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MINISTRY OF ENVIRONMENT
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THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE

BIODIVERSITY AND CLIMATE CHANGE

VULNERABILITY ASSESSMENT AND ADAPTATION MEASURES

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BIODIVERSITY AND THE CHALLENGE OF CLIMATE CHANGE

This publication summarizes key findings from an assessment of the vulnerability of biodiversity in the Republic of Macedonia to climate change and possible adaption measures and strategies.

This assessment was made as part of the Republic of Macedonia's Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change by the Ministry of Environment and Physical Planning with support from the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF).

The full report is available at:
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THE IMPORTANCE OF BIODIVERSITY TO HUMAN DEVELOPMENT

Biodiversity plays a vital role in human society and economy, providing numerous goods and services on which populations depend for their livelihoods, including foods, fibres, fuels, clean water and air, productive soils, medicines and natural pest and disease control.

In the field of medicine alone, many groundbreaking pharmaceutical advances, including treatments for cancer and other major diseases, have been achieved through research into rare plants and animals in their natural ecosystems and habitats—species that have adapted to specific environments over millennia and whose irretrievable extinction may deprive humanity of innumerable medicinal resources.

Biodiversity, moreover, has inestimable cultural, aesthetic and recreational values. Indeed, the United Nations emphasizes the intrinsic value of biodiversity irrespective of human needs and interests.

The Republic of Macedonia has a rich and unique biological diversity due to its geographic complexity and a combination of continental and Mediterranean climates—a biodiversity comprising some 22,000 species, including over 1000 identified endemic species.

Much of the country's population, especially in rural areas, depend directly for their livelihoods on biodiversity, while the functioning of the entire society and economy can be said to depend indirectly on maintaining the productivity of crucial ecosystems at risk from the effects of climate change.

THE IMPACT OF CLIMATE CHANGE ON BIODIVERSITY

Climate change is a major threat to biodiversity because species have evolved to live within certain climates and are often unable to adapt to the impacts of rising temperatures, greater aridity and more extreme weather events. And because of the complex relationships within ecosystems, the migration or extinction of any one species will inevitably place other species at risk.

Already the current rate of species extinction throughout the world is over a hundred times greater than in pre-industrial times. This accelerating loss of biodiversity is due not only to climate change but to other anthropogenic factors such as human population growth, land cover and land use, exploitation of certain species to the exclusion of others, deforestation, the introduction of non-native species and the pollution and degradation of soil, water and air.

The latest reports of the Intergovernmental Panel on Climate Change (IPCC) confirm that a large percentage of the world's species face an increased risk of extinction unless actions are taken to mitigate and adapt to climate change.

Rising temperatures, droughts and floods and other extreme weather events are already jeopardising the habitats and survival of many plants and animals. Increases in temperature affect the timing of animal and plant reproduction and migration, species distribution, as well as the length of crop growing seasons and the frequency of outbreaks of disease and pests.

Without measures to mitigate and adapt to climate change, more than a quarter of all species on land are estimated to be at risk of extinction by 2050.

Research further suggests that such loss of biodiversity will itself accelerate climate change.

Loss of biodiversity will reduce the productivity of existing ecosystems that have evolved in adaptation to specific local climates. Calculating the complex consequences of such losses in ecosystem productivity is a major challenge requiring the development of new methodologies and tools. A vast amount of data still needs to be acquired for effective modelling and vulnerability assessments.

Possible adaptations to mitigate the negative effects of climate change on biodiversity include changes towards more sustainable land use and land management, reforestation, better coordination and management of protected areas, comprehensive water management strategies and the use of renewable energy sources.

The Ministry of Environment and Physical Planning has produced three National Communications to the UN Framework Convention on Climate Change (UNFCCC), with UNDP's support,. All three documents have included analysis of the impacts of climate change on biodiversity. The methodologies applied for analysing these impacts has been refined with each National Communication.

BIODIVERSITY AND CLIMATE CHANGE IN THE COUNTRY'S PREVIOUS NATIONAL COMMUNICATIONS

The First and Second National Communications based their vulnerability assessments of biodiversity on analysis of vegetation belts, species and (plant) communities as well as refugial zones. These assessments confirmed the negative effects of human activities on the country's ecosystems.

The previous Communications identified the main anthropogenic influences on the vulnerability of the country to climate change as follows:

- The construction of hydrosystems, especially in mountainous areas
- Water extraction systems
- Roads
- Power lines and pylons
- Industrial buildings
- The expansion and abandonment of agricultural lands
- Uncontrolled exploitation of forests

On the basis of expert judgment and relevant literature, the Second National Communication assessed the impact of climate change on the country's main ecosystem types, identifying grassland ecosystems in alpine and subalpine pastures as the most vulnerable.

Alpine grasslands, rocky habitats, screes and rock vegetation are distributed on the highest parts of mountain summits. The country's alpine zones are projected to disappear under the impact of climate change. The species that live in these shrinking habitats will have few opportunities to migrate to other alpine climates.

The Second National Communication further identified a significant threat to the country's biodiversity in the disappearance of vegetation and other species in the 'refugia centres' due to increased temperatures and reduced sums of precipitation. These centres are vital to the country's biodiversity due to the number and variety of species including many endemic and relict species that have found shelter in these areas over millennia of natural and human influences.

The Second National Communication identified many of the species in the country most at risk from the impact of climate change, including 79 fungi and lichen species, 74 species of algae, 392 higher plants, and 113 vertebrates.

The assessments undertaken for the First and Second National Communications also identified some of the key human factors contributing to the vulnerability of the country's biodiversity, including unsustainable agricultural practices, economic hardship, political instability, inadequate spatial planning and inappropriate land use.

The Second National Communication emphasized the following causes behind the growing threat to the country's biodiversity and the consequent susceptibility of ecosystems to the negative consequences of climate change:

- Low awareness of the importance of biodiversity and the need to adapt for climate change
- Limited economic growth and resources and increasingly high levels of poverty
- Political instability
- Uncontrolled urbanisation
- Abandonment of agricultural land
- Migration from villages to towns
- Globalisation and a market-driven shift to high production systems

The Second National Communication further specified the following obstacles to conserving the country's biodiversity:

- Inadequate and incomplete legislation that fails to clarify responsibilities and results in overlapping roles between the agencies responsible for enforcement.
- Non-compliance with existing regulations and policy documents
- Lack of spatial planning regulations for areas with special natural values
- Lack of up-to-date technologies, including appropriate renewable power generation equipment and lack of treatment facilities for wastewater and waste gasses.
- Outdated spatial planning processes, resulting in improper land use changes, construction of infrastructure systems and agricultural conversion.

The sectors found to have the most significant negative impact on the country's biodiversity were agriculture and fishing. Agriculture has reduced biodiversity since the mid-20th century through the drainage of marshes and widescale expansion of farming, accompanied by a decline in pastoralism. Over-fishing continues to pose a grave threat to many species, including some of the country's endemic fish, especially in Lake Ohrid.

Many other sectors were also identified as posing a risk to biodiversity, underlining the necessity of adopting a multisectoral approach to the protection of biodiversity and the development of strategies for mitigating and adapting to climate change. These sectors included:

- **Transport** *(e.g., through the fragmentation of habitats by road construction)*
- **Energy** *(e.g., through pollution and the construction of hydropower reservoirs and power line networks)*
- **Industry & Mining** *(e.g., through soil, water and air pollution)*
- **Tourism** *(e.g., through the illegal construction of holiday homes, incomplete tourist resort infrastructures, littering, etc.)*
- **Construction and Civil Engineering** *(e.g., through land conversion, destruction of animal habitats and pollution due to poor waste disposal)*

BIODIVERSITY AND CLIMATE CHANGE IN THE THIRD NATIONAL COMMUNICATION

The vulnerability assessment of biodiversity carried out for the Third National Communication not only built on previous assessments especially that carried out by the Second National Communication of 2008 but also introduced habitat and species modelling for the most sensitive components of biodiversity.

A key methodological aim in this project was to improve upon the assessments already undertaken. For while the previous studies mainly used expert judgments and comparison with the scientific literature on the subject, the Third National Communication assessment involved modelling software for more accurate predictions of future impacts of climate change on certain plant and animal species.

Another key methodological aim of this project was to check the accuracy of expert judgements as a tool for assessing the vulnerability of biodiversity to climate change. Expert judgments remain an important tool due to the lack of data and continual monitoring of biodiversity components in Macedonia.

Modelling the impact of climate change on biodiversity poses a major challenge for scientists throughout the world because the data and models needed are still incomplete. The direction of adaptations, migrations and successions of different biodiversity components in a certain area or region depends on many complex and interrelated factors.

The capacity of countries to adapt and mitigate the impacts of climate change on biodiversity depend, moreover, upon their technical, financial and institutional capacities.

The Republic of Macedonia is one of Europe's biodiversity 'hotspots' in terms of the number and diversity of species found its territory. However, the latest research suggests that the impact of climate change on the country's biodiversity may be even more severe than projected in previous reports.

A major contributing factor to the vulnerability of the country's biodiversity is the continuing lack of availability of relevant data. The Third National Communication reiterates the urgent need for the country to implement measures to improve its capacity for data collection and monitoring. Such data is essential to identify the most appropriate measures for adaptation to the worst effects of climate change.

Considerations of data availability were a major determining factor in the approach taken in this study, a major component of which involved a species impact assessment using state-of-the-art modelling software.

Species-Impact Assessment

For the purposes of this assessment, species were selected according to the following criteria: data availability, distribution range, taxonomy, ecological characteristics (e.g., phenology, habitats and climate preferences) and threat status. Again, data availability was the most important determinant in the selection.

The species selected for modelling in the assessment included:

- *Querco cocciferae-Carpinetum orientalis Oberd.* (a submediterranean forest community sensitive to the impact of global climate change)
- *Pinetum mugho macedonicum calcicolum* (a mountain pine shrubland community) sensitive to climate change)
- *Pedicularis ferdinandii* (an endemic species found on Mount Jakupica)
- *Trechus goebli* (a species of ground beetle)
- *Crocus cvijicii (an endemic plant species fond on Mount Galichica)*

To model the probable response of these species to the projected impacts of climate change, the Third National Communication project used a state-of-the-art software package called MaxEnt, which is able to estimate shifts in the distribution ranges of species in different conditions. Such distribution ranges of species are to a great extent determined by climate factors.

The modelling of current and future geographic distributions of species requires three types of data:

- information on the species' current geographic distribution
- data on current climatic conditions
- data on predicted future climatic conditions

Given these criteria and the data available, the assessment model took into account a set of indicators of vulnerability, including changes in the distribution of the following species in response to climate change:

- The tree line of Mount Jakupica
- The Kermes oak ecosystem
- The mountain pine ecosystem / community
- Plant species, including *Pedicularis ferdinandi* and *Crocus cvijicii*
- Animal species, including: *Trechus goebli*.

Results of modelling for 4 species

The MaxEnt model was used to predict possible future changes in the distribution of four plant species and one species of ground beetle in response to climate changes.

Table. Spatial analysis of observed and modeled (predicted) distribution.

SPECIES	Modeled distribution (area, km²)			Observed distribution (area, km²)
	Y2000	Y2050	Y2100	
Pinus mugo	182	51	0	10,63
Trechus goebli	108	1	0	22,58
Quercus coccifera	1028	228	1884	805,17
Crocus cvijicii	8	5	29	2,81
Pedicularis ferdinandi	31	0	0	1,52

Crocus cvijicii

Crocus cvijicii is a plant species only known to occur on Mount Galičica. It grows only in high-altitude limestone pastures at 1800–2150 metres.

The model predicts that climate change will have reduced the potential distribution range of this species to just 5km² by the year 2050.

However, according to the model, the potential distribution range of the species will expand to 29 km until year 2100 and will cover the northern (lower) parts of Mount Galičica.

Pedicularis ferdinandi

Pedicularis ferdinandi is an endemic plant species found on Mount Mokra at altitudes of 2100–2300m.

According to the modelling performed for the Third National Communication project this plant species will already have disappeared by 2050 due to the impacts of climate change.

Trechus goebli matchai

Trechus goebli matchai is an endemic species of small ground beetle found at altitudes above 2, 200 metres above sea level. It has been recorded in this country in Solunska Glava, Marina Rupa, Solunsko Pole and Begovo Pole.

The model suggests that that the distribution area of this species will be reduced significantly as a result of climate change by 2050, eventually being confined to Solunska Glava. By 2100, the model predicts, this species will have disappeared completely.

However, expert judgment allows for the possibility that the species may survive by adapting its reproductive cycles and the depth of its habitat underground.

Pinus mugo
(Mountain pine)

Mountain pine is distributed in subalpine and alpine zones on Mount Mokra and the Shar Planina mountains.

The model projects a significant reduction in this species by 2050 and its complete disappearance by 2100.

Quercus coccifera
(Kermes oak)

Kermes oak grows in the south-east of the country between Demir Kapija, Gevgelija and Strumica.

The model predicts a significant eastward shift in the distribution of this species over this century. (This revises the northward shift predicted by the Second national Communication.)

CHALLENGES

The vulnerability assessment of the Republic of Macedonia's biodiversity undertaken for the Third National Communication included a review of the main challenges that need to be overcome to increase the country's capacity to preserve biodiversity. These challenges include:

- The need for more data on the precise distribution, population density and vulnerability of different species, as well as a vegetational map of habitats.
- The need for a monitoring system of climate change impact
- The need for spatial plans to take into account the consequences of climate change on biodiversity
- The need to regulate water extraction
- The need for close intersectoral cooperation
- The need for greater knowledge and expertise
- The need for greater awareness of the impact of climate change on biodiversity
- The need for financial mechanisms to support measures to protect biodiversity

Action Plan

To overcome these challenges and increase the country's capacity to preserve biodiversity, the Third National Communication developed a comprehensive action plan.

Recommendations

To take into account the impacts of climate change when estimating the threat status of species, habitats and ecosystems within the activities of the National Biodiversity Strategy.

To develop precise distribution maps of rare, endemic and relict species of plants, animals and fungi that are sensitive to climate change.

To model sensitive species in relation to climate change

To develop action plans to protect economically important species in the high mountain belt, such as bilberries and chamois, which are vulnerable to climate change

To improve monitoring of the distribution of species vulnerable to climate change.

To adopt policy instruments for the implementation of corridors management plans into national and regional spatial planning

To undertake a case study of implementing the ecological network concept in regional planning based on an inter-sectoral approach

To undertake a detailed revision of the country's system of protected areas in relation to adaptation to climate change.

To establish an intersectoral body with responsibility for managing water resources and biodiversity and a strategy for activities to mitigate and adapt to the impacts of climate change

To develop and implement a communication strategy for raising awareness of the importance of biodiversity and its vulnerability to climate change.

To establish a budget for the study of the impacts of climate change, monitoring and adaptation.