. While focusing on the protection and monitoring of only one type of ecosystem, this legislation has an impact on biodiversity as a whole due to the importance of forest ecosystems as a source of services used by other ecosystems and their close spatial interrelation with small but rich ecosystems such as rivers and lakes, grasslands, and sparsely vegetated ecosystems incorporated in the forests, as well as the heathland and shrubs that mark the forest fringes and in some cases transition into forests.

Legislation concerning the environmental impact assessment and abiotic factors that impact BD&ES

157. At the interface between the environment and human interventions for commercial activities, urban and spatial planning, is the EU impact assessment legislation regulating the strategic assessment (Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment[72]) and the environmental impact assessment (EIA) (Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment[73]).

158. Further relevant legislation covering the protection of the abiotic environment shared between humans and biodiversity within the ecosystems includes Directive 2000/60/EC[74] (Water Framework Directive), under which Member States are required to protect and improve their inland and coastal waters, and Directive 2008/56/EC[75] (Marine Strategy Framework Directive) to achieve good environmental status in their marine environment by 2020. Newer legislation increasingly includes in its scope requirements to assess the policy actions’ impact on ecosystems, one recent example being the revision of the National Emission Ceilings directive (Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC). Relevant for the ecosystem-based approach in coastal zones is also Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning.[76] Although soils are also a vital abiotic factor for ecosystems and vulnerable to erosion from climate change effects, the EU Member States have not yet reached agreement on the stipulations on a Union-wide soil legislation.

[70] http://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf.
[71] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31992R2158.
[72] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32001L0042.
[73] http://ec.europa.eu/environment/eia/pdf/EIA_Directive_informal.pdf.
[74] http://ec.europa.eu/environment/water/water-framework/index_en.html.
[75] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008L0056.
[76] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1511878702172&uri=CELEX:32014L0089.

2.4. Bulgarian CCA Legal Framework and Policies in the Sector

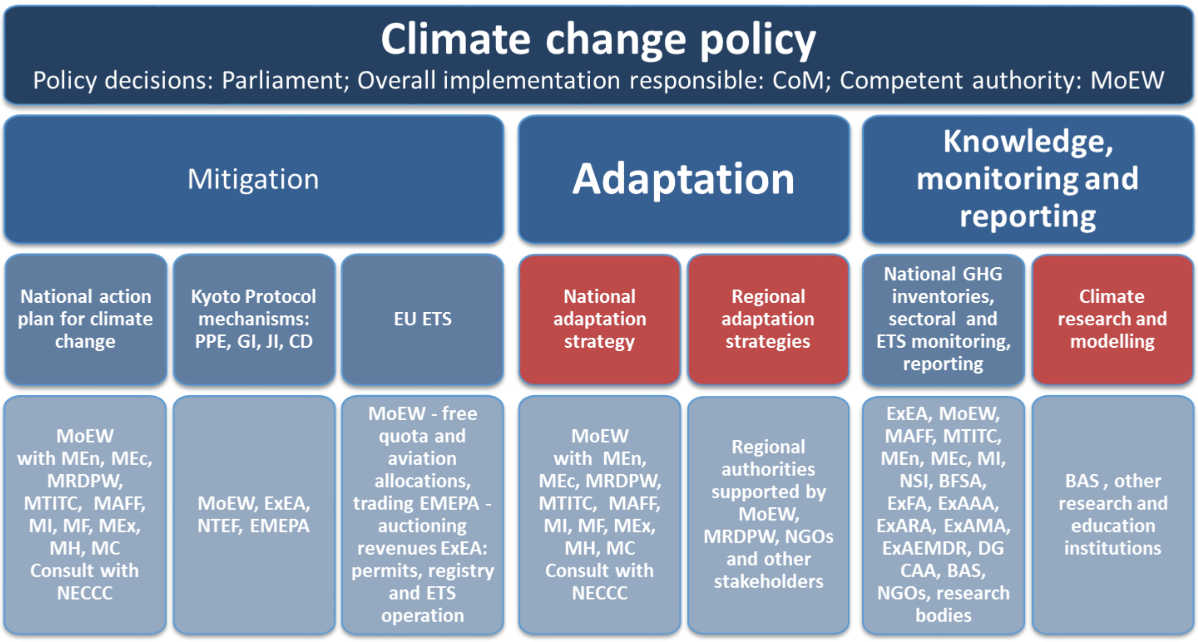
159. As mentioned in the introduction, a cohesive legal connection is yet to be created in Bulgaria between CCA and BD&ES management. A foundation for such cohesive linking is provided by the National Environment Strategy 2009–2018[77] that establishes the climate-induced biodiversity loss as one of the challenges to be tackled. The main national legal document creating such a link is the **Environment Protection Act (EPA)**. This sector-overarching act regulates the strategic process in all areas of environmental protection, monitoring, and management. It mentions both climate change and ecosystems but does not go into specifics such as CCA or ecosystem services that are regulated in other special law. The EPA states the principle of mainstreaming of environmental policies (including climate and biodiversity policies) across other sectors. Article 93 introduces, albeit without mentioning ecosystems, the concept of assessing the carrying capacity of natural environment as part of the EIA. This presents a good basis for introducing a coherent, ecosystem-based approach that would consider the climate resilience of ecosystems and the ecosystem services they provide to facilitate CCA in other sectors. Environmental monitoring is defined as the monitoring of 'elements of environment' rather than holistic monitoring.

160. The two legal acts regulating CCA and biodiversity are presented separately in the following sections, and specific needs are also noted for their alignment in recommendations from this analysis.

2.4.1. Climate change legislation

161. The main piece of legislation related to climate change is the CCMA. It outlines the institutional responsibilities and stakeholder involvement mechanisms, (***Figure 10***).

Figure 10. 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.

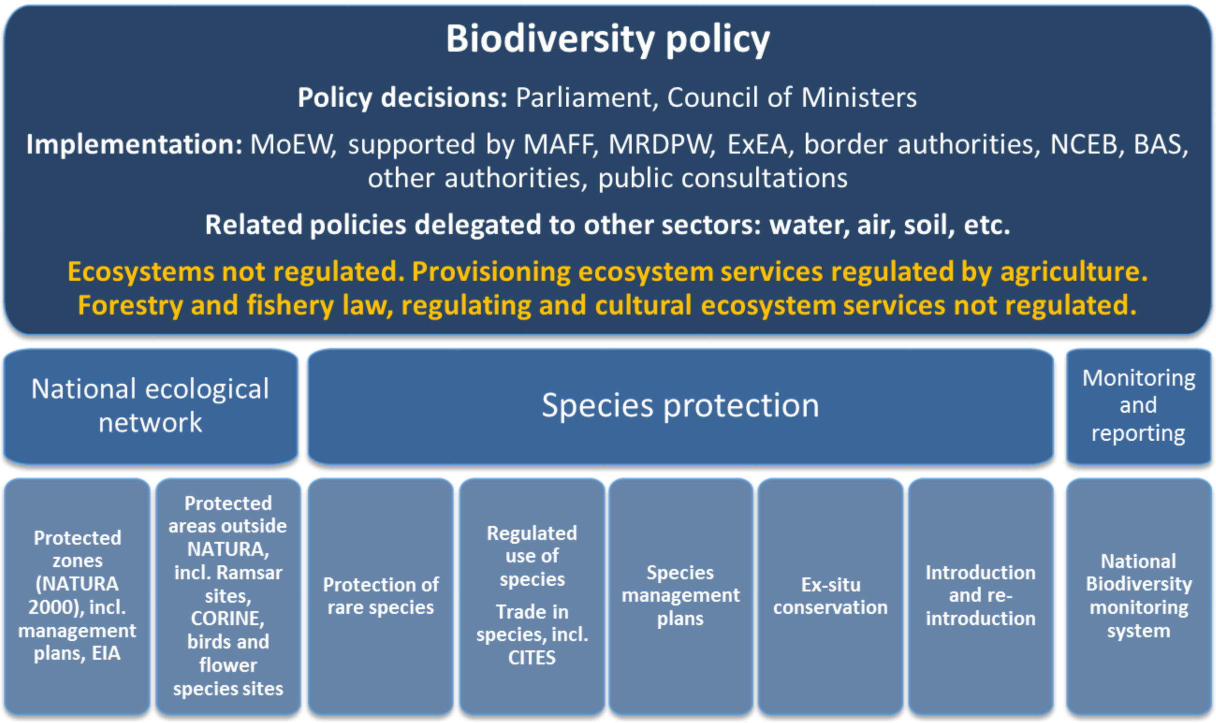
[77] Draft as approved by the Council of Ministers is available at http://www.moew.government.bg/bg/s-reshenie-353-ot-15-maj-2009-g-ministerskiyat-suvet-odobri-nacionalna-strategiya-za-okolna-sreda-2009-2018-g/

162. Due to a traditionally better understanding of mitigation issues and the relative ease of emissions monitoring as compared to climate change effect monitoring, in many projects and the resulting documents, there is a confusion between climate change mitigation and adaptation, although the two areas may involve completely different sets of measures. The primary focus of CCA in Bulgaria tends to be on social adaptation to extreme events, whereas environmental adaptation and its potential for social issues are less well defined and regulated. Specific regulations mainstreaming CCA in other sectors, especially BD&ES, may be appropriate to create synergies with existing legal texts on the biophysical protection of ecosystems. An aspect worth adding is the incorporation and proper valuation for the use of ecosystem services as an adaptation tool for other sectors.

2.4.2. Biodiversity policy and legislation

163. The existing Biodiversity Strategy for Bulgaria was created in the 1990s and a new one is to be produced. This circumstance, along with the generally uneven adoption of biodiversity policies and the ecosystems approach by other sectors on the EU level, has led to a scattering of biodiversity-related legislation across sectors. The ecosystems approach that has the potential to provide the link to CCA, in line with the 7th EAP, needs to be added to this framework in compliance with the overall direction of EU biodiversity policy switch.

Figure 11. Structure and main actors in implementing the Bulgarian biodiversity protection policy



Source: World Bank design.

164. The main legislative act in the area of BD&ES is the **Biodiversity Act**. It defines a National Ecological Network consisting of protected NATURA sites, protected areas outside NATURA, and other important sites such as CORINE sites and Ramsar sites. It also regulates the protection of species in situ or ex situ, limitations in the trade and commercial use of species, and species introduction and reintroduction. The Biodiversity Act regulates the designation and management of protected zones and areas, including management plans and

the Ecological assessment and Environmental Impact Assessment (EIA) of plans, programs, and proposed investment projects. The Biodiversity Act further stipulates the process of preparing and approval of the National Biodiversity Strategy and Action Plan and the bodies responsible for implementing these.

165. In the Biodiversity Act, ecosystems are defined as part of the biodiversity and their protection in the functional sense is mentioned but not elaborated upon; the concepts of ecosystems' carrying capacity and ecosystem services need to be added in the assessment requirements for proposed investments. As with the EPA, elaborating on them could be a good stepping stone to link CCA and biodiversity legislation. In addition, the **Protected Territories Act** differentiates the types of territories to be protected and their respective protection regimes and states the protection of biodiversity, ecosystems, and the abiotic environment as a specific objective of protected territories. This is a good basis for implementing CCA in the protected territories of all types, specifying their respective regional and local adaptation objectives with respect to the BD&ES.

166. As with the EU legislation, other laws related to the biotic and abiotic components of biodiversity are also in force. The legislation most closely concerning the biotic components of biodiversity comprises the Healing Plants Act, the Genetically Modified Organisms Act, the Hunting and Game Protection Act, the Fisheries and Aquacultures Act.

167. Specific ecosystems with high economic importance are regulated by several acts each, such as the legislation related to forestry (Forestry Act, Ownership Restitution over Forest and Forest Fund Land Act) and to agriculture (the Agriculture Act, the Act on Ownership and Use of Agriculture Land, the Agriculture Rents Act, the Livestock Breeding Act, and the Plant Protection Act). While the Forestry Act specifically enumerates all three types of forest ecosystem services (provisioning, regulating, and cultural) and stipulates their valuation, the agricultural legislation focuses on provisioning services, and the concept of ecosystem based CCA is yet to be introduced in its key legal texts.

168. Legislation regarding the abiotic environment vital for biodiversity includes the Water Act, the Soils Act, and the Ambient Air Quality Act. Property and social relationships that heavily influence biodiversity are also regulated in the Spatial Planning Act and the Black Sea Coast Act.

169. To achieve its objectives, the biodiversity legislation also relies on extensive secondary legislation that details implementation procedures and responsible institutions. Some key secondary legislation includes the ordinances on management plans for protected zones and species, the collection of genetic materials from healing plants, handling species individuals (introduction and reintroduction, marking and labeling, rearing in zoos), handling and release of genetically modified organisms, and so on. This secondary legislation was mostly established by 2012 and was not changed in substance since then. It therefore also does not employ the ecosystem service concept developed in later EU documents that could systematically link and focus the analysis of protected zones and necessary investments for sustainable economic activities in them.

170. The biodiversity legal framework currently details and regulates mostly species and habitats protection, and no reference is made to ecosystems or territorial groups of ecosystems

forming landscape mosaics where ecosystems produced in the protected areas may flow and be used for CCA outside them. Integrating the ecosystems approach that is being implemented through a number of strategies and legal instruments at the EU level (such as the 7th EAP, the Biodiversity Strategy to 2020, and the Green Infrastructure Strategy) would touch upon many other policies, such as water, emissions, green infrastructure, and IAS. It presents a challenge while it could also create co-benefits by linking biodiversity and CCA through the bridge of cost savings by ecosystem services that are useful for adaptation in other sectors and mitigation.

171. A key specific of biodiversity legislation and the institutional setup it creates, it creates is the division in responsibilities between institutions, placing BD&ES, on the one hand, and harvesting of provisioning ecosystem services, on the other, under different administrations. This organization causes a potential for institutional and stakeholder conflicts at the national and regional level, as well as a financial bias toward overexploitation of ecosystems for harvesting their tradeable services while externalizing of ecosystem disservices (such as ecosystem fragmentation, diffuse pollution, and so on).

172. To achieve benefits from CCA, a valuation of all ecosystem services, including provisioning and cultural, is necessary. It could create incentives for employing new economic instruments in their sustainable use—in line with the funding priorities for the next programming period of the EU Structural and Investment Funds. In this manner, stakeholders' environmental concerns can be aligned with economic considerations in an informed process of finding trade-offs, and effective financial incentives are more likely to be created for addressing other pressures, in particular IAS and fragmentation in this legal and institutional framework.

173. To strengthen the adaptation gains from biodiversity, the existing institutional division between protecting environment and harvesting benefits from its provisioning services can be alleviated by introducing balanced, ecosystems-based monitoring. The biodiversity monitoring system also was set up before the adoption of integrative EU-level strategies and policies based on the ecosystems approach. It therefore mirrors the overall concept of 'ecosystem elements' instead of a holistic ecosystem approach, leaving out a concept of ecosystem 'health' and resilience that enhances the adaptability to climate change.

174. Successful CCA, however, needs an early-warning system where ecosystem failure could suddenly and catastrophically deprive society (and particularly its vulnerable populations) of important regulating ecosystem services and decrease their climate resilience. Updating the monitoring mechanisms will, therefore, need to include measuring the full stocks and flows of ecosystem services in as nearly real time and as much spatial detail as feasible. Such an update does not need to be prohibitively costly. Optimizing the existing monitoring so that measurements made once can be reused across many reporting mechanisms will save the need to collect data repeatedly for implementing fragmented 'policies'.

175. Also, the increasingly cheap and pervasive new technologies allow unprecedented amounts of spatial observation data to be collected, and machine learning/artificial intelligence tools are also likely to become available for environmental purposes soon.

176. Finally, the optimal reuse of collected information from existing data sources (such as citizen science or the field data collected during the EIA) as part of ecosystem-based monitoring may cut data collection costs, save time, and contribute to achieving a better picture of climate change impacts on ecosystems and biodiversity.

177. Another specific of the current BD&ES framework that causes increasing social tensions is the need of interinstitutional cooperation for decision making. In effect, decision making may be slowed down both due to conflicting objectives on the national and local scale or to insufficient sharing of data and information concerning the benefits of biodiversity. The resulting public controversies lead to lengthy, sometimes polarized, public consultations and legal proceedings. CCA, conversely, requires speed response. The latest legal modifications that reduce the red tape in legal appealing of management plans are a step in cutting the time for decision making. However, much more significant gains in processing time for strategic assessments and EIAs could be achieved if the assessors could use them for focusing their fieldwork and data collection:

- Interoperable, preprocessed shared data on ecosystems condition and services from environmental monitoring and other assessments near the site of interest
- Climate and ecosystem-level projections

178. Opening collected data will arguably result in its better combination to quickly and more precisely retrieve new information. This will support policy implementation and decision making for adaptation in biodiversity and other sectors. It will also result in the more efficient implementation of horizontal legislation such as state aid and green public procurement, as well as better return for money on the investment in data by EU and national budgets. Balancing legitimate public and private concerns such as business and privacy considerations will necessarily set limitations to the opening of data. It will, however, also have numerous added benefits:

- Increased transparency and public awareness about the decision-making process caused by using more open data for justifying informed decisions regarding biodiversity
- Reducing the risks of mismanagement caused by premature and insufficiently well-informed management decisions that may lead to undesired adverse effects on BD&ES and decrease their climate resilience in the long term
- Economic benefits from the access of business to environmental data and models to streamline the use of ecosystem services to cut costs
- Combining strategies in different sectors dealing with various ecosystems to strengthen adaptive capacity
- Simplified data structuring for reporting under different EU policy instruments
- Yielding additional awareness benefits such as informing biologic agriculture and green public procurement

179. A positive aspect of the biodiversity legal framework is that the management plans and EIAs can be used both to set biologically sound measures (including prohibition or limitation of specific uses) and to derive information on past ecosystem condition. Both types

of investigation are elaborated on species and habitats levels and allow conclusions about protected species even in the case of additional conceptual framework being over-imposed in future. The constitution of a new directorate in charge for the EIA with the new Statute of MoEW as of October 1, 2017, is expected to streamline these assessments both within the country and in the cross-border context.

2.4.3. Conclusions and recommendations

180. The adaptation of Bulgarian BD&ES to climate change is currently not the main focus of local and regional adaptation policies, which are, in many cases, focused on reactive actions in response to disasters rather than proactive mitigation of adverse climate change effects on biodiversity.

181. Potential for BD&ES adaptation is contained in the Build Back Better principle adopted in the draft Disaster Preparedness Strategy and similar potential is to be uncovered in other sectors. In the spirit of European strategies that are harmonized to create a common framework for coping with problems across sectors, it is necessary to link the legal framework and its implementation across all sectors in line with the 7th EAP and other relevant strategic documents in CCA, biodiversity, and related policies. The main directions of such alignment are as follows:

(a) **Strategic and legal adjustments**. They should be introduced on several levels:

- **Developing and adopting a new sectoral Strategy for Biodiversity**. Action on this point is paramount for focusing CCA in the sector since without it any adaptation options will be based only on EU strategies and best practices from other countries that may not be entirely appropriate for Bulgaria. This new strategy will bring forward the ‘invisible’ regulating and cultural ecosystem services and the focal point of ecosystems-based solutions to link CCA and biodiversity in line with the 7th EAP, the EU Biodiversity Strategy to 2020, and the CCA Strategy.
- **Developing and adopting a green infrastructure strategy**. Green infrastructure is emerging as one of the key instruments for strengthening the climate resilience of ecosystems outside the protected areas and zones and can be a source of significant cost cuttings in other sectors. Creating green infrastructure can also be a source of new economic development not only in urban but also in economically weaker rural areas. In the absence of a dedicated strategy, however, some ecosystems (such as trees along riverbeds) that may be used for adaptation are outside the scope of strategies and legislation.
- **Aligning the new strategy documents to already developed and/or adopted strategies.** Due to the complex nature of BD&ES and the way regulating ecosystem services are produced and used across ecosystems, the strategic framework should be highly synergetic to existing strategies in related sectors such as the National Environment strategy, National Strategy for Sustainable Agricultural Development, National Strategy for Management and Development of the Water Sector in Bulgaria, National Transport and National Integrated Transport Strategies, National Strategy for Development of the Forest Sector,

National Strategy for Disaster Risk Reduction, the National Energy Strategy, and the National Concept for Spatial Development. In turn, strategic documents related to the population, human resource development and well-being, such as the National Strategy for Demographic Development, National Health Strategy, the National Strategy for Poverty Reduction, and Social Inclusion Promotion, as well as the National Strategy for Sustainable Tourism Development should inform the process of creating the new biodiversity strategy in terms of considering the projections for possible anthropogenic pressures and the demand for ecosystems services that can be expected.

- **Introducing CCA into the climate and biodiversity legislation, as well as the legislation in related sectors**, that is, energy, forestry, agriculture, and transportation, and in the management of water, air quality, waste, emissions, noise, and light pollution. The legislative recognition of regulating ecosystem services as one of the key adaptation benefits of biodiversity, as well as the cultural services as a complementary source of economic resources for adaptation, should be mainstreamed into this legislation to balance the overemphasis on provisioning ecosystem services and operationalize the adaptational and social benefits of protecting biodiversity for all other sectors. The legal framework adaptation should create operational procedures and clear responsibilities across all sectors, in particular in terms of introducing systematic ecosystems-based monitoring and mechanisms to share data, knowledge, and projections on the climate change impacts on BD&ES.

(b) Harmonization of the biodiversity sectoral strategies and legislation with other related legislation, to ensure unified monitoring and free sharing of data on environmental condition. Data from currently unlinked sources, such as EIA reports, sectoral reporting data for different directives, and data from research sponsored using funding from budgetary (such as for the NIMH according to the Water Act) and project sources, should also be shared openly; easy and open provision of data for research related to modeling of climate processes and biodiversity.

(c) Another key aspect is the need for more adequate presentation of ecological aspects of biodiversity loss to society. Fixing attention on the protection of single species does not provide the stakeholders with the reference frame for understanding the potential and benefiting from ecosystem services in business and social life. As a result, proposed policies are not always fit for purpose. Moreover, incorrect communication leads to confrontation between stakeholders on the national and local levels or between representatives of different social and business interests. These tensions can be avoided by achieving constructive consensus on the sustainable use of ecosystem services for the benefit of society.

2.5. Institutional Framework and Stakeholder Community

2.5.1. Institutional framework

182. As noted earlier, there is currently no operational link between climate change and biodiversity strategies and legislation despite the many possible synergies between these areas. This also reflects in the institutional framework, described below, in that some of the functions of key institutions are described based on general legislation such as the EPA instead of more detailed strategic and legislation documents yet to be set in place. Both climate change and biodiversity, being policies to be mainstreamed across sectors, share a joint national institutional framework on the strategic and legislative levels. It consists of the following:

- **The Bulgarian Parliament.** The body in charge of legislating the climate change policy and financial allocations for their implementation.
- **Council of Ministers.** The body in charge of approving the national climate change policy, approving the staff allocations through the Statutes of bodies responsible for climate policy implementation, and drafting the financial resource allocations.
- **MoEW.** As the national body in charge of the overall environmental policy, this is the unifying administration to prepare and implement the strategic and legislation changes necessary in the sectors of CCA and biodiversity. The overall responsibility of the MoEW as a policy-making body in many other relevant sectors such as water, waste, soil, and air quality policies include imposing additional integration requirements on the respective units to achieve a cross-sectoral harmonization for mainstreaming the CCA in BD&ES and the ecosystems-based approach. The newly created Environment Impact Assessment Directorate (operational since October 2017) should also be closely involved in the operationalizing of the ecosystem approach.
- **Other line ministers, agencies, and government-appointed bodies** include policy-making and implementing authorities across sectors affected by or affecting biodiversity, as well as bodies with horizontal functions. The former include the Ministers of Economy, Energy, Transport, IT and Communication, Agriculture, Food and Forestry, Interior, Exterior, Regional Development and Public Works, Health, Education, and Sciences, Labor and Social Policy, and Culture, as well as the State Agency for National Security, the Executive Forest Agency, Bulgarian Food Safety Agency, Executive Agency Automobile Administration, Executive Agency Railway Administration, Executive Agency Maritime Administration, Executive Agency for Exploration and Maintenance of the Danube River, Directorate General Civil Aviation Administration, Bulgarian Academy of Science, National Trust Ecofund, and Enterprise for Management of Environment Protection Activities. The latter include the Minister of Finance and the National Statistical Institute.
- **The ExEA** is currently the main executive body in charge of key activities related to climate change mitigation. According to the EPA, the ExEA is also a focal point for environmental data collection and reporting and in charge of the National Environment Monitoring System. Therefore, it is to be expected that it will play a

key role both in the CCA and biodiversity sectors and ultimately in introducing the ecosystems-based monitoring.

- **Regional Inspectorates of Environment and Water** are the bodies that, together with the local authorities, implement environmental policies at the regional and local levels. Their competencies span both biodiversity and some related sectors under the Minister of Environment and Water. The shared competencies between Regional Inspectorates for Environment and Water (RIEWs) and the regional/local authorities are described in general terms in Article 10 of the EPA and will likely be further specified once the relevant new or amended sector legislation is in place.
- **The National Park Directorates and Nature Park Directorates.** The Rila, Pirin, and Central Balkan National Park Directorates are administrative structures under the MoEW ensuring the implementation of national policies for the protection of their respective territories. Together with the Nature Park Directorates under the Executive Forestry Agency, they manage the bulk of protected areas containing forest ecosystems. Having in mind the importance of forest for the climate change resilience both in other ecosystems and in other sectors, their role in setting up and practical implementation of ecosystems-based monitoring in Bulgaria is likely to increase.
- **Basin Directorates** (BasD) are in charge of the water management policies in the four basin territories of Bulgaria (Danube, East Aegean, West Aegean, Black Sea). The close relation of water and biodiversity policies, also reflected in the environmental objectives of the water legislation, is likely to be reflected in a closer involvement of the BasD in the implementation of the ecosystems-based adaptation and monitoring.
- **Governors** are in charge of implementing environmental policies at a district level across a number of municipalities. While their specific obligations will likely be set in the new or amended legislation, it is to be expected that they will be a focal point of possible conflicts between different stakeholders and will have to develop the capacity of mediating trade-offs between stakeholders.
- **Mayors** are the key bodies to decide on the local policy mix, particularly the selection of adaptation options for all sectors represented on a given territory. As such, they will be instrumental in recognizing and communicating the importance of ecosystem services and their benefits for CCA.

2.5.2. Stakeholder community

183. Biodiversity is a policy area that has many stakeholders in different institutions. Some parts of biodiversity, particularly heavily modified ecosystems used for human habitation (urban), nutrition, and sustenance (that is, cropland ecosystems, fisheries, and freshwater ecosystems) are regulated by other policies both on the EU and national levels—see ***Figure 10*** and ***Figure 11***. The respective stakeholder communities for these sectors are described in detail in the sector reports and will not be repeated here. It is, however, to be noted that in the absence of a common strategic underpinning, there is a chance of conflicting interests. Stakeholders are spread across several institutions and policy coordination may also

be difficult due to organizational reasons.

184. This situation can be further aggravated by the significant material and financial interests invested in some locations where the trade-offs between provisioning or cultural ecosystem services related to tourism and the 'invisible' regulating services vital to climate change that are taken for granted as positive externalities are decided on without a sufficient awareness of the consequences. As a result, such differences lead to controversies in the local spatial planning and slow down the implementation of biodiversity protection. The stakeholders directly related to the climate change or biodiversity policies are as follows:

- **Expert councils** are being created under the EPA and special legislation such as the CCMA. They include the Expert Ecological Councils at the MoEW, ExEA and RIEW; the Basin Councils; the National Expert Council on Climate Change; and the National Council of Experts on Biodiversity. At the MoEW, there are a Higher Environmental Expert Council and a Specialized working group at the Higher Environmental Expert Council (which considers and adopts the Management plans).
- **Regional and branch associations** include the National Associations of Municipalities of Republic of Bulgaria, Regional Municipal Associations, Regional Initiative Groups who are increasingly entrusted with BD projects, and the Bulgarian Association of Municipal Ecologists. It is to be expected that the employer associations and trade unions in branches related to biodiversity (such as beekeeping) as well as specific branch organizations, of the insurance and IT branches, may also be involved in the immediate BD&ES adaptation. Also, branch organizations more involved in related branches will likely be stakeholders in the sector as well. Examples of such organizations are the tourist associations and associations of forest owners.
- **NGOs** have a long-standing engagement both in climate change and biodiversity. Some of them, such as the WWF, the Bulgarian Society for the Protection of Birds, Green Balkans, and BlueLink (to name just a few) are among the pioneers of ecosystems-based approach and will likely continue to be instrumental in citizen science and communication efforts.

2.6. Financial and Human Resources in Bulgaria

2.6.1. Financial resources

185. Bulgarian budget funding on environment (including biodiversity, ecosystems, and CCA) is limited due to the low GDP and the need to prioritize spending commitments on adopted policies across many policies.

186. Funding for both biodiversity and CCA is available from numerous sources, presented in ***Annex 6***. However, a number of objective and subjective obstacles exist to its efficient utilization. These include the following:

(a) **Fragmentation of funding sources.** As evident from ***Annex 6***, many programs fund similarly worded objectives and potential beneficiaries of the funding must follow all of them and apply for funding by several of them with their different schedules, to obtain funding.

(b) **Discrepancies in funding objectives and periods.** Different donors have different funding conditions and planning periods, the programming of each of the funding instruments goes at a different speed, and the program implementation (including calls for proposals, evaluation, and project selection) differs in its timings. Because programs also fund by territory, this often means that the same activities must be funded over different periods. An example is the mapping and assessment of ecosystems and their services. Because EU funding is limited to NATURA 2000, an administrative division by funding source had to be made between mapping of NATURA areas (yet to be funded by the OP Environment) and mapping outside NATURA (concluded with EEA FM funding).

(c) **Different and in some cases overly complicated procedures for obtaining funding and project implementation.** Beneficiaries are responsible for complying with a number of regulations, such as public procurement (which is very competitive in Bulgaria and appeals taking months and years can lead to a project failure), state aid (a subject very much relies on EU Court rulings for defining what is state aid and whether it complies with the Common Market), financial and good governance legislation, and a host of program-specific implementation and reporting rules. In this manner, a significant administrative overhead is placed on project implementation along with the project-specific work that drives the application.

(d) **Too general statement of objectives by program.** Each program has its own 'intervention logic' based on a different set of objectives. These are typically stated in general terms, both in the program and the calls. As a result, the selected projects have a different degree of relevance to the biodiversity and CCA objectives; being implemented in parallel, projects also are not always consistent with each other even if the program's efforts are aimed at links between them.

(e) **Financial and cash flow difficulties.** Own contribution is difficult to commit and raise, which is one of the major obstacles to higher utilization of LIFE+/LIFE funding and may pose an even bigger problem for utilizing financial instruments.

(f) **Need for institutional and financial capacity to negotiate, institutionalize, and implement financial instruments to promote ecosystem services provision for CCA.** Both the institutionalization and the implementation of financial instruments require the involvement of business stakeholders (such as financial institutions, insurance companies, green economy operators, pharmacies, and other businesses benefiting from ecosystem services). However, organizations involved in biodiversity preservation typically do not include business stakeholders; being noncommercial and not-for-profit organizations, they are also in many cases dependent on grant funding and are not credit worthy.

2.6.2. Human resources

187. In climate change, the regulatory obligation to allocate human resources exists mainly for mitigation and not for adaptation because adaptation-related aspects are not yet legislated. In biodiversity, a number of institutions and other stakeholders are involved in different aspects of biodiversity management (see ***Figure 10*** and ***Figure 11***). Currently there

is no institutional framework spanning the two areas.

188. Nonetheless, a body of personal resources already engaged can be tapped into for creating an adaptation institutional framework:

- On a national level
  - Personnel under the competent body - the Minister of Environment and Water. This includes both MoEW staff (Climate Change and Natural Protection Directorates) and the ExEA (EU ETS and Permits Department, departments in charge of the National Biodiversity Monitoring Network)
  - Personnel of other competent authorities in charge of related policies and/or their implementation—the Ministry of Agriculture, Food, and Forestry, the Executive Forestry Agency, the MRDPW, the General Directorate for Fire protection and Population Safety
  - Other stakeholders: academia, NGOs, business associations
- On the regional/local level
  - Regional structures of the MoEW and EFA, including Natura and National Park Directorates, RIEW, Basin Directorates, regional labs
  - Regional structures of other competent authorities involved in climate change mitigation, adaptation, and biodiversity
  - Regional/local authorities and in particular their ecologists
  - Regional/local stakeholders: the wider public, NGOs, business, citizen science volunteers

189. It will be prudent to organize these stakeholders in a single institutional framework to avoid redundancy.

190. It is to be noted that all stakeholders listed above need additional capacity to cope with the different aspects of biodiversity adaptation both within and outside the protected areas. Such capacity is currently short and building it by suitable measures in both formal and informal education is essential.

2.7. Sector Participation in CC(A)-Specific International Cooperation or Information Exchange

191. Bulgaria is an active member in the most important international bodies, networks, and initiatives related to the BD&ES. The knowledge and information exchange, participation in global discussions, development and collaboration in transdisciplinary and multicounty projects, and capacity building in the field of CCA are the most important issues in this specific international cooperation.

Intergovernmental Panel on Climate Change

192. The IPCC, created by the United Nations in 1988, is the leading international body for the assessment of climate change. It pools the efforts of thousands of experts worldwide who have the task of assessing the state of scientific knowledge and research on climate change and regularly preparing comprehensive reports.

193. The global body for implementation of CCA policies is the UNFCCC. The convention has been in force since March 21, 1994. Parties to the UNFCCC are 107 countries that have ratified it. While implementing the UNFCCC, EU Member States adopt their national CCA strategies. Information on these, adaptation strategies, additional documents, and best practices is available at the European Climate Adaptation Platform.[78]

Mapping and assessment of ecosystem services working group

194. The MAES working group is a key support body at the European Commission with participants from the EC, European agencies, and Member States. Its work results in conceptual reports that are drafted with the active involvement of Member States (in the first set of MAES pilots, Member States had the opportunity to co-chair the activities, and Bulgaria co-chaired the Natural Capital Accounting pilot).

195. MAES working group deliverables are incorporated in the Bulgarian mapping and assessment framework, but there is not yet any legal framework for their continuous implementation. In addition, its work is in progress (for example, six new sectoral pilots on ecosystem condition and one horizontal pilot on soils are under way in 2017), and its deliverables are to be included as well.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

196. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is the intergovernmental body that assesses the state of biodiversity and the ecosystem services it provides to society, in response to requests from decision makers. One of the most relevant IPBES deliverables is the Europe and Central Asia regional assessment that also treats climate change pressures on ecosystems. Its second draft was in public consultation until June 26, 2017. Bulgaria joined the IPBES in 2016.

Biodiversity clearinghouse mechanism

197. **The Bulgarian clearinghouse mechanism (CHM)** is a part of the global information exchange network, established by the CBD.[79] Its purpose is to offer directly or make links to the information on biodiversity needed by interested parties. The CHM contributes to the implementation of the Biodiversity Convention in Bulgaria. It follows the general principles of the CHM and provides information from a total of nine nodes—the MoEW, ExEA, other competent ministries and agencies, academic institutions, and NGOs.

International Long-Term Ecosystem Research Network

198. The vision of the International Long-Term Ecosystem Research (ILTER) Network is a world in which science helps prevent and solve environmental and socio-ecological problems. The ILTER Network consists of networks of scientists engaged in long-term, site-based ecological and socio-ecological research. The mission is to improve understanding of global ecosystems and inform solutions to current and future environmental problems. Bulgaria has been a formal member since 2009. The National Long-Term Ecosystem Research Network consists of seven sites—part of the International LTER Network for long-term ecological and socio-ecological researches.

[78] http://climate-adapt.eea.europa.eu/
[79] https://www.cbd.int/.

Ecosystem Services Partnership

199. The Ecosystem Services Partnership (ESP)[80] aims to enhance communication, coordination, and cooperation and to build a strong network of individuals and organizations. The ESP enhances and encourages a diversity of approaches, while reducing unnecessary duplication of effort in the conceptualization and application of ecosystem services. Bulgaria is a formal member with national network since 2016.

2.8. Bulgarian Sector-specific Ongoing and Foreseen CCA (Related) Actions

200. On the initiative of the MoEW for the current programming period 2014–2020, guidelines were developed for the integration of environmental policy and climate change policy in the EU Funds programming. These guidelines contain general provisions on mainstreaming and environmental and climate-related criteria and requirements to be used in the assessment of project proposals and their subsequent implementation. The criteria are divided into two groups—common criteria and specific criteria to each program, co-financed by the EU Funds. The documents aim to assist the managing authorities in mainstreaming climate and environmental issues in the respective OPs. If implemented coherently, this mechanism could help alleviate some of the problems with allocating funding across programs (see sub-chapter 2.6).

201. Full information and all documents related to the integration of environmental policy and climate change policy into European Structural and Investment Funds, as well as into all OPs 2014–2020 could be found at the webpage of the MoEW,[81] including the following documents:

- Guidelines on Mainstreaming of Environmental Policy and Climate Change Policy in CP, CAP, and CFP Funds 2014–2020, Phase: Programming of the Common Strategic Framework Funds[82]
- Guidelines on Mainstreaming of Environmental Policy and Climate Change Policy into European Structural and Investment Funds (ESIF), Phase 'Implementation of the Partnership Agreement and Programmes for the period 2014–2020'[83]

202. **European Economic Area Financial Mechanism 2009–2014** programs BG02 Integrated management of marine and inland water and **BG03 Biodiversity and Ecosystem services** contributed to collecting important environmental data that could be used for sectoral CCA. In particular, BG02 collected MSFD descriptor data and studied pressures on water bodies, whereas BG03 funded the mapping and assessment of ecosystems and ecosystem services at the national level by several projects: PDP02 - Methodological Support for Ecosystem Services Mapping and Biophysical Valuation (**MetEcoSMap**), Freshwater Ecosystem Services Mapping and Assessment in Bulgaria (**FEMA**), Wetland Ecosystem Services Mapping and Assessment in Bulgaria (**WEMA)**, Assessment and mapping of grassland ecosystems condition and their services in Bulgaria (**IBER-GRASS)**, Mapping and

[80] http://es-partnership.org/.
[81] http://ope.moew.government.bg/en/pages/integrirane-okolna-klimat/89#1.
[82] http://ope.moew.government.bg/files/useruploads/files/Programirane/2013_02__22_guidelines_mainstreaming_en_t_ms.pdf.
[83] http://ope.moew.government.bg/files/useruploads/files/guidelines_on_mainstreaming_ep_and_ccp__phase_2.docx

assessment of sparsely vegetated land ecosystem services in Bulgaria (**SPA-Ecoservices)**, Toward better Understanding the Ecosystem Services in Urban environments trough assessment and mapping **(TUNESinURB),** and Improving the Bulgarian Biodiversity Information System **(IBBIS).** Other important projects include the IAS research provided by the East and South European Network for Invasive Alien Species - A tool to support the management of alien species in Bulgaria **(ESENIAS-TOOLS**), the research on climate change impacts on forest ecosystems (**MFORES** project), and citizen science and other policy-related projects for biodiversity outside NATURA 2000.

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

2.9.1. Knowledge and data gaps

203. The functioning of ecosystems and atmospheric events leading to climate change cannot be understood by isolated, insular research. Teamwork between scientists of different branches of science must be combined with increasingly detailed, multiparameter models that include climate data, environmental data, and socioeconomic information. Such models could be used for specifying climate projections, early warning, playing out climate scenarios, and other practical purposes. Examples of such research include Wu et al. (2016), Makarieva et al. (2018), and many others, as well as the holistic prospective promoted by the School of pan-systems analysis (Lin et al. 1995). This type of research is especially necessary for Bulgaria as a country where local data is not abundant and understanding of systemic processes, together with holistic monitoring relying on complementing data series by using earth observation and modelling[84], could help bridging that gap. Prerequisites for applying a holistic approach in Bulgaria are created by the Methodological Framework for Assessment and Mapping of Ecosystem Conditions and Ecosystem Services in Bulgaria, as detailed in its Part A 'Conceptual Basis and Principles of Application' (Bratanova-Doncheva et al. 2017a), and Part D 'Guide for Monitoring of Trends in Ecosystem Condition and Ecosystem Services (Chipev et al. 2017).

204. Research directions in biodiversity and climate change include the improved understanding of ecosystem condition and functioning at the genetic, organism, population, species, habitat, and ecosystems levels and causal relationships between pressures (including climate change), ecosystems, and biodiversity. Research also should focus on ecosystems integrity, resilience, biodiversity, and specific functions, particularly ecosystem services provision under climate change stress and the use of indicator species for triggering adaptation measures. In the context of some practical adaptation measures it would be useful to adopt a landscape-based rather than an ecosystem-based approach (Vos et al. 2010, Plieninger et al. 2012, Plieninger et al. 2013, Haase et al. 2018, and other research), as also detailed in the Methodological Framework for Assessment and Mapping of Ecosystem Conditions and Ecosystem Services in Bulgaria, Part C 'Guide for the in-situ verification of the Assessment of Ecosystems Conditions and Services' (Bratanova-Doncheva et al. 2017b).

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[84] See Gocheva et al., ESP 09 conference proceedings, Book of abstracts, Session T9b, available online at https://www.aanmelder.nl/i/doc/3f6eb86b69ea585707b7d1570e62dd6b?forcedownload=True

205. Data related to ecosystems are collected and sometimes locked in different systems—databases maintained by various public bodies, NGOs, and business. They are not being put together due to limited interoperability and other constraints (such as privacy concerns and the need to minimize disturbance to vulnerable habitats and rare species). Sometimes data are collected 'by policy' and do not fit well together, for example, when water monitoring is organized by water bodies and does not consider the different habitats in a water body (such as streams, meanders, wetlands, and brackish water).

206. Many of these obstacles can be cleared by creating interoperability between databases, data sharing platforms, drafting and implementing access policies, and creating incentives for open sharing at all levels of society. Aligning the objects of measurement is also needed. New data must be collected in a targeted manner to fill knowledge gaps.

2.9.2. Legislative and capacity gaps

207. The issues resulting from dynamic developments in the EU and national legal and institutional framework were discussed in detail in Sections 2.5 and 2.6. The feasible approach to overcome discrepancies and reduce complexity appears to be a holistic ecosystems-based approach to integration and mainstreaming of biodiversity management and CCA. To this end, it appears necessary to modify the climate change-related legislation and biodiversity legislation and particularly to improve alignment between all sectors. It is also necessary to overcome some interinstitutional legislative and capacity gaps, some of which are still under discussion at the EU level.[85]

208. The current climate change legislation provides a clear framework for climate change mitigation. The same framework also needs to be enhanced to cover the CCA aspect, pursuant to the new CCA strategy. The institutions involved in mitigation could be included in similar interinstitutional format to define adaptation pressure scenarios and the appropriate response across all sectors, including BD&ES.

209. The BD&ES legal and institutional framework should be streamlined starting with the objectives of an updated Biodiversity Strategy and a new Green Infrastructure Strategy. Due to the cross-cutting nature of BD&ES, such strategies should include specific objectives and measures on adaptive management to be implemented in several other sectors (as discussed in more detail in Section 2.4.3). Based on this new biodiversity strategy, a review of

[85] For example, the water legislation requires a number of ecosystem-related measurements to be performed—assessment of biological and biochemical water indicators as per the WFD, descriptors to assess the state of marine ecosystems as per the MSFD, and so on. Despite the adoption of the INSPIRE directive, monitoring data for these policies are not always compatible. The reason is the lack of a common understanding about the cross-sector links. As a result, objectives defined in one sector may not be scientifically sound for the purposes of the other sectors and collected data may not be fit for those other sectors' needs. In the example of relation between water and biodiversity legislation, there are several main discrepancies:

(a) There is a discrepancy in the subject of the study. For the purposes of the WFD, a water body is the catchment of a river or underground water body. For large rivers such as the Danube, however, this water body contains multiple and diverse ecosystems between the river's sources and the huge wetlands in its lower course and delta. Accordingly, data collected on the level of a water body are not always sufficient for conclusive results at the ecosystem level.

(b) The criteria for determining the status/condition of a given system (be it a water body or ecosystem) are paramount. The 'one-out-all-out' approach adopted in the WFD for classifying the ecological status of a water body according to its worst indicator is being disputed by a number of ecologists on the grounds of both a general understanding of the status/condition and the different reliability of measurement methods. A comparison of reporting under various directives shows discrepancies between the classification of half the water bodies; in nearly 40 percent of the cases, the status determined by chemical methods suggests a better condition than status determined by biological indicators.

primary and secondary legislation and management procedures should be performed across all sectors involved. To develop synergy with other EU and Bulgarian legislation under review, the monitoring, EIA, protected areas, zones and species management plans ought to be focused on a single conceptual framework based on the ecosystems approach, as follows:[86]

- **Holistic monitoring** rather than 'ecosystem elements' data collection (including monitoring of climate change-induced pressures and their impacts on BD&ES)
- **Management plans.** Ecosystems-related trade-offs with consideration of climate change scenarios and their possible impacts on biodiversity ought to be part of the management plan creation process.
- **EIA.** The current focus on species and habitat-level impact assessment should be replaced by a wider consideration of other unintended harmful impacts due to disrupting ecosystem functioning and their economic and social consequences, in particular the loss of adaptation capacity due to disruption and loss of provisioning ecosystem services. The EIA results should be integrated as one of the information sources for holistic monitoring. Thus, the EIA will systematically contribute to reduced anthropogenic pressure and enhance ecosystem resilience to climate change.

210. Ensuring capacity building at all levels will require both legislative and practical measures to introduce an ecosystems-based approach to education and the planning and commitment of funding for implementing relevant legislation. For example, if ecosystem services by constructed wetlands are to be used as green infrastructure (see Chapter 1 Introduction), the calculation of savings could be performed by means of the widely-used CBA that is routinely performed for EU funding applications. The CBA is a formalized process that includes climate change impact assessment of the proposed project, as well as socioeconomic analysis of social vulnerability, effects on employment, and so on.

2.9.3. Mainstreaming ecosystems considerations in all relevant areas

211. This approach is mandated in the Bulgarian legislation and EU funding rules. However, its full implementation will have to be both reflected in the strategic and legal framework in all sectors concerned and implemented widely during the selection of adaptation options (see Chapter 3). In ***Box 8*** is presented the Estonian Biodiversity Strategy[87] as an example.

Box 8. The Estonian Biodiversity Strategy - cross-sectoral approach to combine nature protection with growth and new technologies

The Estonian Biodiversity Strategy is a holistic, cross-sectoral document based on the review of all international obligations the country has undertaken in the area of environmental protection. It is based on the CBD's premise to combine conservation and protection with equitable use of resources.

The strategy adopts a cross-sectoral approach where for each sector, win-win options are assessed and selected. In this manner, protecting biodiversity also contributes to the development of biotechnology and genetic research, protection of intellectual property,

[86] Specific recommendations to this end are made in the National Methodological Framework produced by project MetEcoSMap. Its latest version, once verified, is to be uploaded at http://bg03.moew.government.bg/node/296
[87] https://www.cbd.int/doc/world/ee/ee-nbsap-01-en.pdf.

education in all stages and forms, landscape planning, and land use policies in agriculture, forestry, construction, fishery, CAP, transport, tourism, and industry. Climate change is also considered in the Strategy as an indirect pressure factor.

This range of issues is essentially the same as the ones covered by the Bulgarian legislation on biodiversity and related sectors and considering them in one strategic document will support the cross-sectoral coherence.

Box 9. The Natural Capital Assessments of the United Kingdom and Spain - a source for management-level macro-economic information

The United Kingdom and Spain are among the first countries to produce management-level information on the aggregate value of ecosystem services. As mentioned in Chapter 1, the preliminary results demonstrate the serious undervaluation of regulating and cultural ecosystem services by traditional economics. Both studies take a gradual approach and start by valuing some of the key ecosystem services in each country.

The U.K. approach is characterized by a strong interagency collaboration over several years (and is still ongoing), under the coordination of DEFRA. It has produced national account-level estimates that were quoted earlier.

The Spanish ecosystem assessment presents another best practice example in terms of stakeholder communication—the visual integration of complex interactions within the socio-ecological system in easily understandable illustrations, as presented in the following figures. Both assessments are also valuable as best practice examples and were considered by many Member States, including Bulgaria.

The Spanish Natural Capital Assessment presents the two aspects of the socio-ecological systems—the DPSIR framework as related to biodiversity and natural capital and the socioeconomic relationships involved in the use of ecosystem services in the figures below.[88]

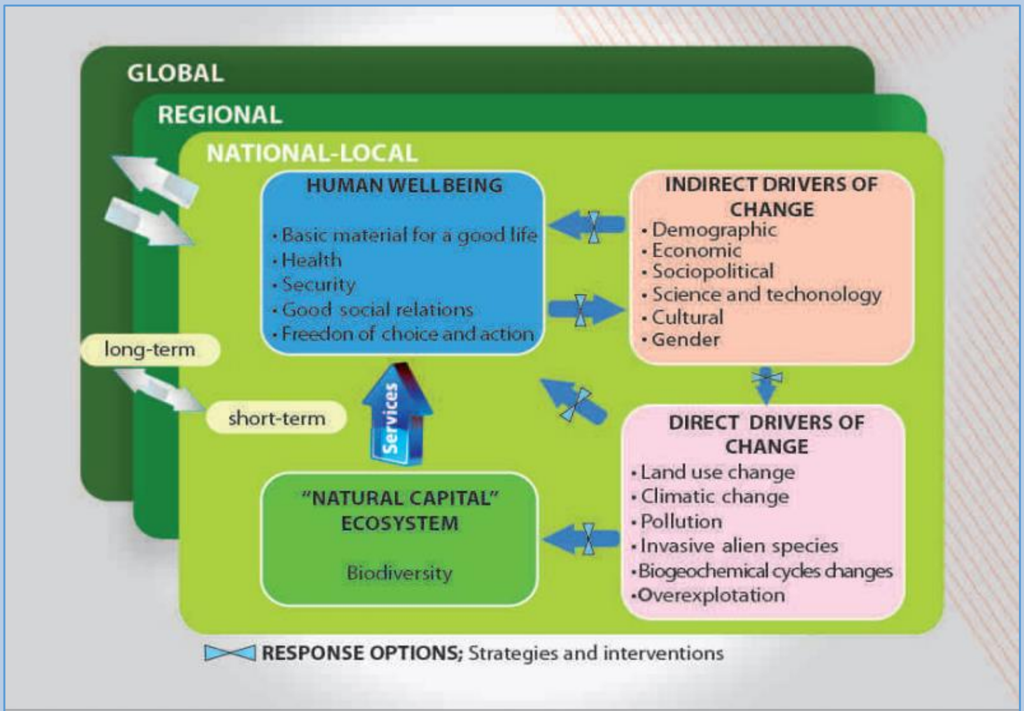


Figure 1. The conceptual framework has been the main tool for organizing the available information for Spain from different disciplines to address the complex interactions that exist between ecosystems, biodiversity and human wellbeing. It shows how the synergistic effect of direct and indirect drivers of ecosystem change affect the flow of ecosystem services affecting human wellbeing at different spatial and temporal scales. It places human wellbeing in the center of the assessment, and all of its components are directed toward that point. (Modified from MA, 2005).

Source: Spain Ecosystem Assessment.

[88] http://www.ecomilenio.es/wp-content/uploads/2015/02/0a.-Introduction.-Part-1.pdf.

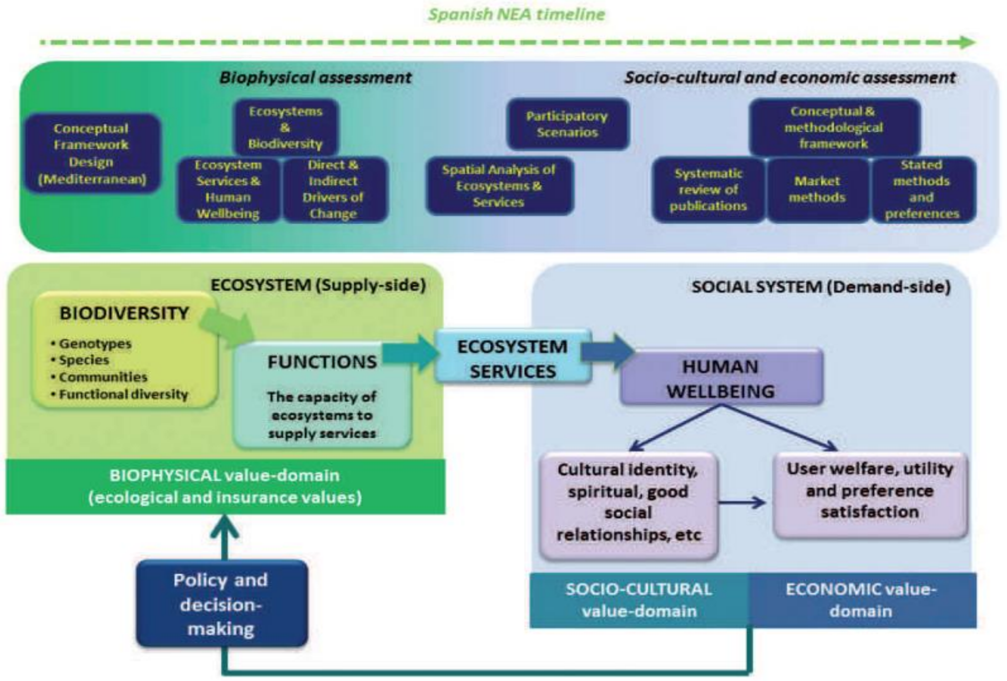


Figure 2. Multidimensional framework for assessing ecosystem services, including methods ranging from biophysical (supply-side) to socio-cultural and economic approaches (demand-side), and how this approach has been incorporated into different steps during the Spanish NEA timeline. Based on Haines-Young and Postchin (2010), de Groot et al. (2010), and Martín-López et al. (2013).

Source: Spain Ecosystem Assessment.

2.9.4. Success factors for and barriers to adaptation and knowledge gaps

212. Progress in adaptation in the BD&ES sector depends on several international and national success factors and their interconnection. As noted in the 7th EAP, global-level factors include the coherent addressing of knowledge and data gaps: *"[...] advanced research is required to fill such gaps and adequate modelling tools are needed to better understand complex issues related to environmental change, such as the impact of climate change and natural disasters, the implications of species loss for ecosystem services, environmental thresholds and ecological tipping points. While available evidence fully warrants precautionary action in such areas, further research into planetary boundaries, systemic risks, and our society's ability to cope with them will support the development of the most appropriate responses."* Practical implementation is within the competence of Member States. For Bulgaria, important national and local-level factors to be considered include the following:

- Achievement of interdependence between the legal framework relating to the climate change and the biodiversity in the **legislation** and their mainstreaming into all related sectors is important.
- Effective **coordination** among authorities supports the involvement of a wide range of stakeholders by ensuring the availability of consistent and reliable information and by ensuring clarity with respect to roles and responsibilities.
- **Stakeholder communication and involvement** on all levels, including active participation of civil society, has a crucial role in this process.
- Ongoing scientific **research** on climate change impacts on BD&ES is mandatory and necessary for developing appropriate policies and improved decision making.

- **Data quality assurance** has an important role in understanding of regime shifts in ecosystems.
- **Expert capacity building**, education, and training are also very important factors.

213. Barriers to adaptation are not simple to define. A lack of resources (for example, human resources, time, money, and equipment) and uncertainties are viewed by European countries as the most important barriers. Uncertainties are a common feature across all levels of advancement in policy making. Policy making can benefit from embedding processes that focus on learning from experiences, reviewing progress and policy objectives, and encouraging innovative experimentation. To further support adaptation in European countries, more information is needed on the costs and benefits of adaptation, as well as on the risks and uncertainties, vulnerabilities at the local level, and the availability of data for monitoring and evaluation purposes.

214. In the context of Bulgaria, a specific barrier to adaptation becoming increasingly obvious is the need for simplification and acceleration of decision making in the sector. This can be achieved by implementing to the extent possible (regarding privacy and business protection) of a single pool of environmental data for the use of decision makers, and the development of tools for informing trade-off decisions based on improved climate and biodiversity modeling, in a sufficiently detailed spatial resolution and as close to real time as possible.

2.10. Conclusions

215. The institutional and legal framework in Europe in the area of BD&ES is work in progress in many areas. The ecosystem services mapping, assessment, and valuation work, as well as practical efforts for ecosystem restoration and the optimization of regulating ecosystem service delivery through ecosystem restoration and green infrastructure are two of the areas with particular significance for CCA.

216. Bulgaria has an institutional framework for ecosystem conservation via protected areas, ex situ facilities, protection of genetic resources, and so on. However, it lags behind in implementing the ecosystem services concept. The current Biodiversity Strategy has expired and a new one is to be developed, together with its Action Plan, according to Article 115 (1) pp. 2 and 3. Another strategic area in need of development is green infrastructure – this is a key area with respect to achieving the 15 percent restoration target set in the EU Biodiversity Strategy to 2020.

217. The legal and institutional framework in Bulgaria currently places the provisioning ecosystem services in the jurisdiction of several administrations under the Minister of Agriculture, Food, and Forestry. Regulating ecosystem services, that are at least equally important in terms of valuation and a significant CCA factor, have not been regulated, except for some in the forestry legislation. This gap needs to be filled both by legal modifications and capacity building in central and local administrations, science, and society.

218. Equally important is the transition from monitoring of abiotic and biotic 'environmental elements' into holistic ecosystems monitoring. This would both facilitate the cost-effective monitoring of ecosystems and provide better ways to explore complex system

level interactions between climate change and ecosystems by collecting relevant and coherent data for more detailed projections. Using other available data (such as Environmental Impact Assessment data, data from implementing other policies, and citizen science/traditional knowledge) in an open, interoperable manner is another potential information source to bridge the data and knowledge gaps and support ecosystem monitoring.

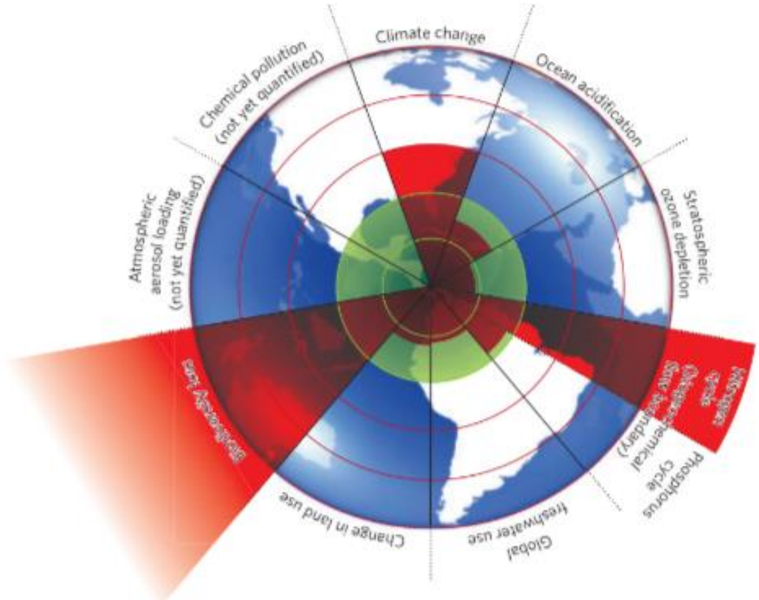
219. For efficient adaptation, both the biodiversity legislation and regional/local climate change adaptation strategies must be adjusted to include the CCA concept in accordance with the to be developed National Climate Change Adaptation Strategy. This will contribute to better-informed decisions about trade-offs and improved stakeholder awareness and communication.

Chapter 3. Adaptation Options

Introduction

220. Ecosystems' size can differ by many orders of magnitude—from a pool to a continent. The timescales of events that influence natural capital are equally widespread—from a few hours for destructive cataclysmic events to hundreds of years for some species' lifespan and millions of years for species evolution, soil formation, and other processes. Against this background, the socioecological system created by human civilization is very new, and our knowledge and tools do not provide sufficient information on ecosystems and the way they change with climate. From the ecological point of view, humans act as ecosystem engineer species.[89] However, the anthropogenic impact on biodiversity, currently on the planetary scale, is immensely stronger than any other species' impact. Moreover, the advances of technology in the last centuries allow us to modify the environment at an unprecedented rate that does not allow ecosystems the time to adapt. The debate about planetary boundaries (limits beyond which our existence is threatened)[90] is gaining momentum, and both biodiversity loss and climate change are among its most critical elements.[91]

Figure 12. Beyond the boundary



Note: The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change, and human interference with the nitrogen cycle), have already been exceeded.

Source: A safe operating space for humanity, Nature, 461, September 2009.

221. Climate change is one of the pressures that influence the BD&ES. Both ecosystems and climate are complex systems, and it is unlikely to fully understand and predict their working in the medium-to-long term. On the other hand, climate is changing, and biodiversity

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[89] A species which modifies its environment, much in the same manner as beaver dam rivers, and thus creating livelihoods for themselves and many other species.

[90] For a concise short introduction see https://www.youtube.com/watch?v=RgqtrlixYR4

[91] A safe operating space for humanity, Nature, 461, September 2009.

is being lost now. Action is needed urgently but inaction or mismanagement can worsen the situation and bring about deterioration of ecosystems or their loss. Along with the important loss of biodiversity, such developments also influence the provision of vital ecosystem services and therefore, may further reduce adaptation options, especially for vulnerable population groups with limited mobility. Optimizing the use of ecosystem services is a potential source of cost-effective solutions for countermanding climate change effects and ensuring win-win solutions in providing equitable access to resources.

3.1. Identified Adaptation Options

222. In the absence of a Biodiversity Strategy, a Green Infrastructure Strategy and legal regulation for some of the ecosystem services that are most relevant to CCA adaptation in BD&ES, the options in this chapter are mainly based on the EU policy documents and scientific developments in the sector. It is, however, to be noted that because of this ambiguity in the strategic and legal framework, the institutional responsibilities for implementing the identified options in this report cannot be focused as precisely in other sectors, and they would need to be further specified during the development of this Strategy's Action Plan. In line with the approach to BD&ES adopted in the strategic EU documents, the approach in this chapter is based on ecosystems and ecosystem services mapping and assessment which emphasizes ecosystems-level functions such as integrity and resilience, and their capacity to produce services relevant to CCA.

223. Insights and practical experience gained during the mapping and assessment of the entire territory outside NATURA 2000 (some 66 percent of the country) using a single methodological framework across all nine ecosystem types that cover the entire spectrum of environmental conditions between marine and dry, sparsely vegetated ecosystems are also referred to.

224. A single, multidimensional measure of ecosystem integrity and its manifestations in the form of ecosystem condition (including biodiversity) and services, referred to as the IP index, was defined from the onset in the National Methodological Framework for ecosystems mapping and assessment. While it needs a more detailed conceptualization, the IP index has emerged as a useful proxy in the ecosystems mapping and assessment context. It is also increasingly clear that a multidimensional measure of ecosystems' conditions requires multiparametric modelling. This holistic approach is at the core of the Ecosystems-based approach to CCA (EbA-CCA) outlined in this chapter.

225. The holistic approach presupposes the impact assessment of various human activities on biodiversity. Such assessment is, to some extent, already legislated for. In practice, however, serious efforts are necessary to align single policies in terms of methodology, implementation, interoperability, and aligning the reporting under different policy instruments. This can only be achieved by applying a single systematic approach to strategy, legislation, monitoring, and the EIA as discussed in Chapter 2. The proposed EbA-CCA is such an approach which, when refined in practical implementation in biodiversity and related sectors, should help determine a relatively small number of indicators to assess the thresholds that should not be exceeded if human survival and well-being are at stake.

226. In the context of selecting adaptation options, EbA-CCA is a cross-sectoral approach to advance natural adaptation solutions, aiming at no net loss, possibly net gain of ecosystem services available to society while at the same time prioritizing, wherever feasible, biodiversity conservation and restoration over other adaptation options. EbA-CCA's overall objectives are to implement adaptation measures that

(a) Enhance ecosystems' resilience and keep their integrity to ensure, if feasible, no net loss when the ecosystem's state changes;

(b) Enhance ecosystem services' use for supporting adaptation in other sectors and fostering economic growth;

(c) Offset irreversible, climate change induced loss of in situ biodiversity by ex situ preservation of unique gene pools;

(d) Reduce net loss of ecosystem services in the adaptation process by trade-off analysis of the changing ecosystems and manage their transition to a new state favorable to humans; and

(e) Minimize disruption and costs caused by climate change and CCA measures to the social and economic activities.

227. Adaptation options can be classified in many ways and grouping them is a challenge to the clear formulation of strategic priorities and prioritization of options. From a management point of view, one must distinguish between gradual state change requiring medium-to-long-term adaptation and rapid ecosystems modifications due to accumulation of pressures or catastrophic events[92] that require immediate improvements in the adaptive management and monitoring.

228. From an ecosystems' point of view, systematization of adaptation options may be attempted with regard to the impact of climate change on ecosystems, habitats, and species involved, and the ecosystem response. For example, ecosystems are known to adapt to and in effect, internalize disturbances if they are occurring frequently, and over time may begin to depend on such disturbances as boosters to ecosystem health and integrity.[93] Such behavior, in turn, can be used in the form of ecosystem services to support the CCA in other sectors. For example, wetlands' inundation resilience can be used as retention volumes for flood protection; afforestation is known to be a cost-effective way of creating wind protection belts in agriculture.

229. **Successful adaptation strategies must be based on the ecosystems' intrinsic structure and properties.** Consideration must be given also to the human aspects of adaptation—desirability and/or hazards of ecosystem changes, feasibility, societal impact, costs and benefit of every potential adaptation path, including the costs of inaction, and the need of differentiated adaptation approaches to different types of climate-induced pressure (direct pressures often require gradual approaches while indirect pressures are chaotic and severe and need emergency response). The grouping of adaptation options in this chapter is

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[92] Rapid and often irreversible state change (such as extinction of key species leading to new population composition and even the change of habitats) is subject to research, that is, P. Petraitis, Multipla Stable States in Natural Ecosystems, Oxford University Press, 2013.

[93] Examples include regularly inundated wetlands and meadows whose biodiversity is well-adapted to such water regime.

based on the target groups and types of measures. The first two groups are mainly related to the national-level coordination and the national and local action. The last three groups are options for operationalizing ecosystems-based adaptation at the local level and summarize the key themes identified during informal consultations with stakeholders.

230. The legal and methodological gaps outlined in this report contribute to a level of uncertainty that probably exceeds better regulated sectors that fall within the boundaries of traditional economics. To reduce this uncertainty and the related societal risks, it is important to implement adaptation options from all five groups and respect their mutual links, as outlined in ***Annex 4***. In particular, the coherent implementation of adaptation option groups C and D can reduce uncertainty in the understanding of the nature of CCA and of ecological phenomena, whereas options of groups A and B relate to capacity building across society and creating a functioning legal and institutional framework. To provide sustainable benefits and not to damage important ecosystems beyond repair, the implementation of adaptation option group E relies on the correct and coherent implementation of all other groups of adaptation options.

3.1.1. Enhance environmental governance

231. Environmental governance is steadily developing but still needs to be amended to include the provisioning and cultural ecosystem services (see Chapter 2). The transition from improving parts of the ecosystem to ecosystem-based management are adopted at the strategic EU level and incorporated in several of the latest EU directives but they require policy making to go beyond 'policies' and create complementarity in legislation, funding, and implementation. This means enacting the consequent rather than the compartmentalized implementation of EU strategies from the point of view of preserving ecosystem integrity in the face of CCA.

Align strategic planning and implementation legislation

- Develop and adopt the new Biodiversity Strategy and Action Plan and a new Green Infrastructure Strategy with regard to ecosystem-based management, conservation, restoration and CCA

232. Adopting the new National Biodiversity Strategy is a key step toward integrating the different EU policies—strategies and legislation—to form a coherent holistic legal framework. Another key strategic document that would boost ecosystem resilience and support the adaptation in other sectors, is the Green Infrastructure Strategy.

233. Both Strategies are organically linked and mutually complementary because of the specifics of protection measures that by their nature are to be delimited on a regional and local level. On any given territory, the conservation of important ecosystems through regeneration to a good condition will have to be combined with the creation of ecosystems for ecosystem services provision, and the decision will have to be made depending on the degree of their degradation and the identified needs for ecosystem services to facilitate climate change adaptation.

- Review and amend legislation and secondary legislation in the environment sector and related sectors to reflect the new Biodiversity Strategy and Green Infrastructure Strategy

234. Sectoral legislation must be aligned with the new Biodiversity and Green Infrastructure Strategies. In the biodiversity sector, this most directly involves the Biodiversity Act (and its secondary legislation) as detailed in Chapter 2. However, both the umbrella Environmental Protection Act and related sectoral laws (together with their secondary legislation) will have to be changed, such as the Water Act, the Atmosphere Air Cleanliness Act, and others, as well as the legislation of other sectors.

235. Such legislation review should be aimed at integrating both the relevant EU strategies, notably the EU CCA Strategy, Biodiversity Strategy to 2020, and Green Infrastructure Strategy and national strategic documents, such as Strategy 2020 and the PAF with a view to making them mandatory and enabling their implementation in a streamlined manner. It should contain provision for holistic ecosystem monitoring, including climate change-induced pressures; creating policies for opening and reuse of data from the EIA, monitoring, and management plans. All of these areas, by themselves, can also benefit from the consequent application of an ecosystems approach to facilitate informed trade-off decisions.

- Link decision making, resource, and funding to efficient assessment of improved ecosystem condition

236. The EU Biodiversity Strategy to 2020 sets measurable targets on restoring ecosystems. These targets are aligned with other strategic objectives but also leave the Member States with a bigger responsibility in determining the path to achieving the targets (the latest example being the proposed modifications in the Common Agriculture Policy.[94] Therefore, the effect of budgetary spending and subsidies, in particular, green agriculture subsidies, should be measured against the improvement of ecosystem conditions and value for money has to be sought, for example, by encouraging the good condition of ecosystems of high natural value. Less effective measures should be discarded even if measuring the physical parameters of their implementation is easier than measuring the ecosystems' condition.

- Operationalize ecosystem-based monitoring and strategic/environment impact assessment

237. The process of enacting legislation is sometimes applied under time pressure and financial constraints, resulting in leaving out important aspects of legislation intent and ultimately in legislative fragmentation. The efficiency of consultation at all levels therefore needs to be enhanced and must be underpinned by tangible and well-presented data. To achieve this, monitoring, as proposed in Chapter 2 and closely linked to strategic and environmental impact assessment must be in place. Monitoring is detailed in the Methodological Framework for Assessment and Mapping of Ecosystem Condition and Ecosystem Services in Bulgaria, Part D 'Guide for monitoring of Trends in Ecosystem

[94] See COM (2017) 713 final The Future of Food and Farming – for a flexible, fair and sustainable Common Agricultural Policy

Condition and Ecosystem Services' (Chipev et al. 2017). It is described as a holistic process containing specific guidance on monitoring by ecosystem type with a calendar of monitoring by years and containing reference to different institutions and stakeholders that ought to be involved. Apart from the direct monitoring data collection, any other fieldwork data and other available information (in particular related to strategic and environmental impact assessments [EIA]) ought to be used for monitoring purposes. To further the synergies between monitoring and EIA, CBA should be used at the appropriate scale and to the highest extent possible. For example, at the project level, by mandating a green scenario to be assessed when applying for EU funding using the EU CBA Guide[95] (which also includes the assessment of the project's climate and environmental impacts). Results should then be used for deciding on trade-offs and justifying the setting up of financial instruments.

CLIMATE CHANGE ADAPTATION OPTIONS	
A.	**Enhance environmental governance**
I.	**Align strategic planning and implementation legislation**
1.	Develop and adopt the new Biodiversity Strategy and Action Plan and a new Green Infrastructure Strategy with regard to ecosystem-based management, conservation, restoration and CCA
2.	Review and amend legislation and secondary legislation in the environment sector and related sectors to reflect the new Biodiversity Strategy and Green Infrastructure Strategy
3.	Link decision making, resource, and funding to efficient assessment of improved ecosystem condition
4.	Operationalize ecosystem-based monitoring and strategic/environment impact assessment

Adjust sectoral legislation to climate legislation

238. The CCMA is mostly focused on climate change mitigation. Its adjustment in line with this strategy will require a cross-sectoral review of strategic documents in all sectors, including BD&ES, to include CCA.

- Revise the CCMA and sectoral strategies/legislation to include the provisions of the CCA Strategy

239. This is a necessary adjustment of legal texts and institutional framework. As noted in Chapter 2, the existing mitigation framework could be used for the adaptation activities as well. In the BD&ES sector, this means that the current or next National Environment Strategy as well as the Biodiversity and Green Infrastructure Strategies that are to be developed, will also need to be aligned to the CCA Strategy and legislation.

- Adjust regional and local adaptation strategies to the amended CCMA and the strategic documents and legislation on BD&ES

240. Regional and local climate change strategies were created in a coordinated manner, but they predated the national CCA Strategy and the Biodiversity and Green Infrastructure Strategies that are yet to be developed. Therefore, their review and adjustment will also be necessary.

[95] http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf.

241. In addition, the holistic approach to monitoring and strategic/environmental impact assessment will most likely require the development of more specific CCA measures to optimize the delivery of ecosystem services across several local units; this, in turn, is likely to increase the relative importance of regional strategies.

CLIMATE CHANGE ADAPTATION OPTIONS	
A.	**Enhance environmental governance**
II.	**Adjust sectoral legislation to climate legislation**
5.	Revise the CCMA and sectoral strategies/legislation to include the provisions of the CCA Strategy
6.	Adjust regional and local adaptation strategies to the amended CCMA and the strategic documents and legislation on BD&ES

Link emissions statistics to new environmental accounts

242. Ecosystem services, particularly the non-traded services, are better suited for policy decision making when their impact is assessed in terms of share of GDP or other appropriate measurement. Carbon emissions are one element of the climate change mitigation policy that needs to be complemented by carbon sequestration by biomass. This ecosystem service, however, is not considered in national accounts. In accordance with the EU Biodiversity Strategy to 2020, a system of national environmental accounts is to be created, and particularly one of them—the carbon account—ought to be linked to emission data from within and outside the EU ETS to create a clear link between climate change mitigation and adaptation and to facilitate reporting in the context of BD&ES as well as the future Natural Capital Accounting (NCA).

- Create carbon environmental accounts

243. Even the best business opportunities of using ecosystem services for CCA cannot be utilized by companies (an in particular by small, medium-sized or micro enterprises) without a clear and easily implemented accounting, economical and reporting guidance on the entire cycle of creating, using and monetizing the benefits from ecosystem services as part of their business. The national ecosystem accounts are a first step towards such mainstreaming of ecosystem services that precedes any changes in the accounting, production, trade and corporate finance frameworks.

244. The National Statistical Institute has applied for a grant provided directly by Eurostat for the creation of environmental accounts. The carbon account is to be one of these accounts, and it should be in line both with Eurostat guidelines and with the National Methodological Framework. However, a much wider societal engagement is needed for operationalizing it.

- Link carbon emission accounts and environmental accounts

245. To form a carbon balance, the new environmental and particularly carbon accounts need to be embedded in the existing system of national accounts in terms of data collection, interlinking, processing, and comparison.

246. This is a prerequisite for reaping the economic benefits from ecosystem-based climate change adaptation since businesses will be able to account, in the same "business-as-usual" accounting and statistical scenario, both for emission credits from climate change mitigation (which create immediate disposable income) and the operational expenses for CCA (such as green infrastructure, ecosystem restoration) which will create future revenues.

CLIMATE CHANGE ADAPTATION OPTIONS
A. Enhance environmental governance
III. Link emissions statistics to new environmental accounts
7. Create carbon environmental accounts **8.** Link carbon emission accounts and environmental accounts

Educate for ecosystem thinking

- Implement new training programs at all educational levels and in informal/non-formal education

247. Greening the economy will need a qualified workforce in many new professions. A key beneficiary of such additions to the education system will be the business involved in the use of ecosystem services – a new emerging area which is likely to help absorbing jobless persons as new technologies (in particular robotics and Artificial intelligence) displace traditional jobs in entire industries such as transport. Adding new training programs also means adjustment of the educational system, and particularly the vocational education and informal/non-formal education sectors to this growing need. The system of approved school programs and vocational training professions will have to be widened by adopting new curricula. These changes must be embraced by the Ministry of Education which sets the institutional framework for formal education, as well as the academic institutions. Initiating such administrative steps is likely to also boost the training offerings by private providers.

- Create specialized education courses for administrations responsible for implementing CCA and BD legislation

248. As noted in Chapter 2, building capacity for adaptive management of complex policies—CCA and biodiversity—is a key prerequisite for successful CCA. The Institute of Public Administration (IPA) and several private sector training providers train the relevant authorities in a wide number of topics related to their work. So far, both ecosystem services and climate change are absent from the regular IPA training catalog and are sporadically provided by training companies upon request. With a movement toward integrated ecosystem-based management, capacity building of public servants and networking opportunities provided by such trainings will become increasingly important for smooth policy implementation and providing institutions will have to adjust their training offerings and (in the case of IPA) also their budget planning.

- Develop skills for ecosystem communication and awareness raising

249. Communicating ecosystem services and their role for creating synergies between CCA in BD&ES and other sectors will be a complicated new subject matter for society. Therefore, special attention should be given to the development of communication skills

among the representatives of all stakeholder groups with respect to this specific aspect of CCA.

CLIMATE CHANGE ADAPTATION OPTIONS
A. Enhance environmental governance
IV. Educate for ecosystem thinking
9. Implement new training programs at all educational levels and in informal/non-formal education **10.** Create specialized education courses for administrations responsible for implementing CCA and BD legislation **11.** Develop skills for ecosystem communication and awareness raising

3.1.2. Knowledge management and stakeholder communication for adaptation

250. This theme contains adaptation options that create and develop the knowledge and stakeholder ownership foundation necessary for the adaptive management approach of EbA-CCA. The knowledge infrastructure has to be in place as soon as feasible, with the objective to enable research on a very small scale, in a manner similar to the way weather events are now predicted for agriculture. Its importance has to be understood by stakeholders at all levels and adopted as part of their objective.

Open and reuse data

- Ecosystem data interoperability between authorities and other actors

251. This option is concerned with the removing of legal and procedural obstacles, creating data and IT infrastructure as the basis for free exchange of data related to ecosystem and climate change between authorities and other data holders, that is, academia, as well as peer review of citizen science data. The practice to require payments for data is a matter of financial disincentive. The option is highly synergetic to the general move of the Government to reduce red tape.

- Open data for public use

252. This option is concerned with the policies for open data access. The right balance needs to be found between sharing data and protecting the legitimate interests of business owners, citizens, and society. Private and business data may not be disclosed; sensitive ecological data about the location of rare species ought to be protected from poachers while still available to academia. All the remaining data, particularly data paid for by the EU or national budgets, ought to be freely available. Practice in other countries (notably the United States of America and the EU) show that opening of data supports not only academia but also the development of innovative and disruptive businesses, whereas efforts are currently underway to establish data marketplaces.

CLIMATE CHANGE ADAPTATION OPTIONS
B. Knowledge management and stakeholder communication for adaptation
V. Open and reuse data
12. Ecosystem data interoperability between authorities and other actors **13.** Open data for public use

Improve communication and understanding of ecosystem processes and climate change as pressure

- Communication and tools for informed prioritization of research and practical action

253. Reaching social consensus on the priorities and engaging all stakeholders is key to coherent action and informed decision making in both CCA and BD&ES conservation/restoration. This means that constant two-way communication along the lines of joint definition of costs and benefits for each adaptation option by local communities and central authorities is the key element in determining the direction of scientific research and practical measures. Communication efforts need to be constructive and focused on decision making. In this respect, producing toolboxes and guidance documents to assist stakeholders has proven to be a valuable avenue for practical communication.

- Interdisciplinary teams and centers of excellence

254. Setting up interdisciplinary research on ecosystems, ecosystem services, and biodiversity, and the impact of climate change on their development needs to be a priority in existing scientific funding instruments, such as the Scientific research fund and OPs. This option refers to creating a research infrastructure that is not necessarily immediately monetized in applied research but provides the basis for projections and models to be used in the adaptation of BD&ES.

- Participative science

255. The systemic nature of CCA and BD makes researching their interactions in the traditional manner impossible (Li, 2000). The emergence of the holistic approach in science, however, causes practical difficulties related to the team size and cognitive limitations of each team member. To address this issue, effective multidisciplinary teams must be organized much in the manner of decentralized development of open source software.

256. To this end, scientists should be encouraged to join teams on an ad hoc basis by distributing funding for science through thematic contests on identified challenges.[96] Obstacles to free sharing of knowledge, for example due to intellectual property rights, must be removed by preferably funding open access publications with open published data and reproducible results.

[96] Similar to the contests funded by the Massachusetts Institute of Technology, see http://news.mit.edu/2016/mit-climate-colab-opens-10-climate-change-contests-0224.

CLIMATE CHANGE ADAPTATION OPTIONS
B. Knowledge management and stakeholder communication for adaptation
VI. Improve communication and understanding of ecosystem processes and climate change as pressure
14. Communication and tools for informed prioritization of research and practical action **15.** Interdisciplinary teams and centers of excellence **16.** Participative science

Restore, enhance, and use local biodiversity knowledge

257. The local population has for centuries learned and transmitted simple but efficient ways to adapt to its natural environment, including climate change. This includes Bulgarian local knowledge and that from further afield. Some plants were introduced centuries ago, such as tomatoes and potatoes from America, and Goji berry from Asia. The local knowledge from these regions can be of use for CCA as well. Care must be taken, however, that the increased commercial use of species (such as bamboo) does not lead to uncontrolled invasion and their introduction must be researched, or example by controlled nursery projects before release.

- Targeted collection of folk customs and traditional knowledge

258. The importance of local and indigenous knowledge is well established and forms an integral part of IPBES work.[97] In some countries, cultural specifics promote serious research to link traditional philosophy and sustainable living practices – an example is presented in Wang et al. (2011). In Bulgaria, in contrast, local knowledge has not been systematically collected and is in danger of being lost.

259. This measure involves preserving the invaluable local knowledge in areas like ecosystem management (such as the 'Koriya' forest belts around settlements practiced in the 19th century), the alimentary and medicinal use of biodiversity to enhance the gene pool (such as local varieties and breeds and their wild relatives, herbs, medicinal plants) and using them in research and adaptation practice.

- Import foreign knowledge

260. Targeted acquisition of other nationalities' local knowledge about plants and animals of foreign origin, including widespread IAS with economic importance, through projects under OPs (Chapter 2), should be pursued. This measure should also include a safeguard component because foreign species must be tested in nurseries before their release in the wild.

CLIMATE CHANGE ADAPTATION OPTIONS
B. Knowledge management and stakeholder communication for adaptation
VII. Restore, enhance, and use local biodiversity knowledge
17. Targeted collection of folk customs and traditional knowledge **18.** Import foreign knowledge

[97] See https://www.ipbes.net/deliverables/1c-ilk

Maximize the use of citizen science

261. Fieldwork for ground truth verification is a traditional bottleneck in ecosystems exploration. New technologies, however, open new frontiers for inexpensive data collection (such as fieldwork supported by autonomous vehicles, Internet of Things devices that are increasingly employed in smart cities, integrated transport systems, and so on, and can also be used for collecting environment data such as temperatures and humidity). It has never been easier to use volunteer data for ecosystems-based monitoring.

262. Nature enthusiasts and volunteers could supply information about the state of biodiversity and even ecosystem services that could assist verification of environmental models and complement other available data, such as the national and local land-use data and detailed remote sensing images.

- Promote ecosystem thinking among volunteers

263. Ecosystem thinking is the next frontier in citizen science; however, it needs to be nurtured instead of focusing on a single species. This means encouraging widespread sharing of information and experience with ecosystem aspects, that is, through specific social networks for volunteers' exchange, interactive augmented reality games with rewards for relevant data collected, and so on.

- Enable volunteer sharing

264. The ease of contribution for non-specialists (that is, mobile applications that share photos, GPS data, smart appliances from the Internet of Things, and so on) is another key success factor. Such options must not place any additional burdens on the persons sharing data, and the collection should be automated to the highest extent possible. Examples include the radio-frequency identification (RFID) tracking of visitors' entrance tickets to measure the disturbance and estimate ecosystem carrying capacity within protected areas or use of volunteers to oversee and charge autonomous monitoring devices placed in the field.

CLIMATE CHANGE ADAPTATION OPTIONS
B. Knowledge management and stakeholder communication for adaptation
VIII. Maximize the use of citizen science
19. Promote ecosystem thinking among volunteers **20.** Enable volunteer sharing

3.1.3. Create space for BD&ES

265. One of the effects of climate change is species migration caused by the change of habitat conditions. Maintaining habitats as large as feasible and connecting smaller habitats to avoid fragmentation are key to adaptation. Bulgaria has a significant number of connected ecosystems in protected zones and areas, which is a unique advantage. Unfortunately, outside the protected areas, land acquisitions and changes in land use, as well as fragmentation of ecosystems by infrastructure (mainly transport) contribute to the decrease of climate resilience of ecosystems and their biodiversity. Local communities should be encouraged to consider the loss of ecosystem services, the consequent decline in climate change resilience and additional replacement costs for loss of ecosystem services when deciding on such trade-offs and be

encouraged to favor win-win options. More specific measures are listed in ***Annex 7*** with example adaptation options by ecosystem type.

266. The measures in this group are closely interlinked and should be implemented together; therefore, the identified adaptation options apply to all measures as a group and are organized in this manner.

Reclaim space from grey infrastructure

267. Green infrastructure is a relatively inexpensive way to harness ecosystem services for adaptation. Costs are saved from the construction and maintenance phases. Also, because additional revenues may be achieved by co-benefits, this may, in many cases lead to savings from the selected adaptation option. Depending on the local landscape and the types of ecosystems available in it, the specific measures of this group may be very different. Examples include the following:

- Restore river meanders to diminish the speed of flow, reduce erosion, and eliminate the need for dykes. Savings are realized mainly due to the erosion protection and mass flow regulation services; however, there are also co-benefits for biodiversity, particularly nursery population ecosystem services.
- Use green infrastructure (constructed wetlands) for water purification. Apart from the immediate use being made of the purification group of services, the setup enhances flood and erosion protection and provides several co-benefits, in particular for biodiversity protection and cultural ecosystem services (recreational or tourism).
- Create urban green spaces, that is, green roofs, semi-grassed alleys, and so on. This approach makes use of the local climate regulation ecosystem service to reduce heat islands and of the flood regulation services to increase runoff to the soil instead of rainwater canalization in case of storms.

Create refugia, reduce fragmentation

268. Relatively small concessions in terms of land can lead to significant improvement of ecosystem climate change resilience. As with most uses of ecosystem services, this is also beneficial for biodiversity and delivers adaptation options to the local community. Examples include the following:

- **Green belts in cropland or grassland landscapes.** They offer nesting sites and living space for species that would otherwise be crowded out by agriculture. At the same time, green belts provide wind protection and can help improve drought resistance by capturing rainwater and transferring it to the groundwater.
- **(Semi)natural urban and peri-urban green space maintenance.** If green spaces in the city are mowed after the end of a grass species vegetation period and shrub undergrowth is not cut down, the biodiversity is supported at zero additional cost. This higher biodiversity, in turn, is conducive to the provision of other ecosystem services, such as pollination and interaction/recreation, and bequest value cultural services.

- Regional/local 'red lines' to prevent loss of ecosystem services vital for CCA

269. To achieve the maximal effect of conservation and restoration measures, a proven tool is the dynamic and spatially explicit map of 'red line' areas. 'Red line' can refer to areas of critically endangered biodiversity, or to urban/rural areas where ecosystem degradation can be of disastrous consequences for climate change adaptation, such as erosion and landslide prone terrains, avalanche zones, water sourcing forests in watersheds or wetlands doubling as flood retention volumes (Jin et al. 2016). As a tool to further the business use of ecosystem services, a spatially explicit map can identify the best locations for green infrastructure where ecosystems provide cost optimal services important to CCA. As a tool for conservation management, 'red line' areas draw the boundaries areas of critical natural capital (Lü et al. 2017) and therefore can help shifting the publuic discussions about the size of protected areas and the limitations of economic activities inside them from controversy to constructive dialogue. Therefore 'red line' areas can be a versatile policy and business tool for planning conservation and restoration (depending on the ecosystem's conservation status and desired services).

- Regional/local BD conservation and restoration programs to boost delivery of ecosystem services

270. Local/regional stakeholder ownership is key for the successful CCA in BD&ES as well as the success of their biodiversity programs, projects and green business. It further is a key for changing attitudes from viewing biodiversity protection as obstacle to business towards recognizing its societal and business opportunities. Based on 'red lines' and dynamic assessment methods to reduce pollution, disturbance and overexploitation, local communities and businesses will be empowered to take climate change adaptation in their own hands and apply valuable indigenous knowledge for better results.

271. While in itself this option does not bring immediate monetary benefits, it is a keystone for sound business plans of local communities and companies wishing to exploit the business-related adaptation options in this report.

CLIMATE CHANGE ADAPTATION OPTIONS
C. Create space for BD&ES
IX. Reclaim space from grey infrastructure
X. Create refugia, reduce fragmentation
21. Regional/local 'red lines' to prevent loss of ecosystem services vital for CCA **22.** Regional/local BD conservation and restoration programs to boost delivery of ecosystem services

3.1.4. Increase CC resilience by reducing pressures not related to CC

272. This option puts the ecosystems' 'health' at the core of adaptation to support biodiversity and allow for the benefits of ecosystem services it provides. More specific measures are listed in ***Annex 7*** with example adaptation options by ecosystem type.

Reduce pollution and disturbance

273. Depending on the landscape and ecosystem type, specific local options may relate to the reduction of stress, air pollution, light or noise pollution, as well as pollution by chemicals. An example of such an approach is the replacement of fertilizers in intensive agriculture by natural nutrients in crop combinations (that is, rotation with nitrate enriching cultures). This helps reduce nutrient pollution in freshwater and salt water bodies and improves drinking water quality for settlements.

274. The measures in this group are closely interlinked and should be implemented together; therefore, the identified adaptation options apply to all measures as a group and are organized in this manner.

Reduce overexploitation

275. Over-extraction of any species will eventually lead to disruption in the food chain and unwanted effects on the ecosystem. Examples of implementing this option in the local context include prudent hunting and foraging to avoid costly reintroduction of species into the disturbed ecosystem. The overall profitability of prevention is illustrated by the opportunity costs of reintroduction as known from EU-funded species projects.

276. To realize the adaptation potential of reducing ecosystem pressures, the local and/or regional stakeholders (depending on the ecosystem seize and location) need to be aware of the ecosystem condition, the quantities of ecosystem services it currently produces. Based on such knowledge, the bottlenecks for optimal production and delivery of ecosystem services will be easier to locate and address.

277. To this end, the amount of extraction and/or disturbance (the carrying capacity) for the ecosystems needs to be identified to avoid the decrease of ecosystem resilience and subsequent loss of ecosystem services.

278. The condition of the ecosystem should be estimated considering all factors that actually impact the ecosystem's condition. Except for very small ecosystems, in most cases such factors are of a systemic nature with significant impacts in space and time (such as soil acidification) and/or result from one-time but significant pressures that exceed the territorial scope of single projects. For example, even if a hotel was developed in a location sufficiently remote and not disturbing the biodiversity in a protected habitat, the road to this hotel may cut the long-term migration route for species if they need to reallocate due to climate change; as a result, the botanical or birdwatching tourism may decrease and negatively impact the visitor numbers and revenues for the hotel.

- Estimate carrying capacity for vital ecosystems and production capacity for their services

279. In order to have an objective measure on when an ecosystem is being overexploited or the pressures it experiences reduce its climate change resilience; an assessment is needed on how much of the particular pressures it can withstand and how much services it can produce without degrading. Such estimates cannot be a ballpark since even ecosystems of the same type will be used differently and exposed to different pressures depending on their geographic location and vicinity to sources of pollution, disturbance and so on

280. In itself, this option is not necessarily a profit bearing exercise. However, it is key to risk mitigation and sustainable adaptation, and a necessary prerequisite for the successful implementation of the economic options in this report.

- Regional/local monitoring and EIA for surveillance of ES exploitation and disturbance

281. Smaller scale monitoring of a community's natural capital is needed at least for ecosystem services on which the population and businesses rely. For example, if a smaller settlement has implemented a constructed wetland for water purification and flood retention, it will need to monitor the sediments level to ensure the retention volume, and to make sure that industrial wastewaters do not poison the reeds and pests or that rodents do not eat it. While national legislation foresees the monitoring of combined impact of different pressures on the environment, such regulations would be too costly and could not be enforced without the engagement of local communities and business. As a result, data on the regional and local level is missing in most locations.

282. On the other hand, Environmental Impact Assessments are mandatory for the major construction and industrial projects. Furthermore, many companies are required by law to perform self-monitoring of important abiotic and biotic elements. In the above example, this could be a factory performing self-monitoring under its water permit. This data, however, is not used beyond the company even if the local community needs it for CCA and even disaster protection.

283. Given sufficient economic incentive, such local data could contribute towards assessing the effects of all pressures on a given ecosystem as well as the influence of such pressures (or their removal) on the gain in ecosystem productivity. It could benefit greatly from combination with open data published by central authorities. To minimize data collection costs for such local level monitoring, self-monitoring measurements can be used in combination with citizen science data.

CLIMATE CHANGE ADAPTATION OPTIONS
D. Increase climate change resilience by reducing pressures not related to climate change
XI. Reduce pollution and disturbance
XII. Reduce overexploitation
23. Estimate carrying capacity for vital ecosystems and production capacity for their services **24.** Use self-monitoring and EIA for tracking ES exploitation, disturbance and ESS stocks

3.1.5. Use the 'invisible ecosystem services' for adaptation and human benefit

284. This group of options emphasizes the co-benefits of using ecosystem services as part of the 'business as usual'. As shown in Chapter 1, these can significantly outweigh the cost of provisioning services, especially for areas where tourism is a priority, but niche offerings are not yet well-developed. Using these solutions can augment the adaptation mix to create incentives for biodiversity preservation while also contributing to societal priorities such as equitable distribution and poverty reduction. It would, therefore, also support local-level investment decisions, particularly if financial instruments are to be employed. More specific

measures are listed in ***Annex 7*** with example adaptation options by ecosystem type.

285. Because businesses can (and often do) develop different activities within a single company or a holding, the options in this group are also highly interlinked and should be combined to maximize business development and ensure market-based mechanisms for providing local communities with equitable and cost-effective access to important ecosystem services.

Optimal use of existing ecosystem services

286. Restoring our links to nature has many material, spiritual and cognitive aspects that can be used for successful CCA. Reviving the traditional knowledge about Bulgaria's biodiversity and introduced species is at the core of optimal use of provisioning services from wild ecosystems, as well as the successful use of genetically diverse local and introduced sorts and breeds for a resilient food and material production.

287. The cultural ecosystems services are another important but underutilized element of natural capital that can support the climate resilience of local communities, in particular the ones heavily dependent on tourism and recreation.

Ecosystem services for CCA as new opportunity for business and society

288. Apart from ecosystem services to be found 'in the wild', the CCA of local communities can significantly benefit from the active production of ecosystem services through ecosystem restoration. Regulating ecosystem services benefiting the local community have, as a rule, to be provided in its vicinity and therefore every 'green' business engaged in a long-term restoration will necessarily create local employment. In this manner, the vulnerable population in remote or rural locations can use the win-win benefits from a better living environment and economic and social cohesion.

➢ Use genetic resources for resilience

289. This option emphasizes the tapping into ecosystem services supplied by less used ecosystems as a CCA support factor. Such use is especially beneficial to small communities and vulnerable/minority groups who in some cases rely heavily on their availability. Examples include the following:

- Use of local instead of imported sorts and breeds, possibly crossed with wild relatives for added resilience. Such a local sort is, for example, the salination and drought-resilient Einkorn wheat (*Triticum monococcum*)—a species with growing popularity as health food of commercial importance.
- Use of local healing plants from natural ecosystems, such as common hawthorn (*Crataegus monogyna*). Combined with local and traditional knowledge, they provide a source of easy to obtain health and improved well-being.

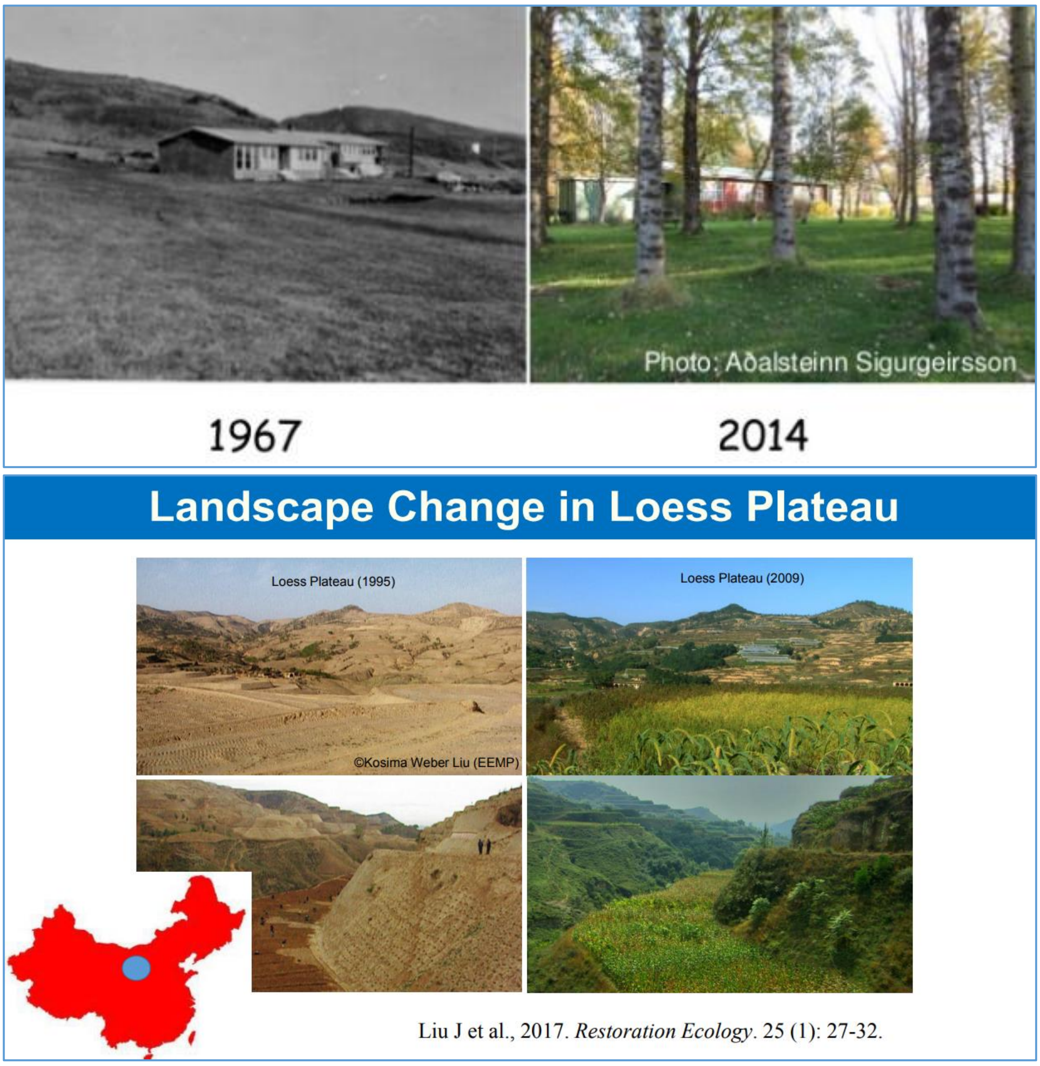
➢ Cultural ecosystem services for recreation and education

290. As detailed in Chapter 2, less well-known ecosystems such as sparsely vegetated lands offer unique experiences, learning, and research possibilities and can generate additional income from niche tourism offerings.

➢ Ecosystem restoration – a long term business opportunity

291. Since Bulgaria has no Green infrastructure strategy, ecological restoration is currently limited to smaller scale projects on terrains whose restoration is provided for by specific legislation (such as re-cultivation of closed landfills or previous industry sites). However, the loss of biodiversity on global, national and regional scale is a prerequisite for the worldwide increase of the ecological restoration projects. Since ecosystem services are a cost-efficient way to achieve CCA, the complex, long-term restoration projects can be a new source of sustainable business. They resemble engineering and construction in terms of project duration and complexity, and due to the local nature of the project, are well suited for regional and local business development and job creation, as outlined by Clewell and Aronson (2013). An estimate of direct and indirect benefits to business from ecosystem restoration are provided in BenDor et al. (2015). Examples for successful restoration projects from all over the world illustrate the complexity and time span of such undertakings.

Figure 13. Long-term ecosystem restoration: examples of afforestation



Sources: Iceland's Policy and Action Plan on Climate Change with a specific focus on Agriculture and Land Use / land use change / forestry[98]; Keynote "Ecological Restoration and Eco-Civilization in China"[99]

[98] https://www.slideshare.net/mmmviestinta/icelands-policy-and-action-plan-on-climate-change

[99] https://www.aanmelder.nl/i/doc/bfe10fd4ef27f1e890f9bcd1418e7d06?forcedownload=True

➢ Local development and equitable access to ecosystem services

292. Ecosystem restoration is also beneficial for local communities. Apart from direct job creation, it also enables the most vulnerable population to ‘produce’ local ecosystems services (such as microclimate regulation, water production and purification), therefore doubling as an avenue for equitable access to these services and an important awareness raising tool on the local and regional levels.[100] Moreover, collateral economic benefits are likely to spread not only within the ‘green economy’ business sectors but also to more remote sectors that are at high risk of climate change adaptation, such as insurance, energy, transport, thereby reducing the costs of living for wide populations.

CLIMATE CHANGE ADAPTATION OPTIONS
E. Use the ‘invisible ecosystems’ for adaptation and human benefit
XIII. Optimal use of existing ecosystem services
XIV. Ecosystem services for CCA as new opportunity for business and society
25. Use genetic resources for resilience **26.** Cultural ecosystem services for recreation and education **27.** Ecosystem restoration – a long term business opportunity **28.** Local development and equitable access to ecosystem services

293. Some best practices in Bulgaria are given in ***Boxes 10 and 11***.

Box 10. Cross-sectoral ecosystems monitoring and evidence gathering in Bulgaria

One of the objectives of program BG03 Biodiversity and ecosystem services (see Chapter 2) is to promote policy considerations related to ecosystem services. To this end, several highly complementary projects were required by the program operator and applied for by different stakeholders in all sectors, including forestry.

To produce compatible maps of different ecosystems that cover the entire territory outside NATURA 2000 in Bulgaria, mapping and assessment of ecosystems and ecosystem services was conducted—simultaneously and using the same approach, for all the CICES ecosystem types, including woodland and forest (Project ‘For Our Future’, http://fofproject.bg/en). Because forestry is a standalone sector with its specialized legislation, special care was given to data compatibility between the forestry databases and the other elements of the BBIS. To this end, the EFA became a partner both in the methodological project MetEcoSMap where they brought in feedback from forest mapping to improve the mapping and assessment of forest ecosystems, and in the project, designed to accept the final mapping and assessment data—IBBIS.[101] Their part in IBBIS was to ensure interoperability by transforming the specific data format that is legally binding for forestry databases and exposing forestry data through web services. This data is then made available for the new ecosystem services module within the BBIS.

In addition to the activities related to mapping and information system interoperability, the EFA also hosts a working group for enacting forest legislation related to ecosystem-based management. To align the Forestry Act chapter on ecosystem services with other related efforts, the new ordinances on forest inventory and Payment for Ecosystem Services (PES) to

[100] See, for example, https://www.youtube.com/watch?v=uA6j_-aEz7Q
[101] http://eea.government.bg/bg/ibbis .

forest owners were aligned with the forest mapping methodology produced in MetEcoSMap. They also were tested in selected pilot sites in another related project—PoliciES.[102]

Box 11. Central - local coordination in CCA

The MRDPW created a unified CCA framework using funding from the Southeast Europe ETC program. After completing it, the framework was communicated to the regional and local authorities and used in preparing the CCA sections of regional development plans.

3.2. Experience with Selecting Adaptation Options in the Sector in Other Countries

294. Adaptation based on an ecosystems approach has a sound base in Finland although the strategy was created long before MAES work was advanced enough to be coupled with CCA. The Finnish strategy is grouped by application areas—an approach that is adopted in this chapter as well. Also, it centers on integrity and introduces an assessment of links between protected areas. Creating space for biodiversity and escape routes in case of climate-induced habitat change is also an option relevant to Bulgaria because of the significant territory of protected zones and areas.

295. Shortage of funds for policy implementation in Bulgaria, especially in smaller communities with limited absorption capacity for project funding, presents a motivation for cutting CCA costs. The adaptation strategy of the United Kingdom spans many connected documents with good structure. One of them is the Economics of Climate Change Adaptation—a document introducing an overview of valuation methods (of which, the focus is on CBA because the other options for adaptation costing are less well-researched in the ecosystem context) and a balanced rating of cost (a similar approach is used but aimed at introducing a no-regrets option wherever possible).

296. As noted in Chapter 2, the biodiversity policy in Bulgaria is fragmented between sectors and national/regional/local policies. Against this background, the German adaptation strategy is notable in its sound scientific foundation and several national and regional research programs for cross-sectoral studies of climate change impact in different federal provinces. This approach is exemplary both in its integral structure in every given project area, and the closeness to stakeholders. It could be replicated when legislating the CCA and setting up the new Biodiversity Strategy.

3.3. Adaptation Options Assessed

297. All adaptation options listed above are zero or low cost and, in some cases, can lead to benefits from the use of surplus ecosystem services. However, due to the ongoing work in ecosystem services' monetary valuation and the very specific context of each local adaptation scenario, it is impossible to go beyond a very general semiqualitative cost estimate on a scale from 1 to 3, with 3 denoting the highest costs. Although specification in valuing the scenarios is necessary, this approximate assessment is based on costs for similar activities in other areas. The estimate of option groups and cost types is as follows:

[102] http://www.wwf.bg/what_we_do/policy_and_green_economy/ecosystem_policies/

- **Group A:**
  - Options 1, 2—cost grade 3, funding needed on IT and research infrastructure and running costs (such as laboratory)
  - Options 3, 4—cost grades 1 to 2, funding needed mainly for volunteer equipment, online tools, and travel to collect and disseminate local knowledge
- **Group B:** Cost grade 2, main costs are likely to be needed for paying for external expertise on specific topic matters
- **Groups C, D:**
  - Options C.1, C.2—cost grade 3, funds may be needed for transforming the landscape to create artificial landscape elements, buy-back of land, and pollution reduction measures.
- **Group E:** Cost grades 1 to 3, with restoration and green infrastructure projects likely to have the highest investment costs

298. Adaptation will have to be performed based on adaptation scenarios spanning all sectors in a given location. Scenarios would be elaborated based on the climate change projections, ideally on a small scale (that is, local). Once more specific threats are known based on the climate change projections, the local community would have to decide on CCA measures in each scenario in response to these threats. The measures selected in each scenario must be mutually complementary and create synergetic effects and span all relevant sectors. BD&ES adaptation will necessarily be one among the many objectives of such adaptation and must bear co-benefits for the total adaptation.

299. When assessing options from the groups listed earlier, the following indicative sequence of steps can be used:

(a) Depending on the climate projections at the local scale, for each location (for example a municipality with urban and rural areas, rivers, and lakes), the projected risks and vulnerabilities induced by climate change are derived.

(b) Based on the expected adverse climate effects, the appropriate mix of ecosystem services can be derived depending on the local conditions, assessment of type and scale of vulnerabilities, and estimated costs of inaction. An indicative set of relations between risks and vulnerabilities and the ecosystem services most appropriate to their adaptation (adapted from the EU publication Nature's role in climate change[103]) is presented in ***Table 4***.

[103] http://ec.europa.eu/environment/nature/info/pubs/docs/climate_change/en.pdf.

Table 4. Assessment grid for available options for ecosystem-based adaptation

Climate impact	Ecosystem-based adaptation	Ecosystem services to optimize for …
Increased droughts	Use appropriate agricultural and forestry practices to increase the water retention capacity and mitigate droughts	**Necessary services** • Surface water for drinking purposes • Groundwater for drinking purposes
		Co-benefits • Genetic material from all biota • Biomass-based energy sources • Mass stabilization and control of erosion rates • Hydrological cycle and water flow maintenance • Flood protection • Storm protection • Ventilation and transpiration • Pollination • Maintenance of nursery populations • Pest control • Disease control • Chemical condition of waters • Global climate regulation by reduction of GHG concentrations • Local climate regulation • Experiential use (relevant for alternative tourism products)
Heat extremes	Increase green spaces in cities to improve the microclimate and air quality	**Necessary services** • Local climate regulation • Ventilation and transpiration
		Co-benefits • Mediation of smell/noise/visual impacts • Groundwater for drinking purposes • Genetic material from all biota • Biomass-based energy sources • Mass stabilization and control of erosion rates • Hydrological cycle and water flow maintenance • Flood protection • Storm protection • Chemical condition of water (fresh or salt) • Pollination • Maintenance of nursery populations • Pest control • Disease control • Chemical condition of waters • Global climate regulation by reduction of GHG concentrations • Experiential use, sacred, and/or religious (relevant for urban recreation, the enjoyment of natural and cultural heritage, and alternative tourism products)
River flooding	Maintain and restore wetlands and riverbeds which will act as natural buffers against floods	**Necessary services** • Flood protection • Storm protection
		Co-benefits • Mass stabilization and control of erosion rates • Groundwater for drinking purposes • Genetic material from all biota

Climate impact	Ecosystem-based adaptation	Ecosystem services to optimize for …
		• Biomass-based energy sources • Hydrological cycle and water flow maintenance • Pollination • Maintenance of nursery populations • Pest control • Disease control • Chemical condition of waters • Global climate regulation by reduction of GHG concentrations • Experiential use (relevant for alternative tourism products)
Increased fire risk	Cultivate diverse forests, which are more robust against pest attacks and present a lower fire risk	**Necessary services** • Pest control • Disease control
		Co-benefits • Flood protection • Storm protection • Mass stabilization and control of erosion rates • Groundwater for drinking purposes • Genetic material from all biota • Biomass-based energy sources • Hydrological cycle and water flow maintenance • Pollination • Maintenance of nursery populations • Chemical condition of waters • Global climate regulation by reduction of GHG concentrations • Experiential use (relevant for alternative tourism products) • Existence and bequest value

(c) Once the assessment of the needed ecosystem services is accomplished, the landscape-level planning of ecosystems for the entire territory can be made as part of the spatial planning to provide the desired ecosystem service mix. This planning may include measures for natural ecosystems or the creation of green infrastructure, depending on the protection status and intended land use.

(d) The planned BD&ES measures should then be included in the funding estimates for CCA either as costs (that is, for planning of green infrastructure) or as cost reductions (that is, cost-savings from the use of ecosystem services instead of other technologies). The balance of necessary funds thus derived will inform on the scope and objectives of specific projects that may apply for funding from EU programs, financial instruments, state budget or other donors, and/or be financed from the municipal budget.

3.4. Cost Benefit Analysis

300. The conceptual framework of the CBA was developed with the purpose of estimating the value of the ecosystem services which are taken for granted by their users and are not included in statistics but deliver value for climate change adaptation.

301. Because Bulgaria does not, as yet, have natural capital accounts, the CBA was based

on EU level accounts, modeling of ecosystem services supply, as well as relations between the ecosystem parameters and the production of the respective services as described in scientific and ecosystem management literature.

302. The severe limitation of available data and models does not allow for a full estimate of the economic benefits of all 90 ecosystem services from the EU ecosystem service classification CICES.[104] Even where services were modeled or approximated, a monetary estimation for the occurrence of co-benefits and trade-offs is not possible within this analysis due to the limits of the models and data used. However, the incremental value, delivered by some essential provisioning and regulation and maintenance services, is illustrated. Even such incomplete calculation of benefits outweighs the adaptation costs in the sector.

The services covered by this partial CBA are presented in ***Table 5***.

Table 5. Ecosystem services considered in the CBA

CICES section	CICES classes	Approximation used in the analysis
Provisioning services	• Surface water for drinking • Surface water used as a material (non-drinking purposes) • Freshwater surface water used as an energy source • Ground (and subsurface) water for drinking • Ground water (and subsurface) used as a material (non-drinking purposes) • Ground water (and subsurface) used as an energy source	Water retention index (WRI) as described by Vandecasteele et al.[105] and modeled by the EU's Joint Research Center (JRC)[106]
Regulation & Maintenance services	• Pollination and seed dispersal • Global climate regulation by reduction of greenhouse gas concentrations	• Crop pollination dependence as described in the JRC report 'Ecosystem services accounting, Part I Outdoor recreation and crop pollination'[107] • Carbon sequestration estimates based on UK and US research[108]

[104] www.cices.eu
[105] https://onlinelibrary.wiley.com /doi/abs/10.1002/sd.1723
[106] https://data.jrc.ec.europa.eu/dataset/06c3f085-c1e3-4228-949d-82a0899b8d7d
[107] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC110321/jrc110321_jrc_technical_report_-_recreation_and_pollination_accounts_final_pubsy.pdf
[108] https://www.forestry.gov.uk/PDF/FCTP004.pdf/$FILE/FCTP004.pdf , https://www.nrs.fs.fed.us/pubs/gtr/gtr_wo059.pdf

303. The CBA for the sector focuses on the assessment of both soft and infrastructural adaptation measures. The effects of these measures on the main performance indicators are assumed to be positive; it can also be expected that they significantly exceed the indicators in the analysis since, at this stage, a more comprehensive indicator set cannot be used for analysis.

304. The effects of these measures on the main performance indicators: 'Incremental utility of improved water retention', 'Incremental utility of improved pollination' and 'Incremental utility of carbon sequestration from forest carbon sinks' are assumed to be positive.

Table 6. Benefits of adaptation measures in the BD&ES sector until 2050 (partial calculation, in € million)

Climate scenarios	NPV (€ million)	Cost-effectiveness/ benefits
Realistic scenario +2°C	7,055.65	140.41
Optimistic scenario +2°C	8,945.92	177.76
Pessimistic scenario +2°C	5,165.39	103.06
Realistic scenario +4°C	7,202.41	143.31
Optimistic scenario +4°C	9,247.32	183.72
Pessimistic scenario +4°C	5,157.51	102.90

305. The CBA is extending the sectoral analyses for sectors particularly susceptible to loss of ecosystem services due to biodiversity loss. Therefore, a positive NPV illustrates monetary value of non-accounted for benefits and avoided losses as a result of applied adaptation measures**.**

306. The projection shows that on average, under the +2°C realistic scenario, the total cash flow in NPV is €7.0 billion and €7.2 billion under the realistic scenario at +4°C. Under the optimistic scenario the projected cash flow in NPV is €8.9 billion at +2°C average and €9.2 billion at +4°C average. Even in the pessimistic scenario and with partial coverage of ecosystem services in the analysis, the future cash flow in NPV is projected at €5.2 billion at +2°C and €5.1 billion at +4°C.

307. The CBA shows that implementing the entire complex of adaptation measures would be effective to optimally use ecosystem services to reap benefits and avoid losses due to climate change**.** Cutting short some of the measures, the investment heavy planning of the location and use of natural capital, can diminish significantly and even negate the positive effects estimated in this analysis, as well as negatively impact many other ecosystem services not currently analyzed.

308. Within the current analysis, the cost-effectiveness of the adaptation measures is used to quantify the effect of investments under each scenario.[109] Under the +2°C realistic scenario the benefit/cost ratio is €140.41 (that is, the benefits achieved per Euro spent), and

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

€143.31under the +4°C realistic scenario. The benefit is higher at +4°C temperature rise. In that case, the benefit is €183.72 per one Euro of investment under the optimistic scenario and €102.90 per one Euro of investment under the pessimistic scenario. A higher effect of investments is observed under the +4°C scenario because the average air temperature during 1991–2015 has already increased by +1.6°C. Thus, to date, the level of the +2°C scenario has already almost been reached.

309. The adaptation measures are linked and interdependent, and therefore should not be ranked for selective implementation because the social and economic benefits are avoided losses of national natural capital.

3.5. Cross-Cutting Issues, Trade-Offs, and Synergies of Adaptation Options

310. The interrelation of adaptation options within the sector and between this and other sectors is presented in ***Table 7*** and ***Table 8***.

Table 7. Relations between adaptation options

Intra-sectoral	Intersectoral
Cross-cutting issues	
• Formulate win-win scenarios: effects of BD&ES CCA options on other sectors and vice versa • Align policies, strategies, measures, funding sources • Rapid, concerted, informed action of local institutions and stakeholders • Overcome sectoral, institutional, spatial fragmentation	• Scales of human activity versus ecosystem boundaries—influences on ecosystems • IAS, pests, and diseases • Ecosystem service—bundling and assessment • Ecosystem service flows and control over them beyond the planning territory
Trade-offs	
• Sector prioritization in the absence of a coherent strategic and legal framework on ecosystem services • Mitigation of BD&ES effects from other sectoral options • Power relations: local damages from/compensation for larger-scale ecosystem service provision	• Ecosystem services trade-offs, typically between provisioning and regulating/cultural services • For example: (a) sell timber and pay more for water supply and purification, wind, and flood protection to replace the loss of ecosystems; or (b) retain forest for water supply and purification, wind, and flood protection
Synergies	
• Optimize investments by smart use of ecosystem services: ○ Local development, job creation ○ Poverty reduction/alleviation - free ○ Ecosystem services use	• Use ecosystems for CCA and climate change mitigation • Reduce pressure sources by optimal ecosystem services use: green versus grey infrastructure, natural agriculture, value-added eco-tourism versus mass cheap tourism, and so on

Table 8. Sector interdependencies

Affecting → Biodiversity and Ecosystems		
CC effect in … (see below)	**Positively**	**Negatively**
Agriculture	Increase of 'green agriculture' subsidized by the EU funds may support cropland ecosystem resilience and raise crop yield. Green refugia in croplands may support ecosystem defragmentation and create migration paths and refugia for species.	Difficulties to meet demand for food and water to sustain the urban population may lead to intensification of agriculture at the expense of biodiversity (pollution, land grabbing) and diversion of water for irrigation.
Energy	Increase of solar energy production may lead to reduction of air and water pollution.	Possible competition for scarcer water resources between water energy production and BD&ES
Forestry	Ecosystem-based forest management may increase production of regulating ecosystem services in the forests (that is, erosion, wind, avalanche protection, carbon sequestration, water production, microclimate regulation) that will benefit adjacent ecosystems and enhance their adaptation capacity. Including other ecosystems in forest management may enhance the production of ecosystem services (that is, rocks and meadows with sparsely vegetated and grassland ecosystems; afforested strips along rivers, roads, and between cropland missives).	Overexploitation of provisioning services and forest management - focusing on their use may lead to disservices that deplete other ecosystems depending on forests (that is, rise in erosion and avalanches under former forest patches, decreased water retention, and so on).
Human Health	Development of urban/rural green infrastructure may support the decrease in pollution and heat-related conditions such as sun- and heat strokes, allergies, and diseases Regulating ecosystem services may provide cheaper, low tech adaptation alternatives for poor and vulnerable population groups who cannot afford cooling or disaster protection and decrease their dependence on the healthcare services.	With increased temperatures, demand for water procedures (senatorial healthcare) may divert or pollute scarce water resource from the wildlife and ecosystems.
Tourism	Combining cultural and natural heritage in tourism bundles may create new, higher- income tourist products. Using new technologies (such as virtual reality tours) for exploring less accessible ecosystems in a manner that does not impact wildlife so strongly may support enhancement of education.	Overexploitation of cultural ecosystem services beyond the carrying capacity of favorite recreation sites may lead to disturbance to wildlife, pollution, ecosystem deterioration, and therefore, decrease resilience to climate change.

Affecting ➔ Biodiversity and Ecosystems		
CC effect in … (see below)	**Positively**	**Negatively**
Transport	Wind protection belts along the roads may decrease fragmentation and create wildlife migration routes.	Transport corridors are among the main ecosystem fragmentation factors and one of the major pathways for spreading of IAS.
Urban Environment	Green infrastructure (that is, green roofs, walls, parks, and so on) created to reduce heat waves and provide regulating services will also double as urban wildlife refugia.	Introduction of IAS as pets and their abandonment or release is one of the major routes for their spread.
Water	Green infrastructure created for water retention, erosion, and flood protection, doubles as wildlife refugia.	Irrigation infrastructure may divert scarce water from valuable ecosystems and decrease their resilience.

311. ***Table 8*** illustrates how adaptation measures in other sectors impact BD&ES. However, such representation is limited in nature because some of the measures impact more than one sector. For example, creating green belts between croplands and roads means that their adaptation benefits will be of use, to a different extent, both for agriculture and for protecting the transport infrastructure. While transport infrastructure will mostly benefit from the wind and snow protection, the croplands will also use the water filtration and microclimate regulation functions as well as the pollination benefits if pollinators use the new refugium of the green belt. The selection of adaptation options in BD&ES should therefore not be limited to looking into pairs of sectors but also consider all sectors in a holistic manner.

312. As can be seen, the challenges across sectors and within the BD&ES sector vary significantly and are of a completely different nature. However, the matrix of ***Table 7*** must be considered in its entirety when selecting adaptation scenarios.

313. Regarding ecosystem services, their monetary valuation is still a work in progress and more specific guidance cannot be given at this stage. However, it is arguably easier to calculate the costs and benefits for groups of services than for each service separately. These groups are to be selected based on the following principles:

- **By mutual exclusivit**y (that is, unsustainable timber harvesting means destroying the forest and therefore removing erosion and wind protection);
- **By production mechanism and functional complementarity**: if services are delivered together as interlinked byproducts of a given ecosystem (that is, forest growth means more carbon sequestration by timber; at the same time, bigger trees improve the microclimate, protect from erosion, and provide habitats for many species, including pollinators);
- **By the recipients of the respective benefits.** Ecosystem services produced by one ecosystem may benefit another, for example, water purification from a river or wetland ecosystem can be of use for a city’s urban ecosystem; and
- **By their classification within the Natural Capital Accounts** (once such accounts are developed).

314. The bundles of ecosystems can then be valued for the purposes of estimating the costs for each adaptation scenario. ***Box 12*** illustrates the creation of local-level scenarios combining the use of ecosystem services to solve problems in other sectors while also supporting the species and ecosystems adaptation.

Box 12. Yambol area - problem-setting approach

According to sectoral analyses in many sectors, the district of Yambol could be among the major losers from climate change in Bulgaria. It is one of the highest risk areas regarding dry spells, but its irrigation systems are concentrated mainly around the Tundzha River and its tributaries, thus leaving areas not covered by irrigation. The flood risk is high in the lower parts of Tundzha where there also are no dykes. Soils are eroded, and this process is expected to be reinforced by climate change. Depending on the climate scenario, the forests in the region may be seriously damaged by the drier climate or suffer forest loss.

Against this background of complex risks identified by the sector analyses, a regional green infrastructure strategy for restoring ecosystems in Yambol and the upstream region of Sliven can be developed to support the implementation of adaptation measures in other sectors. An example of synergy between measures is the combination of green infrastructure with the following aspects:

- The agricultural measure 'Better management of existing forest areas, hedges, wood buffer strips, and afforested areas of agricultural land'. Planting relatively small but interconnected forest belts may support the regulation of microclimate while using ecosystem services for erosion, wind, and snow/avalanche protection. In the long term, this amounts to reducing the need for soil covering (measure 'Providing a protective coating for the soil surface or residual vegetation in periods of severe rainfall and wind erosion'). Ecosystem services also support the measure 'Improving the maintenance and restoration of the soil structure and increasing the infiltration capacity of the soil'.
- Measures under the heading of 'Biodiversity and the maintenance of genetic diversity in the forestry sector' are supported by the creation of green infrastructure which ensures connectivity and migration corridors between forests, thereby, enhancing the forests' adaptation potential to climate change.
- The green infrastructure and the use of local sorts and breeds support the implementation of tourism sector support the implementation of sectoral adaptation measures in tourism—creating new destinations in the area and new tourism products (for example, hunting, rural, culinary, and botanical tourism, and bird watching) related to the use of the cultural ecosystem services in the region.
- Roadside green infrastructure creates the prerequisites for a cost-effective implementation of the transport adaptation measure 'Program to improve the most vulnerable areas' (for example, planting snow protection vegetation, deploying snow-guarding barriers, and so on).
- Urban green infrastructure supports the implementation of measures to reduce urban heat waves and develop the urban green system; the greening of rooves and walls is a suitable element for implementing the measure 'Creative architectural projects for increasing the comfort and creation of natural ventilation/shade'.

The restoration of meanders along the lower Tundzha River and its larger tributaries would be a factor for the regulation of microclimate and flood protection, contributing to the implementation of the water adaptation measure 'Sensitivity Reduction' by creating retention volumes and reducing the flow speed. Constructive discussion for finding win-win solutions should include all stakeholders in and outside the administrative area of Yambol (in particular from the neighboring area of Sliven where the forest degradation due to fires may result in erosion that can cause downstream flood risk in Yambol) in order to develop win-

win solutions. Examples of win-win solutions can be provided by the NATURA 2000 areas in the port of Antwerp[110] or the Dutch Room for the River program[111] which combine urban planning, flood protection and biodiversity protection.

To develop such regional green infrastructure strategy, the biodiversity critical to CCA could be mapped in high resolution using open data (from NATURA 2000 and the 2016 mapping and assessment of ecosystems outside NATURA 2000), combined with cadaster, municipal and company data. Missing data can be collected by officials and local NGOs by observing the recommendations in the '*In situ* verification guide' of the National Methodological Framework for Ecosystems mapping and Biophysical Valuation. In this manner, 'red line' areas providing services vital for CCA will be identified and their carrying capacity can be estimated. Based on this data and a cost-benefit analysis, the restoration and management strategy for the local ecosystems can be defined and implemented in cooperation with local business.

315. The described process can increase awareness and help local stakeholders to embrace jointly developed decisions on the trade-offs in selecting adaptation options.

316. After the selection, full-scale or more limited CBA may be performed to calculate the monetary flows and externalities associated with the green infrastructure development scenario against the baseline of 'no action' and the costs of BD&ES services loss associated with such a baseline scenario. An example for a project involving green solutions for a wastewater treatment plant is presented in ***Table 9***. In the example, ecosystem services are grouped into bundles to meet a water policy objective in the most cost-effective manner.

Table 9. Approach to cost estimate of ecosystem services for CCA

Bundle name	Consists of services:	Information sources for valuation	Internal/ external to the project	Accounting and NCA classification
Water purification	Mediation of waste, toxics, and other nuisances (all services in this group); Mediation of flows (all); Decomposition and fixing processes; Chemical condition of freshwaters; Surface water for non-drinking purposes, Ground water for non-drinking purposes	(a) Opportunity costs calculated as investment in grey infrastructure to achieve the same level of service; (b) Ecosystem state and its correlation with ecosystem services provision capacity (for the polishing wetland only)	Internal	Accounting: sales of services; NCA: water account
Local project externalities	Maintaining nursery populations and habitats, Micro and regional climate regulation; Disease control; Weathering processes, Ground water	(a) Trade statistics—to inform on cross-border ecosystem services flows; (b) Opportunity cost derived from social payments and own-use	External	Accounting: either not available or increased asset value (national standards);

110 http://www.mow.vlaanderen.be/sph/antwerpen/index.php
111 https://www.ruimtevoorderivier.nl/english/

Bundle name	Consists of services:	Information sources for valuation	Internal/ external to the project	Accounting and NCA classification
	for drinking Scientific; Educational; Entertainment; Aesthetic; Symbolic; Existence	statistics—the cost of non-traded ecosystem services that support lower-income households and contribute to alleviating poverty		NCA: ecosystem services account(s)
Global project externalities	Global climate regulation by reduction of GHG concentrations	Commodity price for GHG emissions, or offset pricing	External	Accounting: commodity sales; NCA: carbon account
Additional services' utilization	Experiential use of plants, animals, and land-/seascapes in different environmental settings; Physical use of land-/seascapes in different environmental settings; Fibers and other materials from plants, algae and animals for direct use or processing; Biomass-based energy sources	Sales figures for ecotourism revenues (birdwatching) and biofuels produced from the wetlands	Internal	Accounting: Sales of goods (processed biofuel) or services (ecotourism) NCA: Ecosystem services account(s)

Note: NCA = Natural Capital Account

317. Further examples for indicative costs related to BD&ES sectors in Europe are presented in ***Annex 8***. However, these costs are to be regarded as indicative due to a number of factors such as the scope and activities of the project, or difference in costs for local resources (for example, program BG03 Biodiversity and ecosystems effectively spent only around €300,000 for citizen science support and the results greatly surpassed the planned indicators,[112] whereas the cost was far below comparable costs in ***Annex 8***).

3.6. Priority-Setting Approach

318. 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. In the framework of this report, following EU guidance, the adaptation options specifically identified for the BD&ES sector, have been prioritized.

319. In support of the priority setting, a prioritization meeting was organized in Sofia in

[112] Published at http://bg03.moew.government.bg/node/13

October 2017 inviting a variety of stakeholders from the sector. The meeting used a basic version of the multicriteria analysis (MCA) approach. The 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.

320. The 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.

321. 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.

322. 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; consequently, the wording of some options was different. Second, not all those who were invited to the prioritization meeting used this invitation to attend. 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 according to the stakeholders.

323. 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. This will, by necessity, be a mix of policy decisions and stakeholder inputs because the needs for amending the strategic, legal, and institutional framework in the sector (as identified and recommended in this report) will contribute significantly to the selection and prioritization of adaptation options.

324. The five main priority adaptation options that were tentatively and indicatively identified for the BD&ES sector before applying weights are the following:

(a) Implement new training programs at all educational levels and in informal/nonformal education;

(b) Complete the new Bulgarian Biodiversity Strategy and Action Plan with regard to ecosystem-based management, conservation, and CCA;

(c) Promote ecosystem thinking among volunteers;

(d) Create specialized education courses for administrations responsible for implementing CCA and biodiversity legislation; and

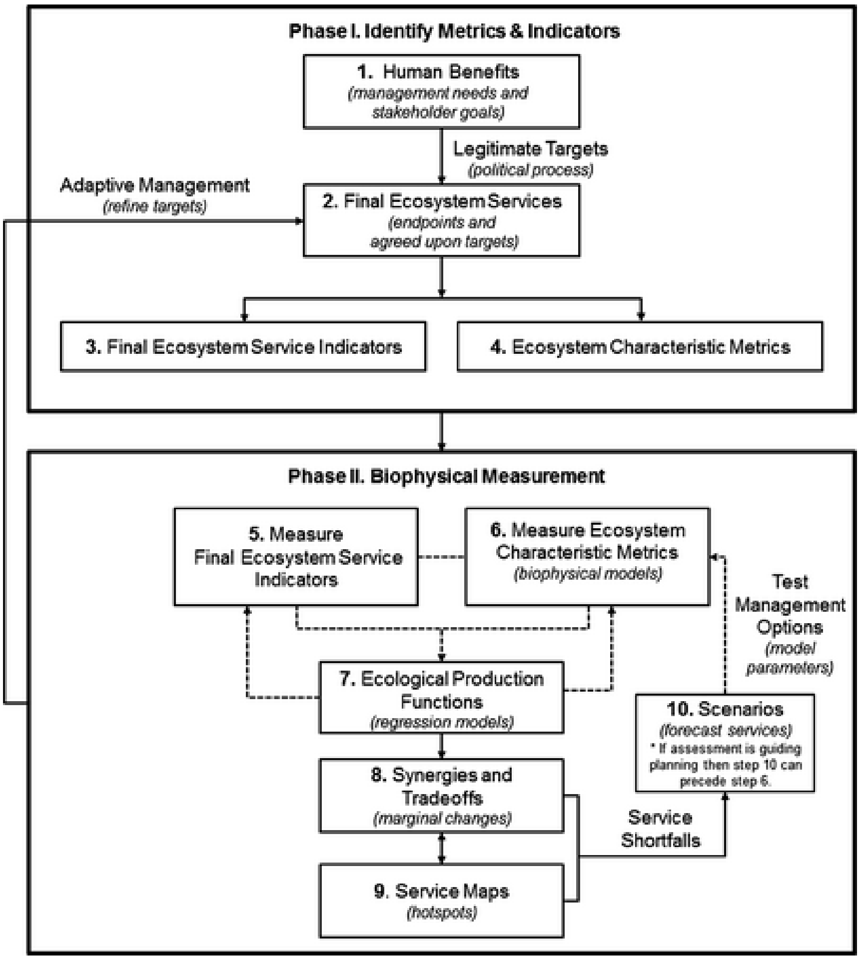
(e) Provide cultural ecosystem services for recreation and education.

325. Further feedback received from stakeholders during the written consultation on this report's final draft indicate the need to include more ecosystem restoration options in line with

Target 2, Action 6 of the EU Biodiversity strategy to 2020, and to introduce a structured prioritization approach that considers interdependencies between the adaptation options. In response to these comments, we performed additional research on the prioritization approaches, with the following main findings:

- Prioritization approaches are most effective in the context of the socio-ecological system (Daily et al. 2009). Purely or predominantly economic models, due to the lack of underlying ecosystem data, by necessarily tend to overemphasize the demand side of tradeable ecosystem services while a very approximate and imprecise value estimate for non-traded ecosystem services is provided by subjective economic techniques (Kahneman et al. 1991).
- Depending on the prioritization scale, projects can use various methodologies – from simple tools as described, for example, in Erazo and Barajas (2015), to large scale, resource intensive efforts based on fundamental and applied science like the framework described by Wong et al. (2014) and illustrated in ***Figure 14***.

Figure 14. Linking ecosystem functions to the policymaking process



Source: Wong et al. 2014.

- No matter of the scale and the degree of professional experience of the stakeholders participating in the multicriteria analysis, appropriate methods that take into account the structural and functional links between ecosystem functions and ecosystem service provision can be selected and are likely to be less biased than a multicriteria analysis which does not assume and consider links between the options (like the multicriteria evaluation in this project).

- Spatially explicit prioritization has a greater value added for policy making at the national and local level and integration into spatial planning policies because it allows the dynamic assessment and where necessary – revision of existing management policies, land allocations and so on based on climate change projections. As illustration, see ***Box 12***.

326. Based on this analysis, we believe that the prioritization of the options outlined in this report must follow a minimal set of principles:

1) No matter of the technical and financial risk assessment, the top priority options must be coherent and if an option is deemed important, all options that form its prerequisite must also of the same or higher priority. For example, prioritizing green infrastructure on the local level without adequate climate change and ecosystem models and projections (or at least approximation based on a sound expert and traditional knowledge for the target area) is likely to be counterproductive and may lead to further degradation of ecosystems and decrease in the provision of ecosystem services.

2) On all levels of policy decision-making, trade-offs must be considered from a holistic prospective and consider all ecosystem services relevant to the planning area. Particularly regulating ecosystem services which are a powerful CCA tool must not be omitted in such analysis on the grounds of missing information. Optimization of ecosystem management for a single ecosystem service or ecosystem services group is not acceptable, no matter how important these services may be for the planning region.

3) The prioritization methodology cannot be composed solely of ‘soft’ measures such as training and awareness raising. EbA CCA requires the delivery of ecosystem services and consequently, adaptation options from groups III, IV and V appropriate to the local conditions must be present in the regional/local adaptation strategy even if their technical, financial, management and so on operational risks are higher than the similar risks for ‘soft’ measures.

327. Taking into consideration the set of criteria thus outlined, we propose to the attention of policy makers and stakeholders the following selection and prioritization of options among the presented in section 3.1:

Table 10. Proposed ranking of climate change adaptation options

Rank	Adaptation Option(s)
1.	Develop and adopt the new Biodiversity Strategy and Action Plan and a new Green Infrastructure Strategy with regard to ecosystem-based management, conservation, restoration and CCA
	Review and amend legislation and secondary legislation in the environment sector and related sectors to reflect the new Biodiversity Strategy and Green Infrastructure Strategy
2.	Interdisciplinary teams and centers of excellence
3.	Operationalize ecosystem-based monitoring and strategic/environment impact assessment

Rank	Adaptation Option(s)
4.	Open data for public use
	Communication and tools for informed prioritization of research and practical action
	Enable volunteer sharing
5.	Adjust regional and local adaptation strategies to the amended CCMA and the strategic documents and legislation on BD&ES
	Local development and equitable access to ecosystem services
6.	Link decision making, resource, and funding to efficient assessment of improved ecosystem condition
7.	Identify regional/local "red lines" to prevent decrease or irreversible loss of ecosystem services vital for CCA
	Develop regional/local programs to conserve and restore biodiversity to increase the delivery of ecosystem services
8.	Ecosystem restoration – a long term business opportunity
	Implement new training programs at all educational levels and in informal/non-formal education
	Create carbon environmental accounts
9.	Cultural ecosystem services for recreation and education
	Use genetic resources for resilience
10.	Targeted collection of folk customs and traditional knowledge

Note: Options with equal importance share the same rank in the table. Depending on the regional and local context, they may be interchangeable or used together. Where all other criteria would result in equal ranking, options that are prerequisite for other options are ranked higher.

3.7. Conclusions

328. Effective CCA requires adaptive ecosystems management in the context of the socioecological systems (EbA-CCA). This concept requires implementing interlinked adaptation options from all five areas identified in this report: governance, knowledge management, creating space for BD&ES, reducing pressures on BD&ES, using ecosystem services for adaptation.

329. The selection and prioritization of adaptation options for a specific location requires the involvement of policy makers and other stakeholders on the regional and local level. It is likely to lead to the definition of ecological 'red zones' to protect both the biodiversity and the provision of important ecosystem services, as well as to specific cost estimates for green infrastructure, ecosystem restoration and conservation, and other specific services that provide for economic growth. Equally important is the monitoring of trends in the anthropogenic pressures on ecosystems and the development of ecosystems. For maximum efficiency and cost-cutting, optimal use of local data, such as self-monitoring and EIA data, local knowledge, and other, must be made.

330. A multicriteria analysis approach would be important for setting priorities and deciding on trade-offs in the use of ecosystems to optimize the desired delivery of different types of ecosystem services. Such approach must consider the links between adaptation options (presented in detail in Chapter 3 and Annex 2), to avoid mismanagement of

ecosystems and their degradation or loss and the corresponding loss of ecosystem services. Spatially explicit representation is especially useful for visualizing and studying the production and consumption patterns of ecosystem services and climate change related factors that may lead to diminishing the ecosystem services provision.

331. The use of ecosystem services that are currently being ignored by the strategic and legal framework may be especially beneficial to the economic development in smaller communities as well as a factor for equitable access to these ecosystem services by vulnerable social groups with limited funds and mobility.

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Annex 1. Potential Climate Change Impacts on the Biodiversity and Ecosystems Sector in Bulgaria

Table 11. Potential climate change impacts on the BD&ES sector in Bulgaria

Affected BD&ES sector aspects	High temp.		Low temp.		Prolonged rainfall		Drought		Water table rise		Sea level rise		Specific effects of climate change relevant for BD&ES: Provisioning ESS		Specific effects of climate change relevant for BD&ES: Regulating ESS		Specific effects of climate change relevant for BD&ES: Cultural ESS		Extreme Weather Events: Electric storms		Extreme Weather Events: Fogs		Extreme Weather Events: Floods		Extreme Weather Events: Avalanches		Extreme Weather Events: Land-slides		Extreme Weather Events: 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	D	P
SPECIES																														
Phenological changes	H	H	H	H	M	M	H	H			L	L	H	H	H	H	L	M												
Physiological changes	H	H	H	H	M	M	H	H			L	L	H	H	H	H	L	M					L	L						
Extinction of species	H	H	M	M	M	M	H	H			M	M	H	H	M	M	M	M												
Diseases, new pests, viruses and fungi	H	H	H	H	H	H	H	H			U	U	H	H	H	H	H	H					H	H						
POPULATION AND COMMUNITY																														
Changes in population size	M	M	M	M	M	M	H	H			M	M	H	H	H	H	L	L					H	H			H	H		
Interaction changes between species – life-cycle changes	H	H	L	L	H	H	H	H			M	M	H	H	M	M	L	L					L	L						
HABITATS																														
Changes in geographical distribution	H	H	L	L	M	M	H	H			L	L	H	H	M	M	M	M												
Species distribution changes	M	M	L	L	M	M	H	H			M	M	H	H	M	M	M	M					M	M			H	H		
ECOSYSTEMS																														
Regime shifts	H	H	M	M	M	M	H	H			M	M	H	H	H	H	M	M					H	H			H	H		
Primary productivity	M	M	M	M	H	H	H	H			M	M	H	H	H	H	M	M					H	H						
Life cycle changes	M	M	M	M	M	M	H	H			U	U	H	H	H	H	M	M												
Environmental and water condition	H	H	M	M	H	H	H	H			-	-	H	H	H	H	M	M					H	H						
Longer growing season	H	H	L	L	M	M	H	H			-	-	H	H	H	H	H	H												
ECOSYSTEM SERVICES																														
Provisioning ESS	H	H	L	L	M	M	H	H			M	M											H	H			H	H		
Regulating ESS	H	H	H	H	H	H	H	H			M	M											H	H			H	H		
Cultural ESS - Recreation	H	H	H	H	H	H	M	M			H	L											H	H			H	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 12. Adaptation options presented in detail

CLIMATE CHANGE ADAPTATION OPTIONS						
A. Enhance environmental governance						
I. Align strategic planning and implementation legislation						
1. Develop and adopt the new Biodiversity Strategy and Action Plan and a new Green Infrastructure Strategy with regard to ecosystem-based management, conservation, restoration and CCA						
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction	
	X	X	X	X	X	
Description	• Rationale: Implementing Art. 115 (1) of the Biodiversity Act, as well as the EU's Green Infrastructure policies in urban and rural areas • Impact: The option is key to BD&ES in Bulgaria and CCA based on ecosystems services delivery • Synergies: The option is synergetic with all other adaptation options presented in the report					
Option's relevance: Economic +++; Ecologic +++; Social +++						
Opportunities that arise	The timing of implementing the measure will allow Bulgaria to develop a modern framework for ecosystem management with organic links to CCA					
Cross-cutting relevance	YES	All institutions involved in, and sectors benefiting from, ecosystem based CCA				
Risks addressed	All ecological and socioeconomic risks					

2. Review and amend legislation and secondary legislation in the environment sector and related sectors to reflect the new Biodiversity Strategy and Green Infrastructure Strategy						
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction	
	X	X	X	X	X	
Description	• Rationale: Implementing the new BD and Green Infrastructure strategies as well as EU's cross-cutting policies for monitoring and reporting the environmental and ecosystems impact of other policies, such as emissions, water, agriculture, and so on (see Chapter 2, sections 2.3 and 2.4) • Impact: The proposed review will introduce the ecosystem services concept in all sectors that impact biodiversity, including sectors under other administrations. It will support the cost-effective implementation of policies in those sectors by providing for the re-use of data and knowledge and creating the legal basis for using natural capital for adaptation. • Synergies: The option is synergetic with all other adaptation options presented in the report					
Option's relevance: Economic +++; Ecologic +++; Social +++						
Opportunities that arise	The proposed review will introduce the ecosystem services concept and its benefits for business and society					
Cross-cutting relevance	YES	All sectors				
Risks addressed	Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital					

<table>
<tr><td colspan="6">3. LINK DECISION MAKING, RESOURCE, AND FUNDING TO EFFICIENT ASSESSMENT OF IMPROVED ECOSYSTEM CONDITION</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic | Ecologic | Social
++ | +++ | ++</td><td colspan="5">Rationale: Aligning the BD and CCA funding mechanisms with the amended legislation as well as the EU wide reassessment of the use of funds for biodiversity initiated under the LIFE program in its call 2017 Impact: The option will support the planning and release of adequate funding for the options proposed in this report and for the ecosystem management in general, operationalizing the mainstreaming of the ecosystem and ecosystem services concepts Synergies: The option is synergetic with all adaptation options presented in the report which require funding from budgetary sources or EU / other donor programs. Highly synergetic to options 12, 13, 15, 16, 21,22, 23. Synergetic to all other options in groups IV-XIV</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Leveraging scarce and/or fragmented available funding for protecting the rich biodiversity in Bulgaria while also supporting CCA and socio-economic objectives</td></tr>
<tr><td>Cross-cutting relevance</td><td>YES</td><td colspan="4">Environmental considerations are mainstreamed across all policies and as such, adequate funding is essential to these sectors too.</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital</td></tr>
</table>

<table>
<tr><td colspan="6">4. OPERATIONALIZE ECOSYSTEM-BASED MONITORING AND STRATEGIC/ENVIRONMENT IMPACT ASSESSMENT</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic | Ecologic | Social
+++ | +++ | +++</td><td colspan="5">Rationale: Implementing the provisions for ecosystem monitoring embedded in EU legislation in a consistent and cost-effective manner while also implementing the Target 2 of EU Biodiversity Strategy to 2020 Impact: The option will support the creation and maintenance of a cross-administrative mechanism for optimal use of data collected under different policies. In this manner, all data submitted to authorities could be re-used for CCA while reducing red tape for business and citizens. Continuous monitoring will also help identify trends in ecosystem developments and help predicting their deterioration for implementing mitigation measures and early warning in case of decreasing climate resilience. Synergies: The option is synergetic all options in this report related to continuous monitoring of ecosystems and planning of their management, in particular 7, 8, 12, 13. It benefits from options 17-20 and provides inputs for options 6, 10, 11, 14-16, 25-28</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Better monitoring will support the valuation and preservation of natural capital, in particular as early warning for possible loss of regulating services related to CCA. The relatively late introduction will allow the use of modern, cost-effective technologies such as earth observation and machine learning/artificial intelligence for remote monitoring.</td></tr>
<tr><td>Cross-cutting relevance</td><td>YES</td><td colspan="4">Ecosystem based monitoring will require and facilitate exchange of data and findings with all sectors affected by the CCA Strategy</td></tr>
</table>

Risks addressed	Risks to all ecosystems, on the entire territory, arising from pressures not identified and/or mitigated

II. Adjust sectoral legislation to climate legislation

5. Revise the CCMA and sectoral strategies/legislation to include the provisions of the CCA Strategy

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X		

Description	
Option's relevance: Economic ++; Ecologic +++; Social +++	• Rationale: Since the development of CCA legislation predated the CCA Strategy, this legislation has also to be updated. During such update, it is necessary to create cross-links to BD&ES legislation along the lines outlined in this report • Impact: Combining two complicated conceptual frameworks using the ecosystem functioning in the context of a socio-ecological system presents a number of scientific and practical challenges. Once accomplished, however, it will positively impact the mainstreaming of biodiversity in all sectors affected by climate change and included in this report by providing a holistic prospective • Synergies: The option benefits from option groups III and IV. It is highly synergetic with the options related to the practical implementation of CCA measures (groups C, D, E)
Opportunities that arise	The growing traction and public awareness of climate change issues (in particular among businesses) can help catalyzing the same process in terms of ecosystem services production
Cross-cutting relevance	Yes — All sectors in this strategy
Risks addressed	Environmental risks for all ecosystem types arising out of policy mismatch and insufficient coordination when implementing CCA in BD&ES

6. Adjust regional and local adaptation strategies to the amended CCMA and the strategic documents and legislation on BD&ES

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	x	x	x	x	x

Description	
Option's relevance: Economic +++; Ecologic +++; Social +++	• Rationale: The option proposes the same activities as in option 5 but replicated on the regional/local level. • Impact: Since the regional/local communities are vulnerable to CC impacts but in most cases, do not have sufficient resources and capacity, EbA-CCA provides for approaches to increasing climate resilience that are more natural, easier to communicate and implement, cost effective and beneficial to local economy • Synergies: The option benefits from option 5 and groups III and IV. It is highly synergetic with the options related to practical implementation of CCA measures (groups C, D, E)
Opportunities that arise	Small and medium-sized enterprises will largely benefit from new local business opportunities. Since most regulating and cultural ecosystem services are local by nature, their bulk will also be provided to and used by local communities
Cross-cutting relevance	YES — All sectors
Risks addressed	Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital

<table>
<tr><td colspan="6">III. Link emissions statistics to new environmental accounts</td></tr>
<tr><td colspan="6">7. CREATE CARBON ENVIRONMENTAL ACCOUNTS</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>Description

Option's relevance
Economic: +++ | Ecologic: + | Social: +++</td><td colspan="5">• Rationale: Implement Target 2 of the EU Biodiversity Strategy to 2020 and prepare for a possible change in EU statistical legislation.
• Impact: The option is mainly of a societal nature. It will help to bring the value of "invisible" ecosystem services to the attention of all stakeholders, notably the businesses who are more likely to develop commercial interest for the production and use of regulation ecosystems services. Another important consideration is the benefit from natural capital accounts to scientists who study the socio-ecological system in its entirety.
• Synergies: The option benefits from options 1 and 2. It is important as a support mechanism to option groups IV to XIV, and in particular to the business-related options 2, 26 and 27</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Creating traction for the policy and practical use of the natural capital concept for developing coherent, scientifically sound policies and sustainable business solutions</td></tr>
<tr><td>Cross-cutting relevance</td><td>Yes</td><td colspan="4">Agriculture, Forestry, Fishery</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital</td></tr>
</table>

<table>
<tr><td colspan="6">8. LINK CARBON EMISSION ACCOUNTS AND ENVIRONMENTAL ACCOUNTS</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>Description

Option's relevance
Economic: +++ | Ecologic: +++ | Social: +++</td><td colspan="5">• Rationale: The option is supporting to option 5 as an institutional background.
• Impact: The correct implementation of this option is a prerequisite for facilitating business and trade by removing various institutional obstacles. In particular, businesses engaged both in climate change and biodiversity restoration may be able to monetize the carbon sequestration ecosystem service.
• Synergies: The option does not, by itself, benefit from any of the other options. It is synergetic with options 5 and 14-16, and supports the implementation of option groups C, D, E</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Enterprise financing and reduction of institutional barriers for developing green business</td></tr>
<tr><td>Cross-cutting relevance</td><td>YES</td><td colspan="4">All sectors</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital</td></tr>
</table>

IV. Educate for ecosystem thinking

9. *Implement new training programs at all educational levels and in informal/non-formal education*

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X		
Description Option's relevance: Economic +++; Ecologic ++; Social +++	• Rationale: In line with the 7th EAP, this option proposes mutually beneficial integration of environmental and social development. • Impact: The option will influence the entire educational system from primary schools to university and informal/non-formal education. It will require the collaboration of scientists and practitioners with the education specialists in order to create appropriate content and organize the teaching/training. Vocational training and university programs may also require field training and familiarization with emerging technologies. • Synergies: This option is primarily of a social nature. It also indirectly supports the options related to capacity building, stakeholder involvement and direct implementation of CCA (options 10-28)				
Opportunities that arise	Absorbing job seekers displaced from other industries where the growing penetration of robotic and Artificial intelligence technologies may reduce the number of workers				
Cross-cutting relevance	Yes	Education, Agriculture, Forestry, Fishery			
Risks addressed	Risks of mismanaging ecosystems by implementing climate-only “solutions” not considering the ecosystem impact. Societal risks in all sectors affected by social pressures of a technological nature				

10. *Create specialized education courses for administrations responsible for implementing CCA and BD legislation*

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X			
Description Option's relevance: Economic +; Ecologic +++; Social +++	• Rationale: This is a specialized option for increasing institutional capacity. Because public administration is typically not taught in depth, many public servants in central and regional/local administrations will need job-specific training for proper ecosystem-based management, tailored to their roles in the process. • Impact: The implementation of this option will benefit both the direct ecosystem-based management and all related sectors where it must be mainstreamed. For correct implementation, it must be linked to the problems of these sectors and provide overview to other linked or horizontal issues, in particular CCA. • Synergies: The option is synergetic with options of groups A and B, and for regional/local administrations – also options 21-24 and 26-27				
Opportunities that arise	Administrations will be exposed to scientific and business implications of ecosystem based CCA beyond their immediate responsibilities and trained in holistic management				
Cross-cutting relevance	YES	All sectors			
Risks addressed	Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital				

11. DEVELOP SKILLS FOR ECOSYSTEM COMMUNICATION AND AWARENESS RAISING					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description Option's relevance Economic: +++ / Ecologic: +++ / Social: +++	• Rationale: This option is related to developing 'soft skills' essential to the holistic EbA-CCA approach. • Impact: As noted in this report, social tensions may be alleviated by rising awareness of the environmental complexity, so stakeholders can develop a common view on the implications of each possible trade-off and find balanced solutions. To achieve this purpose, communication skills must be developed not only for media style short communications but also for policy and scientific briefs and/or longer discussions. The option builds upon option 10 but implies a longer, often on-the-job informal and non-formal training in context of the specific tasks at hand. Such skills may be needed for a wide range of stakeholders, including scientists, business (such as business managers and salespeople for green solutions), administrations. • Synergies: Option 11 benefits from option 10 and is synergetic with options from A) and B) and options 21-24 and 26-27				
Opportunities that arise	The option will support the inclusion of ecosystem-based adaptation in the social agenda at large. As such, it is likely to invite a variety of training offerings from private providers.				
Cross-cutting relevance	YES	All sectors			
Risks addressed	Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital				

B. Knowledge management and stakeholder communication for adaptation

V. Open and reuse data

12. ECOSYSTEM DATA INTEROPERABILITY BETWEEN AUTHORITIES AND OTHER ACTORS					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description Option's relevance Economic: +++ / Ecologic: +++ / Social: +++	• Rationale: This option underpins all options related to data sharing, monitoring and practical EbA-CCA activities. However, it views the problem mainly from institutional angle and therefore supports the implementation of the INSPIRE Directive and national eGovernment efforts. • Impact: The option will support the elimination of inefficiencies and contribute towards including all available data into one "single picture", no matter of data age and format. With the advance of earth observation technologies this also means that the administrations will be required to exchange, share and process big data for scientific, management and monitoring purposes. • Synergies: This option is primarily of a technological nature. It supports all other options in the report, and in particular the options related to collecting, sharing and using data (options 13-27)				
Opportunities that arise	Managing the transition to high-tech environment governance in a time of explosive technological growth				
Cross-cutting relevance	Yes	IT, education, all sectors vulnerable to climate change			
Risks addressed	Risks of mismanaging ecosystems. Technological risks in all sectors affected by shifting technologies				

<table>
<tr><td colspan="6">13. Open data for public use</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic: +++ | Ecologic: +++ | Social: +++</td><td colspan="5">• Rationale: This option also is mainly related to society’s use of data, in particular with regard to data exchange policies.
• Impact: Opening data is key for the correct scientific implementation of climate change in general, and even more so for EbA-CCA. It further is instrumental for the correct policy and management decisions on all levels and as such, may be a powerful factor for reducing risks to CCA. If copyright and other data related restrictions are mitigated, it further has a potential monetary dimension with the emergence of smart contracts that would allow easier data sharing and trading.
• Synergies: This option supports all other options in the report, and in particular the options related to collecting, sharing and using data (options 12 and 14-27)</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Administrations will be exposed to scientific and business implications of ecosystem based CCA beyond their immediate responsibilities and trained in holistic management</td></tr>
<tr><td>Cross-cutting relevance</td><td>YES</td><td colspan="4">All sectors</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital</td></tr>
</table>

<table>
<tr><td colspan="6">VI. Improve communication and understanding of ecosystem processes and climate change as pressure</td></tr>
<tr><td colspan="6">14. Communication and tools for informed prioritization of research and practical action</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic: + | Ecologic: + | Social: +++</td><td colspan="5">• Rationale: This option involves the creation of applied and practical EbA-CCA decision-making tools with sound scientific underpinning, such as multi-parametric models of biodiversity and ecosystem functioning under climate change stress and other pressures, as a way to support informed policy decisions.
• Impact: The option will support mainstreaming EbA-CCA and at the same time mitigate the risks of wrong policy decisions due to lack of understanding and information deficits. Tools for decision making may include parameter exploration of even future scenarios for ecosystem development under climate change stress. There are hundreds of relevant tools relevant for policy and business, and the challenge of this option is to select or further develop the ones most appropriate for the Bulgarian context in terms of accuracy and ease of use.
• Synergies: This option is focused on the science-policy interface. It supports all options in the report which require joint decision making (options 21-28)</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Reducing or removing biases of uni-disciplinary approaches to CCA which may lead to wrong policy decisions with grave consequences</td></tr>
<tr><td>Cross-cutting relevance</td><td>Yes</td><td colspan="4">All sectors vulnerable to climate change</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks of mismanaging ecosystems and causing expensive or irreversible loss of biodiversity</td></tr>
</table>

<table>
<tr><td colspan="6">15. INTERDISCIPLINARY TEAMS AND CENTERS OF EXCELLENCE</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic: +++ | Ecologic: +++ | Social: ++</td><td colspan="5">• Rationale: Informed policy making needs investment in fundamental science. In times of budgetary shortages, focusing the funding of such science to key areas such as CCA will lead to better returns and increase in relevant knowledge.
• Impact: Climate change and biodiversity loss models and projections need appropriate scientific infrastructure. The project-based approach is being practiced in science funding, but the terms of such contests are typically not very focused (see discussion in 2.6.1). Against this background prioritizing funding for EbA-CCA related research could support the implementation of this Strategy. Care should be taken to avoid misleading and biased tools, for example by comparing results from the use of different research methods on the same data.
• Synergies: This option supports all other options in the report, and in particular the options related to policy and community decisions (options 1-8, 21, 23). It benefits from implementing options 9, 20 and 24, and is synergetic with options 12, 19 and 28.</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Relieve social tensions by joint decision making</td></tr>
<tr><td>Cross-cutting relevance</td><td>YES</td><td colspan="4">All sectors vulnerable to climate change or ecosystem degradation</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital</td></tr>
</table>

<table>
<tr><td colspan="6">16. PARTICIPATIVE SCIENCE</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic: +++ | Ecologic: +++ | Social: +++</td><td colspan="5">• Rationale: This option addresses scientific collaboration in the context of cognitive and organizational limitations and scientific bias.
• Impact: Wider participation of scientific and non-scientific stakeholders in the climate change and ecosystem exploration, modelling and projections is important for introducing different points of view and cross-validation of policy decisions.
• Synergies: Same as in option 15</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Support for deepening and awareness bringing EbA-CCA into the social agenda</td></tr>
<tr><td>Cross-cutting relevance</td><td>YES</td><td colspan="4">All sectors vulnerable to climate change or ecosystem degradation</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks to all ecosystems, on the entire territory, arising from mismanagement of natural capital</td></tr>
</table>

VII. Restore, enhance, and use local biodiversity knowledge

17. *Targeted collection of folk customs and traditional knowledge*

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
		X	X	X	X
Description Option's relevance: Economic +++, Ecologic +++, Social +++	• Rationale: Support the IPBES work of Bulgaria. • Impact: The need for long time series of data for climate science and ecology predates the current advanced technologies. Traditional knowledge may help bridging this gap while also focusing public attention on holistic ecosystems management and re-establishing our connections with nature. • Synergies: This option complements all options from group B and can provide useful inputs to the options in groups C and E				
Opportunities that arise	Creating deeper, experiential understanding of holistic science to the general population by return to our own history				
Cross-cutting relevance	Yes	All sectors vulnerable to climate change			
Risks addressed	Risks of mismanaging ecosystems and causing expensive or irreversible loss of biodiversity				

18. *Import foreign knowledge*

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description Option's relevance: Economic +++, Ecologic +++, Social ++	• Rationale: Free trade creates adaptation opportunities by diversifying the gene pool but also increases the risks of spreading invasive species. • Impact: This option illustrates the potential for CCA induced controversies between stakeholder groups. As climate change depletes resources, introducing new commercially important species that prove to be invasive can become a more frequent occurrence. To avoid negative externalities, knowledge about imported species must be collected at the source, combined with observations in Bulgaria and once their impact on local ecosystems is established, transferred to actionable policies. • Synergies: This option can create synergies to all options of groups I and IV and provide necessary inputs to the options of groups C, D and E.				
Opportunities that arise	Relieve social tensions by informed finding of trade-offs				
Cross-cutting relevance	YES	All sectors vulnerable to climate change or ecosystem degradation but in particular agriculture, forestry, fisheries and human health			
Risks addressed	Risks to all ecosystems, on the entire territory, arising from increased vulnerability				

<table>
<tr><th colspan="6">VIII. Maximize the use of citizen science</th></tr>
<tr><td colspan="6">19. PROMOTE ECOSYSTEM THINKING AMONG VOLUNTEERS</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td></td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic: ++ | Ecologic: +++ | Social: +++</td><td colspan="5">• Rationale: Increase the efficiency of volunteer contributions.
• Impact: As discussed in this report, a significant obstacle to active and mass volunteering for ecosystem related citizen science is the entrenchment into equating biodiversity to species in the public perceptions. Volunteering can be supported by easy to understand but sufficiently specific training and coaching or sharing important information via informal channels such as social networks.
• Synergies: This option complements option 4, all options from group B and can provide useful inputs to the options in groups C, D and E. Highly synergetic with option 26</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Creating deeper, experiential understanding of holistic science for active volunteers as multiplier for the quantity and quality of their work</td></tr>
<tr><td>Cross-cutting relevance</td><td>Yes</td><td colspan="4">All sectors vulnerable to climate change but mostly Agriculture, Forestry, Fishery, Urban</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks of mismanaging ecosystems due to biased public perceptions</td></tr>
</table>

<table>
<tr><td colspan="6">20. ENABLE VOLUNTEER SHARING</td></tr>
<tr><td rowspan="2">Relevant to:</td><td>Legislative & institutional framework</td><td>Stakeholder involvement</td><td>Science, knowledge, data</td><td>Ecosystem territorial scope, defragmentation, connectivity</td><td>Ecosystem pressures & disturbances reduction</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Description

Option’s relevance
Economic: +++ | Ecologic: +++ | Social: +++</td><td colspan="5">• Rationale: Capture and systematize volunteer inputs.
• Impact: This option supports the crowdsourcing of data collection for EbA-CCA. If implemented systematically, it can provide significant savings potential for data collection and reduce mistakes in data capture.
• Synergies: Strong synergy with option 4 and useful inputs to options from groups C, D, E.</td></tr>
<tr><td>Opportunities that arise</td><td colspan="5">Increase satisfaction from the joint/networked experience of nature and peer recognition</td></tr>
<tr><td>Cross-cutting relevance</td><td>YES</td><td colspan="4">All sectors vulnerable to climate change or ecosystem degradation</td></tr>
<tr><td>Risks addressed</td><td colspan="5">Risks to all ecosystems, on the entire territory, arising from pressures not identified and/or mitigated</td></tr>
</table>

C. Create space for BD&ES					
IX. Reclaim space from grey infrastructure					
X. Create refugia, reduce fragmentation					
21. REGIONAL/LOCAL "RED LINES" TO PREVENT LOSS OF ECOSYSTEM SERVICES VITAL FOR CCA					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description Option's relevance: Economic + ; Ecologic +++ ; Social +++	• Rationale: Create social consensus about nature protection based on scientific findings. • Impact: As discussed in this report, lack of or deficiencies in strategic vision result in social tensions and the public perception of antagonism between business and nature protection. To reverse this trend, it is imperative to explain to stakeholders the extent of protected areas, the proposed protection measures and eventual scope of their conservation or restoration by emphasizing the win-win combinations where social and economic benefits can be received from and not against the nature. In such a manner decision on protected areas will be smoother and less time consuming, and changes in protected areas location due to species migration and ecosystem transitions can be simplified. • Synergies: This option benefits from all options in groups I, II, IV, V, VI and VII and provides essential inputs to options of group E, in particular option 27. Complements option 23.				
Opportunities that arise	Relieve social tensions while strengthening the strategic vision of stakeholders				
Cross-cutting relevance	Yes	All sectors vulnerable to climate change or ecosystem degradation but mostly Tourism, Agriculture, Forestry, Fishery, Urban			
Risks addressed	Risks of mismanaging ecosystems due to biased public perceptions				

22. REGIONAL/LOCAL BD CONSERVATION AND RESTORATION PROGRAMS TO BOOST DELIVERY OF ECOSYSTEM SERVICES					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description Option's relevance: Economic ++ ; Ecologic +++ ; Social +++	• Rationale: Create a shared, detailed vision among stakeholders about their role in EbA-CCA and expected gains. • Impact: This option is akin to the design phase in construction where the intentions are designed, permits are granted, institutional arrangements are met, and the local communities are informed on the upcoming protection activities, their downsides and expected benefits. • Synergies: Strong synergy with option 4 and prerequisite for implementing projects from group E, in particular option 27. Complements option 24.				
Opportunities that arise	Relieve social tensions while strengthening the strategic vision of stakeholders				
Cross-cutting relevance	YES	All sectors vulnerable to climate change or ecosystem degradation but mostly Tourism, Agriculture, Forestry, Fishery, Urban			
Risks addressed	Risks of mismanaging ecosystems due to biased public perceptions				

D. Increase CC resilience by reducing other pressures					
XI. Reduce pollution and disturbance					
XII. Reduce overexploitation					
23. Estimate carrying capacity for vital ecosystems and production capacity for their services					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description Option's relevance Economic: +++ / Ecologic: +++ / Social: +++	• Rationale: Provide reference for safe operation boundaries in day-to-day business. • Impact: This option provides for a scientifically sound way to measure the limits of possible trade-offs that will not diminish or destroy critical natural capital. Like all options in groups C and D, it works equally well for protected areas and urban/rural landscapes with predominantly modified ecosystems providing ecosystem services. Particularly important for industries with big ecological footprint. • Synergies: This option benefits from all options in groups I, II, IV, V, VI and VII and provides essential inputs to options of group E, in particular option 26.				
Opportunities that arise	Relieve social tensions about single components of environment (such as air pollution)				
Cross-cutting relevance	Yes	All sectors vulnerable to climate change or ecosystem degradation but mostly Tourism, Urban, Agriculture, Forestry, Fishery			
Risks addressed	Risks of mismanaging ecosystems due to biased public perceptions				

24. Use self-monitoring and EIA for tracking ES exploitation, disturbance and ESS stocks					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description Option's relevance Economic: +++ / Ecologic: +++ / Social: +++	• Rationale: Utilize "invisible" ecosystem data for the benefit of local and regional stakeholders. • Impact: This option is, at a smaller scale, similar to option 4. Unlike option 4, it provides local data sources and more detailed spatially explicit representation. Like in option 4, however, sharing the data may be subject to limitations. • Synergies: Strong synergy with option 4 and prerequisite for implementing projects from group E, in particular option 27.				
Opportunities that arise	Relieve social tensions while strengthening the strategic vision of stakeholders				
Cross-cutting relevance	YES	All sectors vulnerable to climate change or ecosystem degradation but mostly Tourism, Agriculture, Forestry, Fishery, Urban			
Risks addressed	Risks of mismanaging ecosystems due to biased public perceptions				

E.	**Use the 'invisible ecosystem services' for adaptation and human benefit**
XIII.	**Optimal use of existing ecosystem services**
XIV.	**Ecosystem services for CCA as new opportunity for business and society**

25. *USE GENETIC RESOURCES FOR RESILIENCE*

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X		
Description Option's relevance Economic: +++ / Ecologic: -- / Social: +++	• Rationale: Sustainable use of genetic resources for improving the supply of provisioning ecosystem services and increase climate resilience. • Impact: The option has predominantly societal direction – food security and access to healing plants for vulnerable population groups. The agricultural and foraging components both place some challenges to sustainable use and the carrying capacity of the respective ecosystems must not be overstretched. Also, careful research is necessary on any sorts and breeds to be introduced as climate resilience measure to identify whether they create pressures on local biodiversity. • Synergies: To avoid loss of biodiversity and ecosystem services, this option must be used together with options 4, 6, 21, 22, 23 and 24. It also benefits from options 4,6,9,10,14.				
Opportunities that arise	Diversify the use of provisioning services to improve climate resilience while also supporting the population				
Cross-cutting relevance	Yes	All sectors vulnerable to climate change or ecosystem degradation but mostly Agriculture and Forestry			
Risks addressed	Risks of ecosystem exploitation and loss of biodiversity, especially in monocultures				

26. *CULTURAL ECOSYSTEM SERVICES FOR RECREATION AND EDUCATION*

Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
		X	X	X	X
Description Option's relevance Economic: +++ / Ecologic: -- / Social: +++	• Rationale: Support sustainable tourism and recreation while contributing to collection of knowledge for ecosystem monitoring and management. • Impact: This option aims at reducing tourism's pressure on ecosystems while also reviving the connection with nature. • Synergies: Strong synergy with option groups IV and VIII. To avoid loss of biodiversity and ecosystem services, this option must be used together with options 4, 6, 21, 22, 23 and 24. It also benefits from options 4,6,9,10,14.				
Opportunities that arise	Practical ecosystem thinking can be learned by recreational and niche tourists. Use of new technologies can open such activities to disabled and vulnerable population groups.				
Cross-cutting relevance	YES	Tourism, Urban, Health			
Risks addressed	Risks of ecosystem overexploitation				

27. Ecosystem restoration – a long term business opportunity					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description **Option's relevance** Economic: +++ Ecologic: +++ Social: +++	• Rationale: Implement the EU and the future Bulgarian Green Infrastructure strategy while supporting the local business and communities. • Impact: If implemented in a timely and holistic manner, this option has the potential to bring Bulgaria at the forefront of achieving the 15 percent restoration target set in the EU Biodiversity Strategy to 2020. At the same time, this is a business niche with the potential to ensure long-term business opportunities and create jobs. • Synergies: This option is also very synergetic since it benefits from all other options in this report. To avoid loss of biodiversity and ecosystem services, this option must be used together with options 4, 6, 21, 22, 23 and 24.				
Opportunities that arise	Bring win-win solutions for EbA-CCA to the attention of local communities to break the confrontation stance in local decision making				
Cross-cutting relevance	Yes	All sectors vulnerable to climate change or ecosystem degradation			
Risks addressed	Risks of mismanaging ecosystems due to non-aligned policies and lacking strategic direction				

28. Local development and equitable access to vital ecosystem services					
Relevant to:	Legislative & institutional framework	Stakeholder involvement	Science, knowledge, data	Ecosystem territorial scope, defragmentation, connectivity	Ecosystem pressures & disturbances reduction
	X	X	X	X	X
Description **Option's relevance** Economic: +++ Ecologic: ++ Social: +++	• Rationale: Utilize the positive externalities from local production and provision of ecosystem services. • Impact: This is a predominantly social option. It aims at taking stock and equitable distribution of ecosystem services towards vulnerable population groups. The option's implementation will require significant capacity building in the administrations and business at national and local levels to correctly account for the ecosystem services to include them in payment and compensation schemes as appropriate. • Synergies: Benefits from option groups III, IV, VIII. To avoid loss of biodiversity and ecosystem services, this option must be used together with options 4, 6, 21, 22, 23 and 24				
Opportunities that arise	Relieve social tensions and maximize the social utility of the produced ecosystem services				
Cross-cutting relevance	YES	All sectors vulnerable to climate change or ecosystem degradation but mostly Urban, Healthcare, Disaster prevention			
Risks addressed	Risks of mismanaging ecosystems due to lack of regulation				

Annex 3. Cost Benefit Analysis

1. General Description

The conceptual framework of the CBA was developed with the purpose of estimating the value of the ecosystem services which are taken for granted by their users and are not included in statistics but deliver value for climate change adaptation.

Since Bulgaria does not, as yet, have natural capital accounts, the cost-benefit analysis was based on EU level accounts, modeling of ecosystem services supply, as well as relations between the ecosystem parameters and the production of the respective services as described in scientific and ecosystem management literature.

The severe limitation of available data and models does not allow for a full estimate of the economic benefits of all 90 ecosystem services from the EU ecosystem service classification CICES. Even where services were modeled or approximated, a monetary estimation for the occurrence of co-benefits and trade-offs is not possible within this analysis due to the limits of the models and data used. Therefore, a full impact assessment is not possible within this incomplete framework. However, the incremental value, delivered by some essential provisioning and regulation and maintenance services, is illustrated. Even such incomplete calculation of benefits outweighs the adaptation costs in the sector. Moreover, the framework used for this CBA can easily be extended by estimating the benefits of additional ecosystem services once new ecosystem valuation data become available.

The services covered by this partial CBA are presented in ***Table 5*** in section 3.4 of this report.

The purpose of this Annex 3 is to:

- Highlight the incremental value attributable to ecosystem services that was not captured by other sectors' CBA, in the climate change scenarios (temperature +2° C and +4°C, and precipitation changes). To this end, to the extent possible, data, models and assumptions underlying the CBA in the Forest, Water, and Agriculture sectors are used.
- Develop a CBA model – appraising the costs of BD&ES adaptation actions, and benefits accrued in the entire economy, thus measuring the efficiency of investments. It quantifies the anticipated costs of adaptation options in the BD&ES sector and benefits from preserving and enhancing biodiversity spilling over to other sectors, with the aim of comparing them and illustrating that even if benefits are only partially accounted for, they outweigh the adaptation costs. Benefits of ecosystem services can be the advantages or positive effects for other sectors of adaptation measures in BD&ES, both in terms of additional monetary benefits and in terms of avoided costs. Costs are the resources required to deliver the BD&ES adaptation measures. The effects are expressed as net present value of partial benefits minus the full cost of adaptation measures taken.

1.1. Description of the Methodology

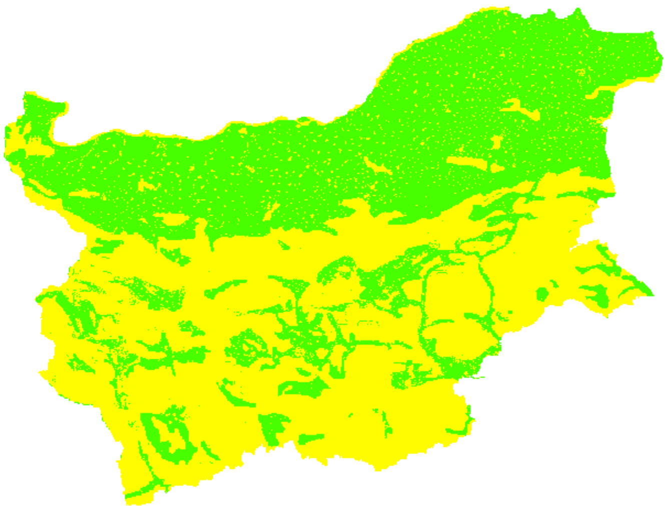
Due to lack of direct ecosystems services' statistic data in the BD&ES sector, the assessments rely on models and statistical data from traded provisioning services (crop, timber, water).

Ecological aspects: assumptions and limitations

Water provision

To construct the estimate for the increment of water provision, the approach considers the area with insufficient water retention index (up to 4 on a scale from 1 to 10) from the JRC WRI model referenced in ***Table 5,*** in section 3.4, after extracting the areas with no data in the model. It is assumed that concentration of conservation and restoration measures in these areas will gain optimal effect. The target areas according to the JRC WRI model cover an area of 30.81 percent of the country's territory and are located within the areas marked in yellow in ***Figure 15.***

Figure 15. WRI for Bulgaria as per the JRC model for 2010.



Green denotes the areas with WRI over 4; yellow denotes areas with no data or WRI below 4 on a scale from 0 to 10

Due to data constraints, only water retention improvements from forests were considered; hence not all of the territory with WRI below 4 was added in the estimate. Since research suggest that afforestation upstream and in elevated areas is one of the most effective measures for improving water retention, we assumed afforestation and forest belts and patches of green infrastructure that would improve the retention in half of the target area, or 15.41 percent of the territory. This assumption places ecosystem restoration just above the restoration minimum as per the EU Biodiversity Strategy to 2020 but below the target of restoring 20 percent of the ecosystems set in adaptation measure 5.1.3 of the proposed CCA strategy since some of the restoration will aim at the provisioning of other ecosystem services (such as flood and landslide protection) that will take place in areas with good water retention.

WRI is a composite index that considers both the biotic components of the ecosystem (in particular, vegetation) and abiotic factors such as soil properties, elevation and slope. A GIS analysis based on the EU level WRI model would introduce far too high uncertainty (pixels with no data account for 7,659,674 ha, or 40.93 percent of Bulgaria in the model). Therefore, it was opted for a conservative estimate based only on the contribution of ecosystems' biotic components (vegetation) to WRI. It is likely that this approach significantly underestimates the full ecosystem impact on WRI.

Pollination

The MetEcoSMap[113] activity on pollination which included also a review of pollinator habitats reveals a significant difference between pollinator habitats based on the landscape composition. Therefore, it is assumed that a better quantification based on ESTIMAP modelling will only be possible once high resolution or very high-resolution EU level products (such as the Copernicus Small Woody Features) or better resolution national models are available. Also, despite the observation that climate change is a key driver for pollinators' decline, no EU wide climate projections are available for this service as yet. Given these limitations, we formulated pollination scenarios of restoration and conservation activities (restoring ecosystems/creating green infrastructure providing pollinator friendly habitats such as forest edges to cover at least 20 percent of the territory as per the option Ecosystem restoration – a long term business opportunity in the proposed CCA strategy and other policies (such as cut in the use of pesticides) resulting in 5 percent to 10 percent increase of the overall pollination ecosystem service flows in areas with unmet demand in the country. The pollination dependence figures from the JRC report on outdoor recreation and pollination[114] were used to estimate the monetary benefit of increase in pollination for selected pollination sensitive crops where statistical data rows are available in Bulgaria: apple, pears, peaches, apricots, cherries, plums, rapeseed, sunflower, beans, tomatoes, peppers, cucumbers. This data-driven approach excludes some crops with insufficient data, such as soybeans. Based on the available data and models there does not seem to be a way to overcome this limitation at present and to provide a precise monetary estimate for all pollinator relating crops; however, the CBA covers the bulk of the pollinator sensitive crops.

Carbon sequestration

The estimate uses the modelling from the Forest CBA to determine the expected total annual increment in tree biomass. The carbon content of this biomass is considered to be 50 percent, and to represent 17.7 percent of the total carbon sequestered in the forest ecosystems (with the biggest part of the sequestration taking place in the soil, and some attributable to the undergrowth).[115] The approach relies on research not relating to Bulgaria and additional fieldwork would be needed to estimate and reduce the degree of uncertainty.

[113] www.metecosmap-sofia.org
[114] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC110321/jrc110321_jrc_technical_report_-_recreation_and_pollination_accounts_final_pubsy.pdf
[115] https://www.forestry.gov.uk/PDF/FCTP004.pdf/$FILE/FCTP004.pdf

CBA model aspects and assumptions

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 or direct gains). Costs and benefits are expressed in monetary terms and a discount rate is used to determine the NPV of the adaptation measures.

The dependent variables are the main sectoral indicators where the independent variables are climatic (temperature and precipitation). Linear extrapolation of the key indicators was accounted aiming at identifying how the sector would develop under each scenario. Extrapolation quantified each individual indicator.

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 BD&ES sector that spill over to other sectors through the ecosystem services.

1.2. Data used for the CBA

The primary data used for the cost part of 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. Cost distribution over time is estimated having in mind the legal, budgetary and EU fund programming constraints likely to influence the start and end years of spending per adaptation option.
To calculate benefits, official statistical data was used as far as available, and complemented with EU level accounts and model estimates, as well as calculations underlying the Agriculture, Forestry, and Water sectors. In case of missing national data or data series, the respective models were used only partially to the extent possible. In particular:

- The calculation of water provision does not take into account the water provision of grassland and wetland ecosystems
- The calculations on enhanced pollination potential does not take into account all possible pollinator dependent crops.

1.3. Model Specifications - assumptions and limitations

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

- The projected trend value of the forestry indicator (total annual increment, thousands of cubic meters per year) based on historical data (1960–2015) and total used water and CO_2 allowances Euro/t.
- The main performance indicators included in the analysis are:
  - Incremental utility of improved water retention as a means to estimate surface and groundwater provision services for drinking and non-drinking purposes;
  - Incremental utility of improved pollination for highly dependent crops;
  - Incremental utility of carbon sequestration from forest carbon sinks.
- 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 partial (currently quantifiable) positive effect of the implementation of climate change adaptation options in the BD&ES sector that spill over to other sectors through the ecosystem services.

2. Results of the Regression Analysis

A full regression analysis of the correlation between climate change factors and sectoral performance indicators could not be performed because of insufficiently available statistical data or models for the BD&ES sector. In the current analysis, only some of the benefits were covered for 13 out of 90 CICES ecosystem services (see ***Table 5,*** Ecosystem services considered in the CBA). This limited information availability hinders the correct accounting of the relationship between performance indicators and climate change parameters.

In addition, multiple co-benefits were not accounted for in the current analysis due to a lack of appropriate data, datasets or models. For example, co-benefits of afforestation beyond the water retention include ecosystem services from CICES classes 'Dilution by freshwater and marine ecosystems', 'Mediation by other chemical or physical means (for example, via filtration, sequestration, storage or accumulation)', 'Mediation of nuisances by abiotic structures or processes', as well as the better crop provision due to the increased water availability for irrigation. The restoration and conservation in all ecosystem types provides ecosystem services related to air purification, flood and landslide protection, as well as habitat preservation and other services relevant to the CCA which also were not included in the CBA for lack of suitable models and national data.

In Bulgaria, the variety of economic benefits from BD&ES and the spill-over effects to other economic activities are not yet accounted and evaluated, and to our knowledge the current analysis is the first attempt at complex multi-service valuation that covers the entire territory of the country.

Results CBA BD&ES Sector

The baseline scenarios for sectors Forest, Water, and Agriculture were 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. These baseline scenarios reflect a continuation of current policies and plans in the respective sectors (that is, a future in which no new measures are taken to address climate change).

BD&ES represents natural capital with a high non-market value which, however, varies between ecosystem types. Sustainable use of these services across other sectors has great potential for the economy. The assumption of the CBA is that climate change can negatively affect the production functions of ecosystem services and, therefore, adaptation measures can help preventing losses and preserving the revenues from commercially used ecosystem services high while at the same time reducing climate vulnerability and risk exposure.

Overall, the effects of climate change on the performance indicators of key ecosystems are negative, as demonstrated in the sector analyses for Forest, Agriculture, and Water. 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, water used, carbon content, crop yield, crop output.

3. Results of the Cost-benefit Analysis

The CBA for the sector focuses on the assessment of both soft and infrastructural adaptation measures. The effects of these measures on the main performance indicators are assumed to be positive; it can also be expected that they exceed significantly the indicators in the analysis since a more comprehensive indicator set cannot be used for analysis at this stage.

The effects of these measures on the main performance indicators: 'Incremental utility of improved water retention', 'Incremental utility of improved pollination' and 'Incremental utility of carbon sequestration from forest carbon sinks' are assumed to be positive.

Table 13. Benefits of adaptation measures in the BD&ES sector until 2050 (partial calculation, in € million)

Climate scenarios	NPV (€ million)	Cost-effectiveness/ benefits
Realistic scenario +2°C	7,055.65	140.41
Optimistic scenario +2°C	8,945.92	177.76
Pessimistic scenario +2°C	5,165.39	103.06
Realistic scenario +4°C	7,202.41	143.31
Optimistic scenario +4°C	9,247.32	183.72
Pessimistic scenario +4°C	5,157.51	102.90

The CBA is extending the sectoral analyses for sectors particularly susceptible to loss of ecosystem services due to biodiversity loss. Therefore, a positive NPV illustrates monetary value of non-accounted for benefits and avoided losses as a result of applied adaptation measures**.**

The projection shows that on average, under the +2°C realistic scenario, the total cash flow in NPV is €7.0 billion and €7.2 billion under the realistic scenario at +4°C. Under the optimistic scenario the projected cash flow in NPV is €8.9 billion at +2°C average and €9.2 billion at +4°C average. Even in the pessimistic scenario and with partial coverage of ecosystem services in the analysis, the future cash flow in NPV is projected at €5.2 billion at +2°C and € 5.1 billion at +4°C.

The CBA shows that implementing the entire complex of adaptation measures would be effective to optimally use ecosystem services to reap benefits and avoid losses due to climate change**.** Cutting short some of the measures, in particular the investment heavy planning of the location and use of natural capital, can diminish significantly and even negate the positive effects estimated in this analysis, as well as negatively impact many other ecosystem services not currently analyzed.

Within the current analysis, the cost-effectiveness of the adaptation measures is used to quantify the effect of investments under each scenario.[116] Under the +2°C realistic scenario the benefit/cost ratio is €140.41 (that is, the benefits achieved per Euro spent), and €143.31under the +4°C realistic scenario. The benefit is higher at +4°C temperature rise. In that case, the benefit is €183.72 per one Euro of investment under the optimistic scenario and €102.90 per one Euro of investment under the pessimistic scenario. A higher effect of investments is observed under the +4°C scenario because the average air temperature during 1991–2015 has already increased by +1.6°C. Thus, to date, the level of the +2°C scenario has already almost been reached.

The adaptation measures are linked and interdependent, and therefore should not be ranked for selective implementation because the social and economic benefits are avoided losses of national natural capital.

4. Conclusion

Overall effects of the adaptation measures will be cost saving as a result of avoided costs and direct benefits of using eco-system services for adaptation. The NPV calculation shows that investments in climate change adaptation measures in the BD&ES sector are economically efficient. Moreover, combining measures will generate synergetic effects.

The multiplier effect, after applying soft adaptation measures, shows a positive return on investment.

Among the ecosystem services covered in the CBA in the BD&ES sector, a key effect of successfully applying adaptation will be the prevention of WRI decline until 2050. Since water is a vital ecosystem component at risk with climate change, the improved water

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

provisioning due to a better WRI is likely to have multiple co-benefits across all sectors and render positive effects that far exceed the estimates in this CBA.

A main driver in terms of immediate value added is the incremental value derived from pollination if pollinator habitats are restored in suitable green infrastructure along the pollinator dependent crops. Improving pollinator habitats is a ‘low hanging fruit’ of BD&ES adaptation since it does not require large scale ecosystem conservation and restauration. Instead, a change in the use of pesticides and small-scale green infrastructure such as green belts (or the combination of orchards with other pollinator dependent crops) are likely to be sufficient for increasing the yields in areas with unmet pollination demand.

The third service covered in the CBA illustrates the link between climate change mitigation and adaptation that can be achieved in a cost-effective manner using ecosystems services. Using the models from the forest CBA, it was estimated that the sustainable development of Bulgaria’s forests can help absorbing CO_2 worth between €36.5 million. and €43.6 million at no additional cost. It is imperative to consider these figures when weighting the trade-off between timber yield and forest management.

The current analysis underscores the importance of investment in adaptation measures and the very high potential effects they can have. Despite its limited scope, the CBA reveals that ecosystem services are of great importance for humans and biodiversity. Ecosystem services that could not be included in the CBA are also a source of great societal benefits that currently are not being accounted for. For example, the EU level account for outdoor recreation published by JRC (referenced in ***Table 5***) reveals a strong increase of the value of outdoor recreation in Bulgaria – from €231.21 million in 2000 to €1,014.13 million in 2012. The EU level accounts for 2018 are not published yet at the time of this CBA and hence no data series can be used for including this value in the analysis and illustrate the incremental benefits of cultural ecosystem services. However, the CBA model is flexible enough to allow for the easy incorporation of this and other services in the future and revealing the multiple benefits from ecosystems services to policymakers and stakeholders.

The limited data and model availability for Bulgaria, coupled with the complexity of estimating cross-sector effects based on proxy data and scientific literature, does not allow for an attempt to determine the exact timing of ensuing benefits from the ecosystem services within this CBA. Another important consideration in BD&ES adaptation is the early warning for potential loss of biodiversity and the associated ecosystem services. Modelling these interactions is a good example for research directions necessary to be explored with the scientific infrastructure and by the interdisciplinary teams envisaged in the draft Strategy.

Annex 4. Biodiversity and Nature Conservation in Bulgaria in Figures

Facets of biodiversity in Bulgaria[117]

Bulgaria is a country of exceptional biodiversity, despite its small area, containing 94 species of mammals, 383 species of birds, 36 species of reptiles, 16 species of amphibians, 207 species of marine and freshwater fish, as well as some 27,000 species of insects and other invertebrates. Bulgaria also is home to over 3,500 species of vascular plants and 6,500 species of nonvascular plants and fungi. The NATURA 2000 sites occupy 34.4 percent of the territory. Forest ecosystems in Bulgaria comprise more than 37 percent of the total area and contain 202 NATURA 2000 sites hosting 27 habitats.

Conservation status of species and habitats in Bulgaria

The following figures show the percentage of biogeographical assessments in each category of conservation status for habitats and species.[118]

Figure 16. Conservation status of habitats

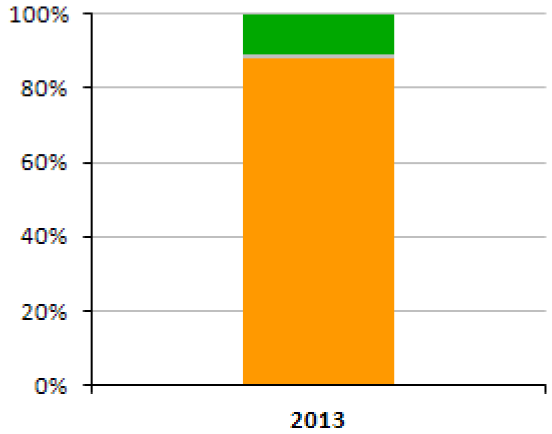
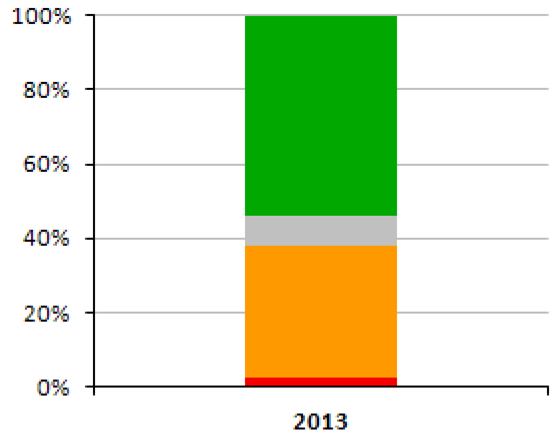


Figure 17. Conservation status of species



Note: ■ = Favorable ■ = Not reported ■ = Unknown ■ = Unfavorable-inadequate ■ = Unfavorable-bad.

This diversity is in part due to the range of elevation in Bulgaria (from sea level up to almost 3,000 m a.s.l.) and the country's transitional position between different climate types and vegetation regions. The Balkan Peninsula was one of the most important refugia for species in Europe during the large glaciations contributing to very high diversity in ecosystems and number of species. Bulgaria has an important role in the region as one of the most forested countries.

Protected areas in Bulgaria

As of December 31, 2016, 1,012 protected areas were recognized with a total area of 584,501.2 hectares, approximately 5.3 percent of the country's territory.[119] This includes 3 national parks, 35 managed reserves, 55 reserves, 11 nature parks, 344 natural landmarks, and 564 protected locales.

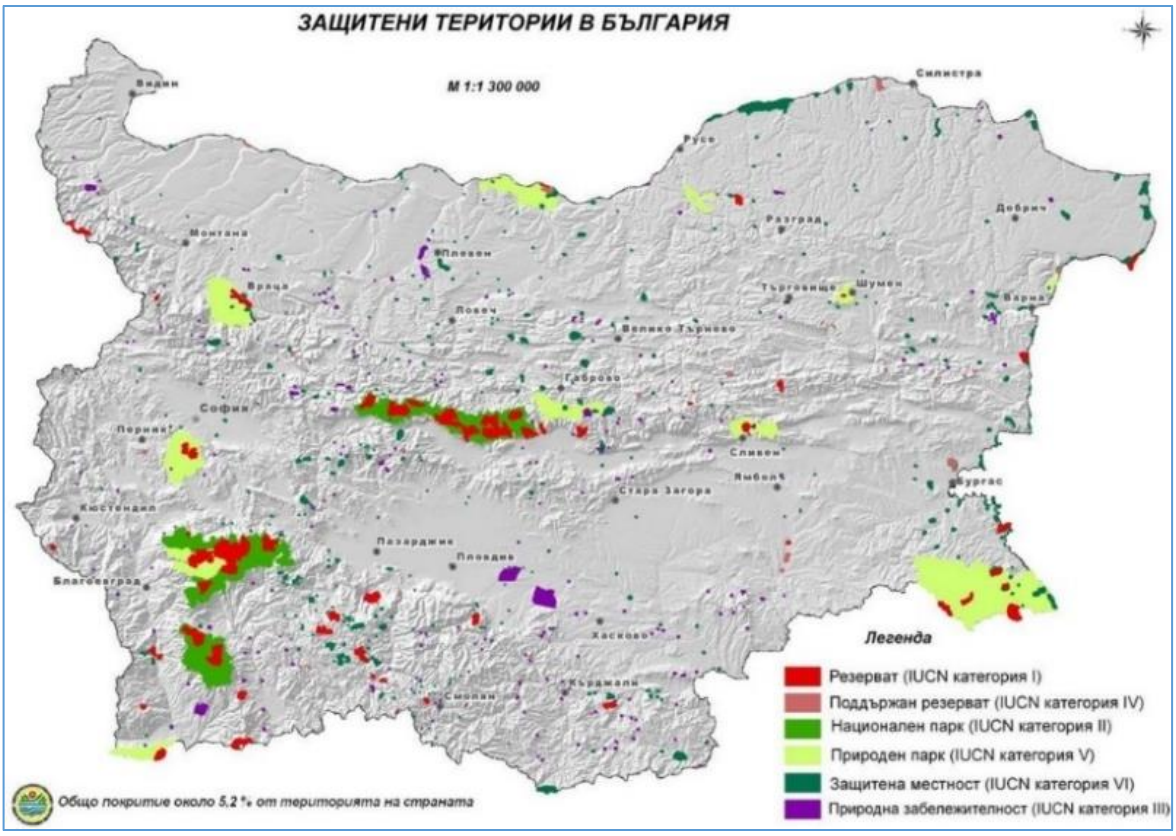
[117] MetEcoSMap Project 2017.
[118] National Summary for Article 17 - CIRCABC, *https://circabc.europa.eu/sd/a/c3d5d7f4-fc6f-4f0e-ad96-9522d398d3b6/BG_20140528.pdf*
[119] Almanach, MoEW, 2016.

Many Bulgarian protected areas are included in various international, regional, and sub-regional networks set up in the framework of international agreements such as UNESCO's Convention Concerning the Protection of the World Cultural and Natural Heritage. Bulgaria's 11 wetlands identified as of international importance under the Convention (Ramsar sites) total 49,912.43 hectares, representing 0.45 percent of the country's territory. Most of Bulgaria's wetlands or parts of them have been designated as protected areas within the meaning of the Protected Area Act; the importance of such protection is reinforced by the fact that the few wetlands outside protected areas face severe anthropogenic pressures and many are being replaced by other ecosystems, mostly cropland.

In conclusion, the protected area system in Bulgaria is well developed and ensures the protection of the most valuable natural ecosystems, plant and animal species with a conservation importance and their habitats, remarkable landscapes and important abioic objects. The main problems are related to infrastructure development for tourism impact, urbanization, and pollution. Although tourism is increasing, analyses of carrying capacity have not been carried out for the main touristic natural areas in Bulgaria.

As can be seen in ***Figure 17***, protected areas and attractive tourist destinations overlap in many places. This is to show a possible correlation between some categories of successful tourism business and the use of cultural ecosystem services, but it also creates additional anthropogenic pressures on ecosystems that are likely to further reduce their climate change resilience.

Figure 18. Spatial distribution of protected areas in Bulgaria

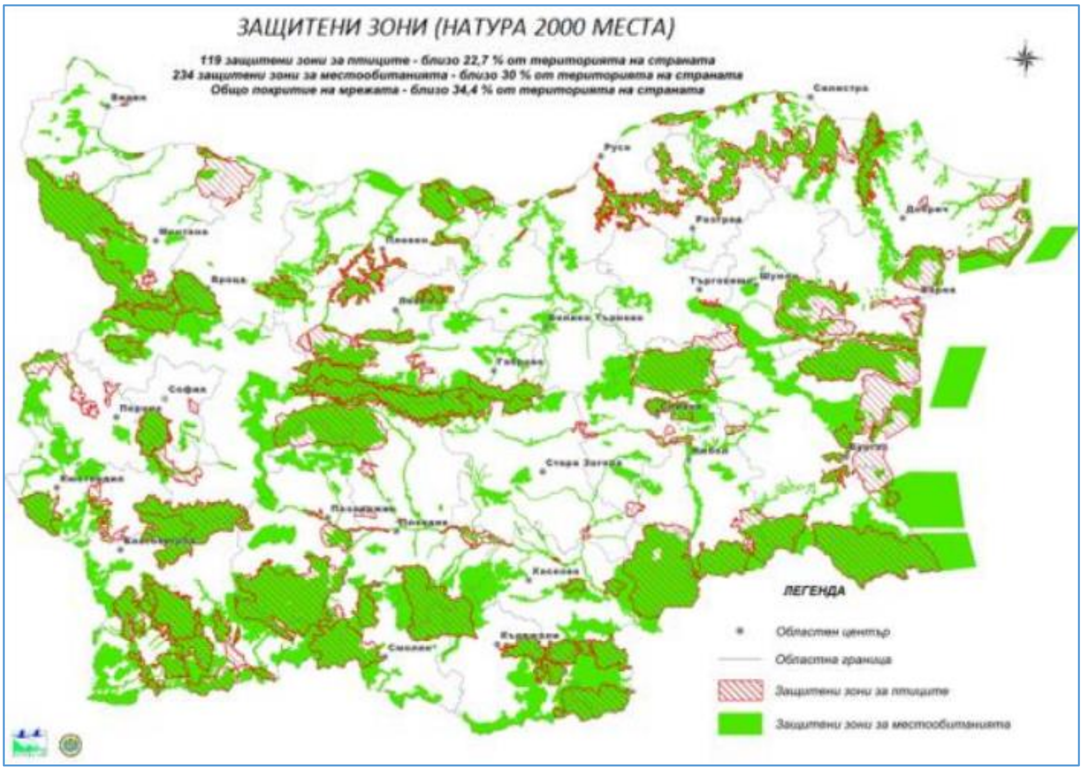


NATURA 2000 network in Bulgaria

NATURA 2000 is a network of protected areas in Europe with the objective to provide long-term protection in a favorable status of European significant plant and animal species and the places they inhabit. Sites in the network provide space for nature, but they must be protected and enhanced as part of the broader issue of managing the entirety of Europe's green infrastructure. These sites are also central to ensuring that biodiversity can adapt to the changing environment, particularly as a result of climate change. Over time, the species and habitats at any individual site may change, but the suite of sites in both the terrestrial and marine environment will remain essential safe havens for Europe's biodiversity. However, the issue of climate change has not yet been adequately considered within the framework of management and restoration of NATURA 2000.[120]

The NATURA 2000 network in Bulgaria is managed by the National Nature Protection Service Directorate. Bulgaria has adopted 233 Natura 2000 sites under the Habitats Directive (Sites of Community Importance/SCIs). Three of them are entirely marine sites, while 14 include marine sites in their territory. Bulgaria has also designated 119 Natura 2000 sites under the Birds Directive (Special Protection Areas/SPAs). In total, the SCIs and SPAs cover 41,048 km^2 of Bulgaria's territory of which 38,222 km^2 of land and 2,827 km^2 of its marine territory. Bulgaria's Natura 2000 network purposefully preserves 90 habitat types, 121 species other than birds, including 27 priority habitats and 8 priority species as well 120 birds. Their distribution is illustrated in ***Figure 18***.

Figure 19. Protected areas (NATURA 2000 network)[121]



[120] EU Guidelines on climate change and NATURA 2000, European Union, 2013.

[121] Protected Areas Information System for NATURA 2000 sites (http://natura2000.moew.government.bg/):.

The conservation status of species and habitats in Bulgaria and the European level is analyzed by biogeographic regions (National Priority Framework 2013). The EEA (2002) classifies three biogeographic regions in Bulgaria: Continental, Alpine, and Black Sea. The Alpine region includes the mountainous areas in the country and is characterized by predominantly natural and semi-natural ecosystem types. Continental mainly includes the plain part of the country dominated by urban and agricultural ecosystems. The Black Sea region includes the coastal zone along the Black Sea. From this classification, the most vulnerable to climate change are the Alpine zone and the Coastal zone.[122]

[122] Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change, 2014.

Annex 5. Ecosystems, Their Mapping, and Assessment in Bulgaria

Table 14. Common International Classification of Ecosystem Services (CICES)

Theme	Service class	Service group	Service type	Sub-types	Examples and indicative benefits
Regulation and Maintenance	Regulation of wastes	Bioremediation	Remediation using plants	for example, by method	Phytoaccumulation, phytodegradation, Phyto-stabilization, rhizo-degradation
			Remediation using micro-organisms	for example, by method	In situ (Bioremediation), ex situ (composting), bioreactors
		Dilution and sequestration	Dilution	for example, by method	Wastewater treatment
			Filtration	for example, by method	Filtration of particulates and aerosols
			Sequestration and absorption	for example, by method	Sequestration of nutrients in organic sediments, odor removal
	Flow regulation	Air flow regulation	Windbreaks, shelter belts	for example, by process	
			Ventilation	for example, by process	
		Water flow regulation	Attenuation of runoff and discharge rates	for example, by process	Woodlands, wetlands and their impact on discharge rates
			Water storage	for example, by process	Irrigation water
			Sedimentation	for example, by process	Navigation
			Attenuation of wave energy	for example, by process	Mangroves
		Mass flow regulation	Erosion protection	for example, by process	Wetlands reducing discharge peak
			Avalanche protection	for example, by process	Stabilization of mudflows, erosion protection (reduction)
	Regulation of physical environment	Atmospheric regulation	Global climate regulation (incl. C-sequestration)	for example, by process	Atmospheric composition, hydrological cycle
			Local & regional climate regulation	for example, by process	Modifying temperature, humidity and so on; maintenance of regional precipitation
		Water quality regulation	Water purification and oxygenation	for example, by process	Nutrient retention in buffer strips and so on, translocation of nutrients
			Cooling water	for example, by process	For power production
		Pedogenesis and soil quality regulation	Maintenance of soil fertility	for example, by process	Green mulches; n-fixing plants
			Maintenance of soil structure	for example, by process	Soil organism activity

Theme	Service class	Service group	Service type	Sub-types	Examples and indicative benefits
	Regulation of biotic environment	Lifecycle maintenance & habitat protection	Pollination	for example, by process	By plants and animals
			Seed dispersal	for example, by process	By plants and animals
		Pest and disease control	Biological control mechanisms	for example, by process	By plants and animals, control of pathogens
		Gene pool protection	Maintaining nursery populations	for example, by process	Habitat refuges
Cultural	Symbolic	Aesthetic, Heritage	Landscape character	for example, by resource	Areas of outstanding natural beauty
			Cultural landscapes	for example, by resource	Sense of place
		Spiritual	Wilderness. Naturalness	for example, by resource	Tranquility, isolation
			Sacred places or species	for example, by resource	Woodland cemeteries, sky burials
	Intellectual and Experiential	Recreation and community activities	Charismatic or iconic wildlife or habitats	for example, by resource	Bird or whale watching, conservation activities, volunteering
			Prey for hunting or collecting	for example, by resource	Angling, shooting, membership of environmental groups/ organ.
		Information & knowledge	Scientific	for example, by resource	Pollen record, tree ring record, genetic patterns
			Educational	for example, by resource	Subject matter for wildlife programs and books and so on
Provisioning	Nutrition	Terrestrial plant and animal	Commercial cropping	for example, by crops	Cereals, vegetables, vines and so on
			Subsistence cropping	for example, by crops	Cereals, vegetables, vines and so on
			Commercial animal production	for example, by animal	Sheep, cattle for meat and dairy products
			Subsistence animal production	for example, by animal	Sheep, cattle for meat and dairy products
			Harvesting wild plants and animals for food	for example, by resource	Berries, fungi and so on
		Freshwater plant and animal	Commercial fishing (wild population)	for example, by fishery	By species
			Subsistence fishing	for example, by fishery	By species
			Aquaculture	for example, by fishery	By species
			Harvesting fresh water plants for food	for example, by resource	Water cress
		Marine plant and animal	Commercial fishing (wild population)	for example, by feature	Includes crustaceans
			Subsistence fishing	for example, by habitat	Includes crustaceans

Theme	Service class	Service group	Service type	Sub-types	Examples and indicative benefits
			Aquaculture		Includes crustaceans
			Harvesting marine plants for food	for example, by resource	Seaweed
		Potable water	Water storage		Spring, well water, river, reservoir, lake
			Water purification		Wetlands
	Materials	Biotic materials	Non-food plant fibers	for example, by resource	Timber, straw, flax
			Non-food animal fibers	for example, by resource	Skin, bone and so on, guano
			Ornamental resources	for example, by resource	Bulbs, cut flowers, shells, bones and feathers and so on
			Genetic resources	for example, by resource	Wild species use in breeding programs
			Medicinal resources	for example, by resource	Bio prospecting activities
		Abiotic materials	Mineral resources		Salt, aggregates, and so on (exclude subsurface assets)
	Energy	Renewable biofuels	Plant based resources	for example, by resource	Wood fuel, energy crops and so on
			Animal based resources	for example, by resource	Dung, fat, oils
		Renewable abiotic energy	Wind	for example, by resource	
			Hydro	for example, by resource	
			Solar	for example, by resource	
			Tidal	for example, by resource	
			Thermal	for example, by resource	

Source: The CICES Classification - Table 2 (V3, 2011).

According to MAES typology, there are three major types of ecosystems at level 1 in Bulgaria: **terrestrial, fresh water,** and **marine.** At level 2, the major ecosystem types are further subdivided into a total of nine Class 2 types—urban, cropland, grassland, woodland and forest, heathland and shrub, sparsely vegetated land, wetland, rivers and lakes, and marine ecosystems.

The proposed typology combined the CLC classes with the EUNIS habitat classification types.[123]

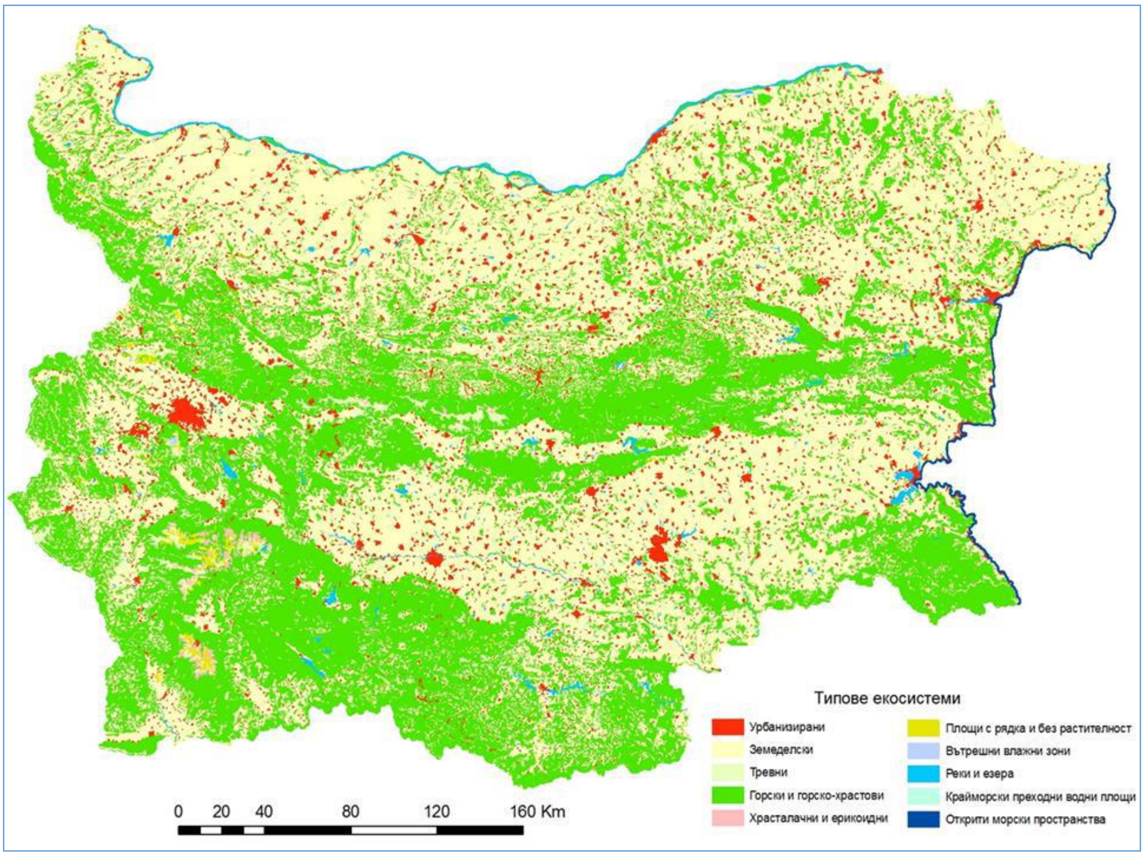
[123] MetEcoSMap Project, 2017, www.moew.government.bg.

Table 15. General ecosystem topology: CICES level 2 ecosystem types in Bulgaria, by area

Level 1	Level 2	Area[a] (km^2)	Percentage
Terrestrial	Urban	5,584.0	5.0
	Cropland	53,506.8	47.4
	Grassland	8,168.1	7.2
	Woodland and forest	43,004.0	38.1
	Heathland and scrub	317.5	0.3
	Sparsely vegetated land	569.9	0.5
	Wetlands	105.8	0.1
Fresh water	Rivers and lakes	1,158.2	1.0
Marine	Marine inlets and transitional waters Coastal areas Shelf Open ocean	379.0	0.31

Note: a. Risk and Vulnerability Analysis and Assessment of the Bulgarian Economic Sectors to Climate Change 2014.

Figure 20. Ecosystem types in Bulgaria[124]



In Bulgaria, the Methodological Framework was developed in 2016–2017 (MetEcoSMap Project,[125] funded by the EEA FM). It includes the methodology for mapping and assessment of condition for each ecosystem type (9) and the ecosystem services that they provide,

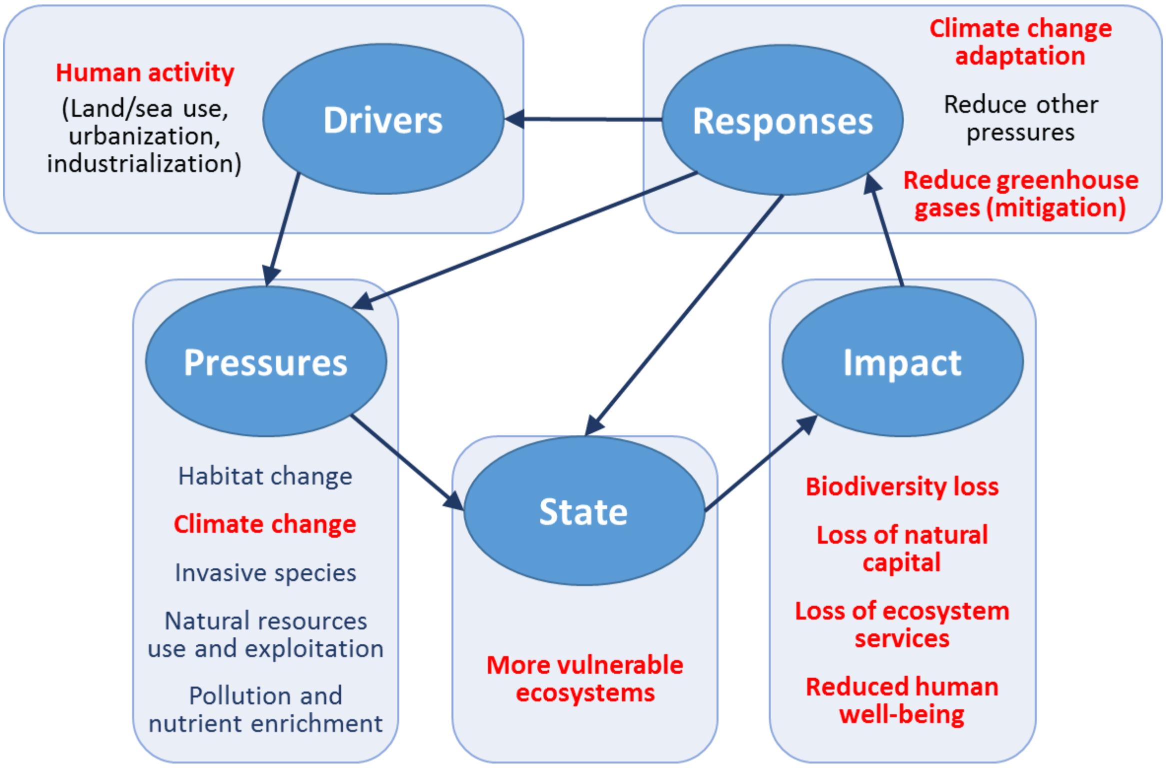
[124] MetEcoSMap Project, 2017, www.moew.government.bg.
[125] MetEcoSMap Project, BG03, www.moew.government.bg.

Monitoring guide at the ecosystem level and in situ verification guide. The mapping and assessment of all ecosystem types in Bulgaria are being finalized in 2017—**FEMA**, **WEMA**, assessment and mapping of GRASSLAND ecosystems condition and their services in Bulgaria (**IBER-GRASS)**, mapping and assessment of sparsely vegetated land ecosystem services in Bulgaria (**SPA-Ecoservices**), Ecosystem services mapping and assessment of heathland and shrubs ecosystems in Bulgaria (outside NATURA 2000), Ecosystem services mapping and assessment of cropland ecosystems in Bulgaria, Toward better Understanding the Ecosystem Services in Urban environments through assessment and mapping **(TUNESinURB),** Forest ecosystem services (**For our Future**), **IBBIS, and** East and South European Network for Invasive Alien Species [a tool to support the management of alien species in Bulgaria **(ESENIAS-TOOLS)**]**.**

Annex 6. Climate Change as Pressure on the Ecosystems and Biodiversity in the Context of the DPSIR as Applied to Ecosystems

The DPSIR framework is a concept widely used to present the dynamics of different environmental and anthropogenic factors on ecosystems and biodiversity. ***Figure 20*** illustrates the causal relations of direct and indirect effects of climate change on BD&ES in terms of the DPSIR[126] framework, which is also one of the guiding principles used in the Methodological framework for assessment and mapping of ecosystem condition and ecosystem services in Bulgaria to link one-time mapping with continuous ecosystem monitoring.

Figure 21. The DPSIR framework and its relation to CCA



Source: World Bank design.

As can be seen from the figure, the analysis shows that the DPSIR allows monitoring of causal links and supports decision making on the selection of specific CCA measures. The Drivers and Pressures parts of ***Figure 20*** are for the most part out of the scope of this report. Drivers are related to GHG emissions that lead to the specific Pressure - climate change. As some ecosystems can capture and retain carbon, enhancing their adaptive capacity and improving their condition will contribute to reducing pressure and mitigating climate change, but these effects are not always significant, and their measurement is associated with practical difficulties.

CCA is mainly related to state monitoring, impact assessment, and adequate response. Given the importance of ecosystem services for human well-being in all spheres, improving the state

[126] https://www.eea.europa.eu/publications/92-9167-059-6-sum/page002.html

of ecosystems is one of the factors to prevent a number of undesirable impacts, including loss of biodiversity.

Annex 7. Funding Opportunities

Funding program	Relevant Priority Axe(s)	Possible use for CCA
OP Environment 2014–2020	Priority Axis 1: Water Investments aimed at achieving compliance with Directive 91/271/EEC, Directive 98/83/EC, Directive 2013/51/EURATOM, and Directive 2000/60/EC	Suitably designed water monitoring may provide a targeted early-warning mechanism for water-related ecosystem stress—such as droughts or extreme rainfalls
	Priority Axis 3: NATURA 2000 and Biodiversity Investments aimed at achieving the objectives of Directive 92/43/EEC, Directive 2009/147/EC, and the EU Biodiversity Strategy to 2020 (Objectives 1 and 2): • Measures and activities in accordance with the NPAF.	Relevant to EU Biodiversity Strategy to 2020, in particular: • Target 1: Full implementation of Birds and Habitats Directives • Target 2: Maintenance and restoration of the ecosystems and their services Relevant to the NPAF's objectives set in Priority 3, p. 3.7 Climate change, and Priority 5, as well as specific measures M13 and M 23
	Priority Axis 4: Flood and Landslides Risk Prevention and Management Investments aimed at the implementation of country's commitments resulting from Directive 2007/60/EC: • Measures related to flood risk prevention and management, including ecosystems-based solutions	May enable countrywide use of ecosystem services for cost-effective flood protection measures
EEA FM 2009–2014, Program BG03 Biodiversity and ecosystem services	Increased awareness of and education in BD&ES services, including awareness of and education in the link between biodiversity and climate change and economic valuation of ecosystems (projects are concluded but bilateral funding was increased with unspent allocations and is still available until the end of 2017)	The most relevant contribution is provided by the project on improving the BBIS, including new modules on IAS and ecosystem services. The improved system will be more accessible to stakeholders and better suited to extracting information for CCA studies
	Increased protection of native ecosystems against IAS (projects are concluded but bilateral funding was increased with unspent allocations and is still available until the end of 2017)	Study of IAS and development of early-warning mechanisms for IAS invasions; risk assessment and stakeholder work on IAS; IAS pathways of distribution Regional IAS network to provide information to the BBIS

Funding program	Relevant Priority Axe(s)	Possible use for CCA
	Improved integration of biodiversity considerations in sectoral policies and legislation (projects are concluded but bilateral funding was increased with unspent allocations and is still available until the end of 2017)	Created a National Methodological Framework for ecosystem and ecosystem services mapping and assessment (final version under review). This framework is also relevant for the future mapping and assessment in NATURA 2000, to be funded by the OP Environment Mapped and assessed the ecosystems condition and services provision outside NATURA 2000 (some 66 percent of Bulgarian territory) in the frame of 7 projects that explored the 9 main ecosystem types. Projects concluded as of April 2017 and results are to be published in the BBIS Projects that study climate change impact in forests and genetic diversity
EEA FM 2014–2021, Program Environment protection and climate change	Programming details not available yet, according to preliminary discussions, the program may fund the completion of the National Methodological Framework to add monetary valuation of ecosystem services and natural capital accounting, as well as ecosystems monitoring activities Climate change objectives related to the CCA strategy were also under discussion	Possibly very relevant but details are not known at this stage
Program for the Environment and Climate Action (LIFE)	CCA is one of the three priority axes in the climate action priority area. The program also focuses on BD&ES	Priorities are set in Regulation No 1293/2013, the multiannual working programs and the specific calls for proposals LIFE funding is intended for priorities not covered by other financing instruments and as such covers a broader area of environmental topics
INTERREG Danube Transnational Program	Environment and culture responsible Danube region The program envisages investing in the creation and/or maintenance of ecological corridors of transnational relevance in the Danube region for environmental risk management	Relevance to BD&ES-related CCA actions by all types of actors—national authorities, regional authorities, NGOs, and business. Priorities are specified on call by call basis

Funding program	Relevant Priority Axe(s)	Possible use for CCA
INTERREG Balkan - Mediterranean	Priority Axis 2: Environment Specific Objective 2.1: Promoting ecological connectivity and transnational ecosystems' integration Specific Objective 2.2: Fostering transnational cooperation for resource efficiency and climate change resilience	Relevance to BD&ES-related CCA actions by various types of actors: • Local, regional, and national authorities • Environmental and development agencies • Protected/designated areas' management organizations and bodies • NGOs and civil society organizations • Umbrella organizations of small and medium enterprises (SMEs) Priorities are specified on call by call basis
INTERREG Europe	Priority Axis 4: Investment Priorities 6(c) - conserving, protecting, promoting, and developing natural and cultural heritage 6(g) - supporting industrial transition toward a resource–efficient economy, promoting green growth, eco-innovation and environmental performance management in the public and private sectors	Relevance to BD&ES-related CCA actions mainly by public actors The third and, possibly, last call for projects is open until June 30, 2017
ESPON 2020	Priority Axis 1: Territorial Evidence, Transfer, Observation, Tools, and Outreach	The program supports the territorial dimensions of all EU policies, including • CCA and risk prevention and management • Environmental protection and resource efficiency Priorities are set by the users of the program's products who may benefit from the spatially explicit project results
Black Sea Basin ENI CBC Program 2014–2020	Specific Objective 2: Promote coordination of environmental protection and joint reduction of marine litter in the Black Sea Basin	While the program's main environmental focus is on waste prevention, management, and removal in the Black Sea Basin, it also identified the complex of transboundary ecological problems around the Black Sea (decline in living resources, chemical pollution, biodiversity change, habitat destruction, invasion by alien species, climate change impacts, and mesoscale variability in the circulation system)

Funding program	Relevant Priority Axe(s)	Possible use for CCA
INTERREG - IPA CBC Bulgaria - Serbia	3.1 Joint Risk Management: Preventing and mitigating the consequences of natural and man-made cross-border disasters 3.2 Nature Protection: Promoting and enhancing the utilization of common natural resources, as well as stimulating nature protection in the program area, through joint initiatives across the border	Relevance to reactive CCA—disaster resilience, as well as protection and enhancement of biodiversity, nature protection, and green infrastructure, including ecosystems protection and restoration, introduction to low carbon practices and shared CCA practices. Priorities are specified on a call-by-call basis
INTERREG CBC Greece - Bulgaria	Specific Objective 1.1: Protection, management, and promotion of the environmental resources	BD&ES-relevant CCA can be promoted in line with the following program objectives: • To protect and promote the rich and diverse natural resources of the area as a vehicle for balanced and economic development • To promote joint risk management in the fields of water management, waste management, and risk management against natural and anthropogenic disasters Priorities are specified on a call-by-call basis
INTERREG IPA CBC Bulgaria - Turkey	Priority Axis 2: Improvement of the Quality of Life Sphere of Intervention 2.1: Protection of environment, nature, and historical and cultural heritage	BD&ES-relevant CCA can be promoted in line with the program objectives. Priorities are specified on a call-by-call basis
INTERREG IPA CBC Bulgaria - FYR Macedonia	Priority Axis 1: Environment Specific objectives:	BD&ES-relevant CCA can be promoted in the areas of investments in the improvement of green infrastructure, training and capacity building, and flood and fire prevention Priorities are specified on a call-by-call basis
INTERREG CBC Romania - Bulgaria	Thematic objective 5: Promoting climate change adaptation, risk prevention and management.	Bigger BD&ES relevant CCA projects, including investment projects for disaster resilience; projects relating to ecosystems and nature management Priorities are specified on call by call basis

Funding program	Relevant Priority Axe(s)	Possible use for CCA
Advisory Assistance Programme (AAP) of the German Federal Government	In the framework of the bilateral cooperation with Germany, Bulgaria implements projects under AAP of Germany's Federal Ministry of Environment, Nature Protection, and Nuclear Safety.	The Federal Ministry provides financial support and consultancy to Central and Eastern European countries, including the new EU members in their efforts to achieve progress in environmental protection and the implementation of EU environmental legislation through exchange of knowledge and experience, raising the environmental standards and awareness. Until now, a multitude of projects were funded and successfully implemented under the program, covering the areas of wastewater treatment, water pollution prevention, recycling, air quality control, nature protection, and so on. At present, the work related to management of European and international projects is being performed by the Coordination on EU Affairs and International Cooperation Directorate

Annex 8. Example Adaptation actions on local or regional level by Ecosystem Type

1) **Urban green infrastructure and species refugia**
   - Soft, low-cost, immediate greening options—create refugia for urban biodiversity
   - Climate-proof the urban infrastructure by introducing green infrastructure into the urban planning
2) **Green connectivity, environmentally sound pest control, and genetic diversity in agriculture**
   - Use ecosystem services (erosion and wind protection) by the creation of green belts and grass borders that double as refugia
   - Discourage the destruction of small but valuable existing refugia—wetlands, trees, rocky, and grass patches
   - Enhance pollination by diminishing the use of repellents, pesticides, and other chemicals
3) **Restructure green subsidies to promote grassland areas of high environmental value**
   - Introduce ecosystem assessment to green subsidies
4) **Detail forest inventories to improve land use and manage valuable ecosystems**
   - Include appropriate classification aligned with the ecosystem types/subtypes classification for ecosystem inventories to identify valuable inclusions
   - Facilitate the land use of small valuable ecosystems as such instead of general forest management
5) **Optimize the use of heathland and shrubs provisioning and cultural ecosystem services**
   - Encourage the management of heathland and shrubs ecosystems rather than their extermination, by incorporating it in the local development plans
   - Promote projects (and the industry's investments) for creating awareness and sustainable use of heathland and shrubs genetic resources
6) **Sparsely vegetated land—areas for botanic tourism and high-tech exploration**
   - Discourage the destruction of SPA ecosystems, that is, by introducing an analog to the 'polluter pays' principle at a central and/or a local level
   - Create niche tourism offerings
   - Explore innovative ecological education options, with focus on disabled people, that is, using drones and virtual reality tours.
7) **Promote recreational and industrial use of wetlands**
   - Promote the creation of urban and peri urban recreational wetlands as part of urban planning

- Discourage the drainage of wetlands, especially outside NATURA 2000 sites
- Educate engineering and environmental specialists for creating constructed wetlands with optimal land use

8) **Green water purification solutions to reduce nitrate loads and household waste/wastewater impact on water ecosystems**
   - Conceptual aligning and/or cross-walks between measurements according to the WFD/Nitrates directives and ecosystem management
   - Systematic introduction of CBA in greening wastewater (and possibly also waste) infrastructure

9) **Integrate ecosystem considerations in marine and coastal management policies**
   - Create the necessary research infrastructure (ships and equipment) for assessing BD&ES
   - Conceptual alignment between instruments regulating the marine and coastal zone management
   - Enhance cross-institutional dialog in preparing national positions

Annex 9. Costs and Benefits for CCA Measures in Europe

Categories	Options	Description of the option	Cost	Cost-effectiveness/cost benefit	Source
A. Knowledge management and stakeholder communication for adaptation	Open and re-use data	**Ecosystem data interoperability between authorities and other actors:** This option is concerned with the removing of legal and procedural obstacles, creating data and IT infrastructure as basis for free exchange of data related to ES&CC between authorities and other data holders, that is academia, as well as peer review of citizen science data. The practice to require payments for data must be a matter of financial disincentive. The option is highly synergetic to the general move of Government to reduce red tape.	**GBIF—the Global Biodiversity Information Facility (Denmark):** Center that provides free and open access to biodiversity data worldwide	First, data sharing accelerates the pace of science by enabling researchers to discover and re-use relevant data, combine data from multiple sources, and ask new questions. Second, public trust increases as science is made more transparent and findings can be reproduced and verified. Third, it has further been argued that access to research data represents one of our human rights.	(Michener 2015)
	Open and re-use data	**Open data massive for use by every interested party:** This measure is concerned with the policies for open data access. The right balance must be found between sharing data and protecting the legitimate interests of business owners, citizens and the society as a whole. Private and business data may not be disclosed; sensitive ecologic data about the location of rare species ought to be protected from poachers while still available to academia.			

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	Improve understanding of ecosystem processes and climate change as pressure	**Interdisciplinary teams and centers of excellence:** Set interdisciplinary research on ecosystems, ecosystem services and biodiversity as a priority in existing scientific funding instruments, such as the Scientific research fund and Operational Programmes.	**ALTER-Net:** is a network of partner institutes from 18 European countries. ALTER-Net integrates research capacities across Europe: assessing changes in biodiversity, analyzing the effect of those changes on ecosystem services and informing policymakers and the public about this at a European scale. Originally funded by the European Union's Framework VI program to stimulate a collaborative approach, ALTER-Net is now operating independently, contributing to the lasting integration of Europe's research capacity on biodiversity.		
	Improve understanding of ecosystem processes and climate change as pressure	**Participative science:** Encourage scientists to join teams on ad-hoc basis by thematic contests on identified challenges. Remove obstacles to free sharing of knowledge, that is due to intellectual property rights, by preferably funding open access publications with open published data and reproducible results	**lifeBiodiscoveries** - Invasive species control through public participation. The project is aiming to develop an alternative to the traditional models of invasive species control, combining a public component and strong support for volunteering. **Project budget: €1,322,947**	• It aims to show through its management model based on public participation that it is possible to achieve a better cost/benefit ratio • Control of invasive species on 75 hectares of Machada forest; • Use of grazing to control invasive plants during the three final years of the project on an area of 10 hectares; • Improvement or construction of 10 km of nature trails;	(EC-Environment, Accessed in November 2017)

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	Restore, enhance and use local biodiversity knowledge	**Targeted collection of customs and folk knowledge:** reserve the invaluable local knowledge in areas such as ecosystem management (such as the 'Koriya' forest belts around settlements practiced in the 19th century), the alimentary and medicinal use of biodiversity to enhance the gene pool (such as local sorts and breeds and their wild relatives, herbs, medicinal plants), use them in research and the adaptation practice.	**The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES):** IPBES established a task force on indigenous and local knowledge systems.	Report: 'Indigenous and Local Knowledge of Biodiversity and Ecosystem Services in Europe and Central Asia'	(IPBES, Accessed in November 2017)
	Restore, enhance and use local biodiversity knowledge	**Import local knowledge:** Targeted acquisition of other nationalities' local knowledge about plants and animals of foreign origin, including widespread invasive alien species with economic importance, via projects under Operational Programmes. This measure has also to include a safeguard component since foreign species must be tested in nurseries before their release in the wild.			
	Maximize the use of citizen science	**Promote ecosystem thinking between volunteers:** Ecosystem thinking is the next frontier in citizen science; however, it needs to be nurtured instead of focusing on single species.	**CSMON-LIFE - Monitoring biodiversity by a Citizen Science approach for solving environmental problems:** The CSMON-LIFE project aims at contributing to a new strategic	• At least 30 citizen scientists trained with the skills necessary to perform data validation; • A network of at least 2,000	(EC-Environment, Accessed in November 2017)

Categories	Options	Description of the option	Cost	Cost-effectiveness/cost benefit	Source
	Maximize the use of citizen science	**Enable volunteer sharing:** The ease of contribution for non-specialists (that is mobile applications that shares photos, GPS data, and so on) is another key success factor.	approach, by enlarging and improving the knowledge base for biodiversity policies in Italy. This goal will be achieved by involving citizens in data collection and validation. The project will promote active collaboration among scientists, public administrations and citizens in discovering, monitoring and protecting biodiversity, thus providing a further contribution to the needs of policy makers. **Project budget: €2,206,700**	citizen scientists; • At least 20,000 records collected; • Dissemination of the aims of the project both in the whole study area and at the national level through different media, to reach at least 200,000 citizens;	
B. Improving governance	Adjust climate legislation to sectoral legislations	1. **Revise the CCPA to include the provisions of the Climate Change Adaptation Strategy** 2. **Adjust regional adaptation strategies to the amended CCPA** 3. **Complete the new national Biodiversity Strategy and Action Plan with regard to ecosystem-based management, conservation and climate change adaptation** 4. **Review and amend legislation and sub-legislation to reflect the new Biodiversity strategy**	**CYPADAPT:** Development of a national strategy for adaptation to climate change adverse impacts in Cyprus: The aim of CYPADAPT was to strengthen and increase Cyprus adaptive capacity to climate change impacts through the development of a National Adaptation Strategy **Project budget: €1,358,847**		(EC-Environment, Accessed in November 2017)

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	Align strategic planning and implementation legislation	**Link decision making, resource and funding to efficient assessment of improved ecosystem condition:** The EU Biodiversity strategy to 2020 sets measurable targets on restoring ecosystems. Therefore, the effect of budgetary spending and subsidies, in particular green agriculture subsidies, should be measured against the improvement of ecosystem conditions. Less effective measures should be discarded even if measuring the physical parameters of their implementation is easier than measuring the ecosystems condition.			
	Align strategic planning and implementation legislation	**Operationalize good institutional interaction:** The process of enacting legislation is sometimes applied under time pressure and financial constraints, resulting in leaving out important aspects of legislation intent and ultimately in legislative fragmentation. The efficiency of consultations on all levels needs therefore to be enhanced.			

Categories	Options	Description of the option	Cost	Cost-effectiveness/cost benefit	Source
	Improve fossil fuel carbon statistics in national accounts and link to new environmental account	**Create carbon environmental accounts:** The National Statistical Institute has applied for a grant provided directly by Eurostat on the creation of environmental accounts. Carbon account is to be one of these accounts, and it should be in line both with Eurostat guidelines, and with the National Methodological Framework.	**EU ETS National Allocation Plan :** The European Union Emissions Trading System (EU ETS), also known as the European Union Emissions Trading Scheme, was the first large greenhouse gas emissions trading scheme in the world and remains the biggest. For each EU ETS Phase, the total quantity to be allocated by each Member State is defined in the National Allocation Plan (equivalent to its UNFCCC-defined carbon account)		(EC-Eurostat, Accessed in November 2017)
	Improve fossil fuel carbon statistics in national accounts and link to new environmental account	**Link fossil fuel carbon accounts and environmental accounts:** To form a carbon balance, existing accounts need to be embedded in the existing system of national accounts in terms of data collection, processing and comparison.			

Categories	Options	Description of the option	Cost	Cost-effectiveness/cost benefit	Source
	Educate for ecosystem thinking	1. Implement new **training** programs on all educational levels and in informal/non-formal education 2. Create specialized education courses for administrations responsible for **implementing** CCA and BD legislation	**Wallasea Island (UK):** In particular, the public was educated about the ecological reality that certain ecosystems are always in a state of flux and thus cannot/should not indefinitely be preserved in a static state. Management and administration: **€222,000** per year Ecosystem maintenance and/or restoration: over **€5.8 million** Land purchase and physical implementation works: around **£17.5 million**	**Biodiversity conservation objective:** Offset historical losses of coastal habitats	(Naumann et al. 2011)
C. Operationalizing ecosystem-based adaptation	Create space for biodiversity and ecosystems	**Re-claim space from grey infrastructure:** Green infrastructure is a relatively inexpensive way to harness ecosystem services for adaptation. Examples include: (a) Restore river meanders to diminish the speed of flow, reduce erosion and eliminate the needs for dykes. (b) Use green infrastructure (constructed wetlands) for water purification. (c) 3. Create urban green spaces, that is green roofs, semi-grassed alleys, and so on	**Wallasea Island: Wild Coast Project (UK):** 'Grey' infrastructure flood defenses were constructed but have recently been found to no longer be economically viable. The aim of the project is thus to combat the threats from climate change and coastal flooding by restoring the wetland landscape of mudflats and saltmarsh, lagoons and pasture. Management and administration: **€222,000** /a Ecosystem maintenance and/or restoration: over **€5.8** million Land purchase and physical implementation works: around **£17.5** million	**Biodiversity conservation objective:** Offset historical losses of coastal habitats	(Naumann et al. 2011)

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			Netherlands, Room for River Project: Typical cost rate for reducing high water levels varies between river branches ranges from **€8,000** per m^2 in the river Maas to **€26,000** per m^2 in the river Waal		(CPB 2017)
	Create space for biodiversity and ecosystems	**Create refugiums, reduce fragmentation:** Relatively small concessions in terms of land can lead to significant improvement of ecosystems' climate change resilience. Examples include: (a) 1. Green belts in cropland or grassland landscapes. (b) 2. (Semi) natural urban and peri-urban green space maintenance.	**LIFE IGIC - Improvement of green infrastructure in agroecosystems: reconnecting natural areas by countering habitat fragmentation** **Project budget: €1,246,704**	The main objectives of the LIFE IGIC (biodiversity) project are to develop a green infrastructure (GI) network in agro-ecosystems and to demonstrate its potential at regional, national and EU level. On the one hand, this GI will reduce habitat fragmentation by reconnecting existing natural areas; on the other hand, it will enhance the conservation of biodiversity in the project area.	(EC-Environment, Accessed in November 2017)
	Increase climate change resilience by reducing anthropogenic pressures not related to climate change	**Reduce pollution and disturbance:** Depending on the landscape and ecosystem type, specific local options may relate to the reduction of stress, air pollution, light or noise pollution, as well as pollution by chemicals. Example: the replacement of fertilizers in intensive agriculture by natural nutrients in crop combinations.	**Éclaire: Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems (IIASA, Austria):** Health driven air pollution policy will also reduce excess nitrogen on nature by ~44 percent. An illustrative ECLAIRE scenario that reduces excess deposition with 2 percent more will cost €23 million.	The benefits of such an additional reduction will be 50-100 percent higher, depending on the methodology for biodiversity valuation.	(ECLAIRE 2015)

Categories	Options	Description of the option	Cost	Cost-effectiveness/cost benefit	Source
	Increase climate change resilience by reducing anthropogenic pressures not related to climate change	**Reduce overexploitation:** Over-extraction of any species will eventually lead to disruption in the food chain and unwanted effects on the ecosystem. Example of implementing this option in the local context includes the prudent hunting and foraging to avoid costly re-introduction of species into the disturbed ecosystem.	**Sustainable Hunting Initiative:** The Birds Directive aims to provide a framework for ensuring that this activity does not jeopardize the conservation efforts undertaken for certain species (listed in Annex II) in the EU.		(EC-Environment, Accessed in November 2017)
	Use the 'invisible ecosystems' for adaptation and human benefit	**Use genetic resources for resilience:** This option emphasizes the tapping into ecosystem services supplied by less used ecosystems as climate change adaptation support factor. Such use is especially beneficial to small communities and vulnerable/minority groups who in some cases heavily rely on their availability. Examples: (a) 1. Use of local instead of imported sorts and breeds, possibly crossed with wild relatives for added resilience. (b) 2. Use of local healing plants from natural ecosystems, such as *Crataegus monogyna* and the introduced *Lycium barbarum* shrubs.	**LIFE PonDerat - Restoring the Pontine Archipelago ecosystem through management of rats and other invasive alien species:** Eradicate and control alien animal species (such as rodents and feral goats) in order to restore island habitats (6,220*, 3,170*, 5,320, 5,330, 1,240) and communities and improve the breeding performances of native species **Project budget**: €1,788,216		(EC-Environment, Accessed in November 2017)

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	Use the 'invisible ecosystems' for adaptation and human benefit	**Cultural ecosystem services for recreation and education:** less well-known ecosystems such as the sparsely vegetated lands offer unique experiences, learning and research possibilities and can generate additional income from niche tourism offerings.	**Urban woods - Demonstration of ways to increase peoples' recreational benefits from urban woodlands:** The project was a collaboration between forestry organizations in Sweden and France that also involved several municipalities in both countries. It aimed to demonstrate ways to stimulate and improve recreational possibilities of urban woodlands for the public. **Project budget: €3,102,612**	• The project helped establish pilot recreational areas in 14 urban forests surrounding Stockholm and Paris. • 10,000 participants attended guided tours	(EC-Environment, Accessed in November 2017)

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Note: Research for this annex was based on the first draft of this report. Names of the adaptation measures may be different from these in the current final version