4th NATIONAL

CLIMATE CHANGE COMMUNICATION

Republic of North Macedonia
Ministry of Environment and Physical Planning

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Publisher: Ministry of Environment and Physical Planning
Skopje, 2023.
ISBN: 608-4860-03-6

This document provides comprehensive guidelines on the integration of climate change priorities into national policies, development strategies and programmes for relevant sectors. It aims to strengthen dialogue, information exchange and cooperation amongst all the relevant stakeholders, including the governmental and non-governmental, academic and private sectors. This document was produced with the technical and financial support of the United Nations Development Programme (UNDP) and the Global Environmental Facility (GEF).

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Abbreviations

AR4	Fourth Assessment Report
BAU	Business as Usual
CCPP	Combined Cycle Power Plant
CH4	Methane
CHP	Combined heat and power
CNG	Compress Natural Gas
CO2	Carbon dioxide
COP	Conference of the Parties
CORINAIR	CORe INventory AIR emissions - Emission Inventory Guidebook
CORINE	Coordination of Information on the Environment
CSC	Climate Service Center
DALY	Disability-Adjusted Life Year
DNA	Designated National Authority
DOC	Degradable Organic Carbon
EE	Energy Efficiency
ETS	Emission Trading System
EU	European Union
FAO	Food and Agriculture Organization
FNC	First National Communication
FOD	First Order Decay
FP	Framework Program
GCM	Global Climate Model/General Circulation Model
GDD	Growing Degree Days
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse gas
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HACCP	Hazard Analysis Critical Control Point System
HFC	Hydrofluorocarbons
HPP	Hydro power plant
IBRD	International Bank for Reconstruction and Development
ICEIM-MANU	Informatics and Materials of the Macedonian Academy of Sciences and Arts
IPA	Instrument for Pre-Accession Assistance
IPARD	Instrument for Pre-accession Assistance for Agriculture and Rural Development
IPCC	Inter-governmental Panel on Climate Change
IPPC	Integrated Pollution Prevention Control
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
JRC	Joint Research Center
LPG	Liquefied Petroleum Gas

LULUCF	Land Use, Land-Use Change and Forestry
MAFWE	Ministry of Agriculture, Forestry and Water Economy
MBT	Mechanical and biological treatment
MOEPP	Ministry of Environment and Physical Planning
MRV	Measurement, Reporting, and Verification
MSW	Municipal Solid Waste
NAMA	Nationally Appropriate Mitigation Actions
NCCC	National Climate Change Committee
NDE	National Designated Entity
NEAP	National Environmental Action Plan
NGO	Non-governmental organization
NMVOC	Non-Methane Volatile Organic Compounds
NOx	Nitrous Oxides
NPV	Net Present Value
NWMP	National Waste Management Plan
PFC	Perfluorocarbons
PP	Power Plant
PV	Photovoltaic
QELRC	Quantified Emission Limitation and Reduction Commitment
R&D	Research and Development
RDF	Refuse Derived Fuel
RES	Renewable energy source
SE	South East
SEEFCCA	South East European Forum on Climate Change Adaptation
SEEVCCC	South East European Virtual Climate Change Center
SME	Small and Medium Enterprises
SNC	Second National Communication
SoVI	Social Vulnerability Index
SOx	Sulphur Oxides
SRES	Special Report on Emissions Scenarios
TNA	Technology Need Assessment
TNC	Third National Communication
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
UV	Ultra Violet
WHO	World Health Organisation
WMO	World Meteorological Organisation
WMRs	Waste Management Regions
ZELS	Association of the units of Local Self-Government of The Republic of Macedonia

Units

EUR	Euro
GWh	Gigawatt hour
kt	kilo tonne
ktoe	kilo tonne of oil equivalent
m_3	cubic meter
MEUR	Million Euros
MKD	Macedonian Denar
Mt	Mega tonne
MW	Megawatt
Nm^3	Normal cubic meter

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1 Executive Summary

1.1 Introduction

North Macedonia is a non-Annex I party to the United Nations Framework Convention on Climate Change (UNFCCC). It ratified the Kyoto Protocol in 2004, and signed and ratified the Paris Agreement in 2016 and 2018 respectively, thus committing to taking an active role in global efforts for GHG emissions reductions.

Through its nationally determined contribution (NDC), North Macedonia has committed "to reduce the CO 2 emissions from fossil fuels combustion for 30%, that is, for 36% at a higher level of ambition, by 2030 compared to the business as usual (BAU) scenario."[1]. The North Macedonia's enhanced NDC has strengthened its GHG targets by 2050 to 53% emission reduction in relation to 1990, that is 82% net GHG emissions reduction.

North Macedonia's commitment to fulfilling its international obligations under the UNFCCC is presented in this Fourth National Communication. This report provides a background of the national circumstances, and the country's policy and institutional framework for climate change. It includes the results of the new GHG inventories for 2019 and provides plans and measures for emissions reductions in key sectors.

This National Communication also presents the climate profile of the country, highlighting the sectors and regions most vulnerable to climate change impacts, while providing analysis of potential adaptation measures.

The report provides recommendations on measures to build capacity, facilitate financial investments and improve technology transfer. Finally, it summarises the ongoing activities related to education, information and public awareness of climate change.

The information described in this Fourth National Communication summarizes the efforts made in the country related to climate change management, with emphasis on the period following the publication of the Third National Communication (TNC) in 2014.

1.2 National circumstances

The Republic of North Macedonia is a small, landlocked country in the middle of the Balkan Peninsula in Southern Europe, with a total surface area of 25,713 km2, out of which hills and mountainous terrain cover 79%, plains 19.1%, and water surfaces approximately 1.9%. **Macedonia has a population of 2,022,547, of whom 58% live in urban areas.** The western part of the country is the most heavily populated. In recent years, people have migrated into the cities, looking for employment. Approximately 25% of the population lives in the capital city of Skopje, which is in the northern part of the country.

North Macedonia became an independent state in 1991 and was classified as an EU candidate in 2005. It has a democratic political system. Foreign trade accounts for more than 90% of gross domestic product (GDP), making it vulnerable to external events. Unemployment has recently improved to historically low levels, down from 36% in 2005 to 17% in 2019. Life expectancy at birth is 76.7 years. Health care is delivered through a system of health care institutions that cover the country's territory relatively evenly. This makes it possible for around 90% of the population to obtain health services in less than 30 minutes.

Climate in North Macedonia is diverse and is influenced by the Mediterranean Sea and by the European continent to a varying extent. The highest values of annual air temperatures are recorded in the Gevgelija and Valandovo Region, where the mean is higher than 14oC. The coldest month in Macedonia is January, and on average July is the hottest month. The highest temperature from 1951 through 2021 was recorded in 2012 at 41.0 °C. The frequency of heat waves 2 has also increased from 1987 onwards. And in contrast to the first half of the period, a heat wave has been recorded in almost every year since 1987. The air temperatures in 2020 in Republic of N. Macedonia continued to reflect trends of a warming planet, with positive anomaly from the normals. The mean air temperatures anomaly in 2020 was from 0.4° to 1.4°C above the reference period 1981-2010. The anomaly of the mean maximum air temperatures in 2020 was from 0.2° to 3.8°C above the reference period

1 Climate Change Mitigation Report, June 2022

1981-2010, while the mean minimum air temperatures anomaly was from -0.9°C to 1.9°C 3 .

Precipitation in the Republic of North Macedonia is unequally distributed. Two basic pluviometric regimes are present in Macedonia: Mediterranean and continental. In the area with the Mediterranean precipitation regime, November, October and December are the months with highest level of precipitation; in the area with a continental climate, the highest amount of rainfall occurs in May and June.

Biodiversity in Macedonia is noted for its species richness and level of endemism, underlining the country's importance of a "hotspot" for biodiversity in Europe. Despite its small land area, it represents one of the most important centres in Europe, having almost 700 endemic animal species. The country has four national parks which are heritage sites of nature and culture.

In 2020, **energy** supply in North Macedonia came from oil (39%), coal (29%) and natural gas (11%), with biofuels, hydro and renewables making up the remainder. Natural gas is imported from Russia. It was the first country to build a sizeable wind facility in the Western Balkans and has plans for additional solar PV capacities.

Industry comprises 18% of GDP and is important to the economy, consisting of manufacturing (food, metals and textiles) and energy supply.

Road **transport** has the highest share of energy consumption (98%) although, levels are small compared to EU averages (650 toe versus 200 toe per 1000 inhabitants). It has well-developed road transport infrastructure which is the dominant mode of transport. Emissions from railways are nearly 0.4% of all transport emissions and those from domestic aviation are close to zero. Emissions from transport are showing an increasing trend, being 26.5% higher in 2019 compared to 2014.

Agriculture continues to be a key economic sector in North Macedonia, playing a critical role in the social and economic stability of the country. Agriculture contributes 10% of GDP (2017) and 18% of total employment. However, productivity is low and land is fragmented. 40% of arable land and 80% of pastureland is owned by the state, with nearly a third of arable land abandoned or not utilised. There is limited opportunity for smallholders to produce at scale and adopt new innovations.

Forest cover in North Macedonia has grown by nearly 5% between 2010 and 2018, dominated by native beach and oak species. 90% of the forests are owned by the state; 92% of those have a commercial value are publicly managed and the rest are managed by national parks. Logging is subject to allowed volumes and is predominantly used by the domestic industry.

The tourism sector in North Macedonia does not play a significant part in the economy; however, recent government action has given it higher priority. The tourism sector includes winter sports, wine, hiking, history and culture. 64% of tourists are foreign and increased by 7% in 2020 compared to the previous year.

1.3 National policy and institutional framework for climate change

Climate change policy for North Macedonia is included in the National Strategy for Sustainable Development (2010) and the Second National Environmental Action Plan (2006). More specifically, in 2020 the Strategy for Energy Development was developed and incorporates climate change related laws and regulations and offers a set of ambitious and specific numerical targets for 2040 following the EU climate change policy track. It maps out six strategic goals including energy efficiency, energy security and decarbonisation.

The Government has confirmed that it plans to implement the most ambitious, green scenario, which involves phasing out coal completely by 2040. Additionally, 45% of total energy production would come from renewable sources. The strategy predicts phasing out coal by 2025, which would make North Macedonia the first country in the Western Balkans to set a concrete goal to eliminate coal power before 2030. The strategy also predicts solar and wind power plants to be the fastest-growing technologies for electricity production.

Accession to the European Union is a priority for the Republic of North Macedonia. In the process of harmonisation of the country's environmental legislation with the EU's *Acquis Communautaire, new laws have been adopted. As part of mutual efforts together with EU, national institutions have prepared and adopted a Long-term Strategy and Law on Climate Action" to establish a comprehensive legal and long-term strategic framework.*

The **Ministry of Environment and Physical Planning (MOEPP)** is the key governmental body responsible for development of climate change policies. The MOEPP has been designated as the **National Focal Point to the UNFCCC** and the National Authority for the implementation of the Kyoto Protocol. The UNFCCC Gender and Climate Change Focal point has been

nominated from the **Ministry of Labour and Social Policy**. In addition, a **National Climate Change Committee (NCCC)** was established by the Government consisting of representatives of all relevant stakeholders as a participatory platform aimed at providing high-level support and guidance for overall climate change policies in the country.

Climate change issues are incorporated into the Law on Environment, including details on the preparation of GHG emissions inventories as well as an action plan on measures and activities to abate the increase of GHG emissions and to mitigate the adverse impacts of climate change.

The First, Second, and Third National Communication on Climate Change were adopted by the Government of North Macedonia and submitted to the UNFCCC Secretariat in 2003, 2008, and 2014 respectively. These highlight to the international community the steps the country has taken towards mainstreaming climate change issues into policies and processes. This Fourth National Communication (NC4) represents a further step forward in the process.

In addition, three Biennial Update Reports (BURs) have been carried out (the last in 2021) to build on the findings and recommendations of the National Communications, as well as the outcomes of the ongoing complementary projects in the country.

1.4 National GHG inventory

The figures below (total emissions and removals by sector) show the trends in GHG emissions and removals for the period 1990–2019. These trends have been developed from North Macedonia's updated GHG emissions inventory for 2017-2019. The most significant share of emissions is from the energy sector, accounting for 75.4% in 2019, followed by the agriculture (excluding FOLU) with 12.1%, industrial processes and product use (IPPU) sector with 6.8% and the waste sector with 5.6% share.

The aggregate GHG emissions and removals (net emissions) in 2019 are estimated to be 12,902 Gg CO_2-eq (including the FOLU sector). Table 11 shows the time series of emissions and removals (given in Gg CO_2-eq) from 1990 to 2019. There are significant fluctuations in the net emissions in 2000, 2007, 2012, 2017, and 2019, where one can notice increased emissions in the FOLU sector (instead of removals) due to the intensified forest fires/wildfires. The net GHG emissions in 2019 increased by 18.7% compared to 1990, or 48.2% compared to 2016, mainly because instead of sinks, emissions occur from the forestry sector. However, in recent years, minor variations in the emissions are noticeable for the other sectors, explained more in the subsequent chapters for each sector.

Table 1-1: GHG emissions and removals by sector (in Gg CO_2-eq)

Sector	1990	2000	2005	2014	2015	2016	2017	2018	2019
Energy	9,608	9,744	9,247	8,045	7,697	7,447	7,964	7,430	8,501
Industrial Processes and Product Use	932	888	862	836	734	768	588	651	763
Agriculture (without FOLU)	1,468	1,244	1,203	1,127	1,164	1,203	1,755	1,704	1,368
FOLU	-1,546	10,056	-2,028	-3,252	-890	-1,321	1,360	-1,763	1,634
Waste	407	413	435	574	595	607	611	622	635
Total (incl. FOLU) – Net Emissions	10,870	22,346	9,719	7,330	9,299	8,704	12,278	8,644	12,902
Total (excl. FOLU)	12,415	12,290	11,747	10,582	10,190	10,024	10,918	10,407	11,268

Not accounting for emissions from the FOLU sector, total GHG emissions in 2019 are 11,268 Gg CO_2-eq, which is a decrease of 9.2% compared to 1990. In general, since 2012, there has been a decreasing trend in emissions, reaching the lowest level of 10,024 Gg CO_2-eq in 2016, despite minor variations in 2017 and 2019, due to increased domestic electricity production.

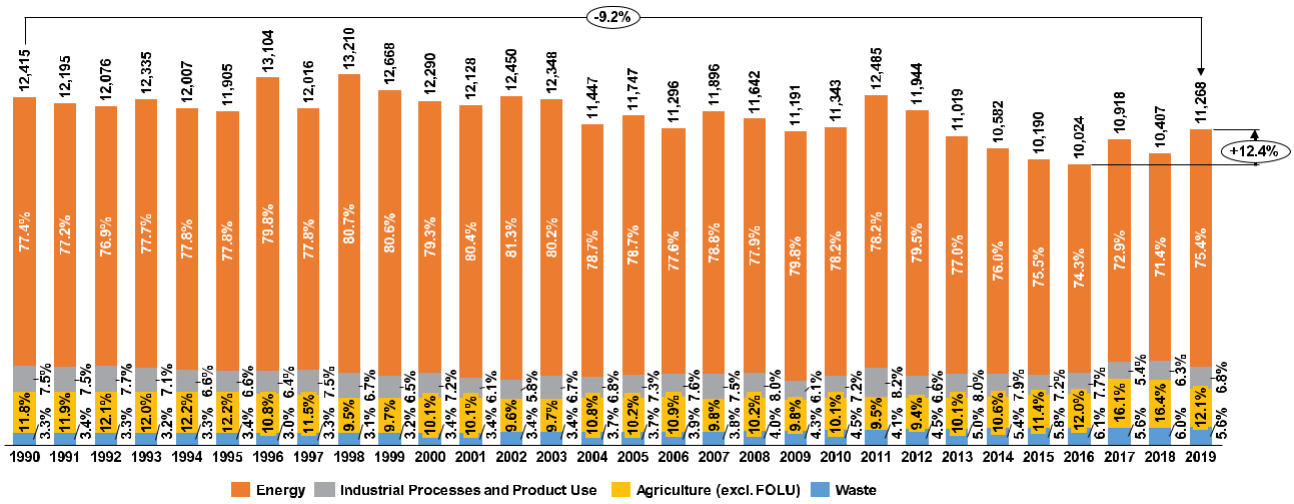


Figure 1-1: Total GHG emissions by sector, excluding FOLU sector (in Gg CO_2-eq)

1.5 GHG projections and mitigation measures

North Macedonia has committed to reduce GHG emissions by 51% by 2030 (compared to the reference year 1990) as part of its mitigation target through its NDC. The focus of the Macedonian NDC is on mitigation policies and measures which lead to GHG emissions reduction, and particularly to CO_2 emissions from fossil fuels combustion which covers almost 80% of the total GHG emissions in the country. The following sectors dominate emissions: energy supply, buildings, and transport.

To assess the mitigation potential of certain measures and policies, all sectors recognized by the Intergovernmental Panel on Climate Change (IPCC) methodology have been modelled: Energy, Industrial Processes and Product Use, Agriculture, Forestry and Other Land Use and Waste. The GHG projections have been produced under four scenarios: **without measures scenario (WOM),** with **existing measures (WEM), with additional measure (WAM)** and with extended measures (e-WAM).

A summary of the business-as-usual WOM scenario shows:

- The total GHG emissions from all sectors is expected to increase by 37.3% in 2040 compared to 1990, or by 64.7% compared to 2005, reaching 16,844 Gg CO2-eq in 2040.
- Without the FOLU sector, this increase is even more dramatic, i.e. 57.7% in 2040 compared to 1990.
- The largest amount is from the energy sector, which increases its share by up to 81% in 2040.
- The fastest growing sector in terms of emissions is the waste sector, where the emissions in 2040 are 2.25 times larger than in 1990.
- The only sector that is absorbing CO_2 emissions (has negative emissions) is the FOLU sector, and the amount of emissions absorbed is increased in 2040 compared to 1990 and 2005, but it is decreased by 13% compared to 2016.

The IPCC methodology does not include emissions from electricity imports, as well as from international aviation. To compare the inventory results of Macedonia with the results from other countries, electricity imports and international aviation (MEMO) are also presented. Using this approach, in 2040 GHG emissions increase by 30.8% compared to 1990. The difference between these two approaches is mainly due to the import of electricity, which in the IPCC approach reduces the GHG emissions.

Figure 1-2. Comparison of total GHG emissions from all sectors in WOM, WEM, WAM and e-WAM scenarios, 2030 [Gg Co_2-eq]

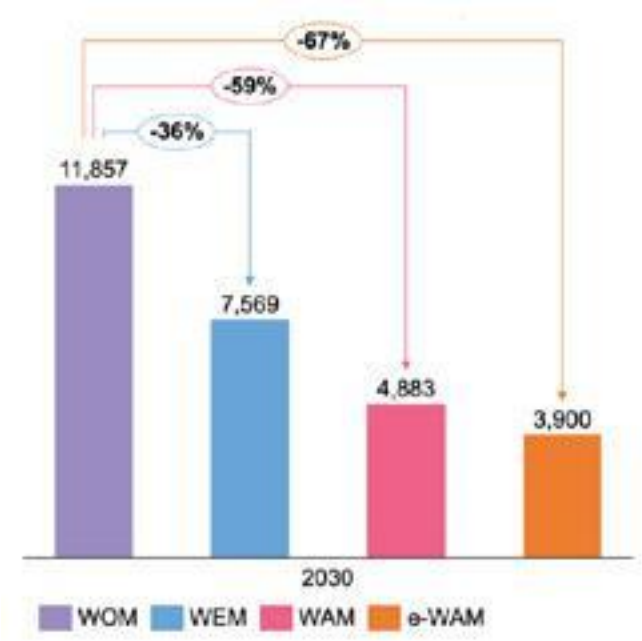
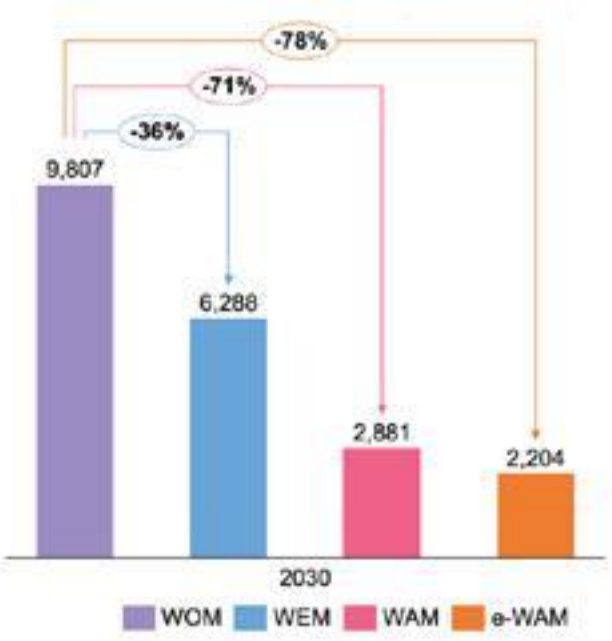


Figure 1-3. Comparison of total GHG emissions from all sectors without MEMO in WOM, WEM, WAM and e-WAM scenarios, 2030 [Gg Co_2-eq]



A summary of the WAM scenario shows:

- the total projected GHG emissions and removals in 2030 are 6,059 and 3,854 Gg CO2-eq, respectively, or the net-emissions are estimated to 2,204 Gg CO2-eq. This is a reduction of 82% in 2030, compared to the 1990 level.
- Compared to the WEM scenario, there is 65% net-emissions reduction in 2030 in the WAM scenario.
- The differences between WEM and WAM scenarios are due to the energy sector (NB: the AFOLU and waste sectors are the same in both scenarios), mainly from electricity and heat production (73% of the difference between the net-emissions in the scenarios).

Figure 1-4. GHG emissions and removals (net-emissions) by sector in WAM (in Gg CO_2-eq)

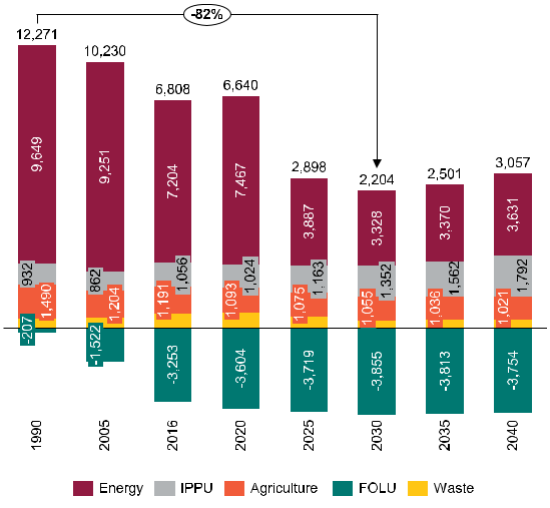
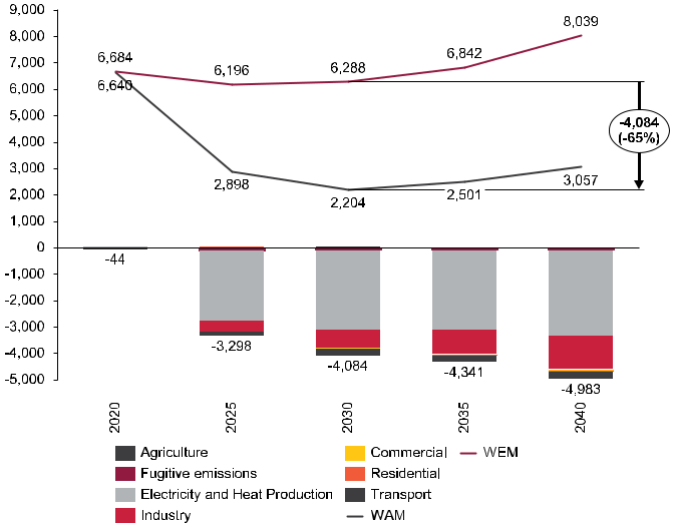


Figure 1-5. Difference between GHG emissions and removals in WEM and WAM scenario (in Gg CO_2-eq)



Source: National GHG Mitigation report under 3rd BUR, MARKAL results from the Strategy for energy development up to 2040, project team analyses

The mitigation actions defined by North Macedonia by 2030 include:

- **Energy generation:** (i) Reduction of network losses; (ii) Large hydro power plants; (iii) Renewable energy sources without incentives; (iv) Solar roof top power plants; (v) incentives feed-in tariffs, (vi) Development of the biofuels market

- **Energy efficiency:** (i) Phasing out of incandescent lights (ii) Improvement of the street lighting in the municipalities; (iii) Retrofitting of existing buildings; (iv) Increased use of heat pumps; (v) Biomass power plants (vi) Solar thermal collectors (vii) Construction of new buildings and passive buildings

- **Transport sector:** (i)Increased use of the railway (ii) Electrification of transport (iii) Advanced mobility

- **Agriculture sector:** (i) Reduced enteric fermentation in cows (ii) Manure management.

- **Land Use, Land Use Change and Forestry (LULUCF):** (i) Integrated management of forest fires; (ii) Afforestation (iii) Conversion of land use of field crops above 15% inclination (iv) Biochar (v) Photovoltaic irrigation.

- **Waste sector:** (i) Landfill gas flaring (ii) Improved waste and materials management

1.6 Climate vulnerability and adaptation measures

The results from the climate projections show that North Macedonia will have a hotter and drier climate by 2050, with an increase in hot temperature extremes and a decrease in cold temperature extremes. Despite projections for drier conditions, an increase in extreme precipitation events is expected, resulting in an increased risk of flash floods. In the summer period, the number of consecutive dry days is projected to increase, leading to more frequent droughts. The expected growing season is also expected to shift, resulting in a longer growing season. Climate projections show that these climate extremes including droughts, floods and heatwaves will increase in frequency and magnitude in the future.

Observations of climate change in North Macedonia recorded since the middle of the 20th century include:

- Increases in the average mean annual temperature in comparison with the period from 1961 to 1990 range from 0.2°C to 0.5°C.

- Among the ten warmest years for the period 1951-2012, five of the last six most recent years are included (2007, 2008, 2009, 2010 and 2012).

- Precipitation observations have indicated a general trend of decreasing rainfall.

- The greatest frequency of heat waves has occurred in the last ten years, with maximum occurrences at the greatest number of stations in 2012 and 2007.

North Macedonia is particularly vulnerable to climate change and variability as well extreme climate events. The sectors most at risk are the water sector, agriculture (crop production, soil and livestock), forestry and biodiversity. North Macedonia recognizes the need to address the effects of climate change by promoting effective adaptation measures for the key vulnerable sectors. Summary of the vulnerability analysis and proposed adaptation measures by sector includes:

- **Water sector:** In the years of intensive water use, the WEI (water use index) was about 20%, and at peak times, as in 2012, up to 35%. With irrigation of less than 10% of agricultural land and climate change causing more frequent and intense heat waves and droughts, losses in agricultural production can be expected.

- **Forest sector:** The Macedonian forestry sector will be faced with higher mortality of trees, insects and fungi infestation, larger number of heavy rain days and more forest fires. Forest fire trends have changed, with the period between two severe fire events shortening. In 2018, forest management activities were significantly interrupted because of heavy rain days, disrupting wood production. In the summer period of 2019, many of the water springs into the forest area in the region of Shtip dried up. This was accompanied with a strong attack of fungi and insects. Adaptation measures include capacity building, forestry and landscape management, and monitoring.

- **Agricultural sector:** Drought is occurring almost every season in most of the agricultural areas in North Macedonia and is projected to be more severe with climate change, further reducing crop yield. Extreme precipitation events are

causing low permeable soils to become waterlogged, destroying sensitive crops. Irrigation is prioritised as one of the best adaptation options for crop production in North Macedonia. Climate change has a severe negative effect on livestock's productivity and welfare, resulting in frequent and prolonged heat stress. Adaptation includes technical solutions to ventilation, air circulation and ventilation.

- **Biodiversity** is highly vulnerable to climate change with consequences such as the invasion of alien species and the movement and migration of threatened plants and animal species. Since the third National Communication, the first National Red List of priority fauna has been prepared, as well as the adoption of policy instruments for bio-corridor management and planning, and improved monitoring and management of protected areas.

- **Livelihoods:** A livelihood vulnerability approach was used to measure the exposure, sensitivity and adaptive capacity of different regions and municipalities in North Macedonia. The findings confirm that the human capacity to cope with the effects of climate change is not equally dispersed and varies greatly across the municipalities, especially in line with indicators on primary education (almost 40% variation) and people engaged in agriculture (50% variation). Policy response options should account for the uneven distribution of impacts across different territorial units and ultimately the affected population in different regions and municipalities.

1.7 Constraints and gaps: Climate finance, technology transfer and capacity building needs

In recent years, the country has made progress in developing climate change actions for adaptation and mitigation, through the articulation of strategies at the sectoral, national and regional levels. Despite these advances and the recognition of the problems facing the country's future, there are still some needs to be met and challenges to be overcome in terms of financing, capacity and technical assistance in the different areas of climate change management.

Based on the analyses conducted for this National Communication of the current country status of research, development, innovation and technology transfer related to climate change and the possibilities offered by the utilization of the UNFCCC technology mechanism it is evident that the country will benefit greatly from the utilization of the Technology Transfer mechanism.

As a non-Annex I country, the Republic of North Macedonia is eligible for usage of the Technology Transfer Framework themes and financing mechanisms for technology transfer. The technology transfer framework gives many financing options for the introduction of state-of-the-art technologies to the country.

Therefore, it is highly recommended to select and nominate a National Designated Entity (NDE) as a focal point for the Technology Transfer (TT) mechanism. Establishing the NDE will serve as a national focal point with the goal of providing continuous information about financing through donor programmes for R&D and Innovation activities related to the climate change actions. Also, the NDE will develop networks between implementers and beneficiaries (end users as well as companies and industry) for technology transfer. As a main financial source for facilitating the NDE's functioning and operability, the EU Green Deal's Investment Plan should be considered. To establish and reach full operability of the NDE, the following 6 main recommendations are provided:

- Development of a central portal of projects
- Maintain a list of forthcoming funding opportunities
- Intensive collaboration with advanced practices, technologies and initiatives from various parts of the world
- Partner strategically with major stakeholders and national authorities
- Promote inter-sectoral collaboration among authorities, organisations and societal spheres

It is noteworthy that in the period of 2019 to 2022, N. Macedonia implemented the project "Strengthening institutional and technical Macedonian capacities to enhance transparency in the framework of the Paris Agreement" as part of the Capacity-building Initiative for Transparency (funded by the Global Environment Facility). This project allowed for many tools to be taken up and incorporated for better information gathering and dissemination amongst stakeholders related to climate change broadly and the national communication process more specifically. This included - amongst other things – development of a measurement, reporting, and verification (MRV) platform to track measures and the main-streaming of gender considerations within the analyses of various sectors.

1.8 Education, information, and public awareness

Education: The research and analysis performed in **formal education** showed that a certain level of development has been achieved in relation to climate change teaching in the education system in North Macedonia, especially on **primary and secondary education**. However, the inclusion of this content in formal education is segmented in individual subjects, without a holistic approach. Important recommendations that would contribute to improve climate education and increase the climate literacy include the Inclusion of climate change education in key strategic documents from the Government, as a long-term goal excluded from political discussions, and an alignment between educational initiatives and sustainable development policies.

Information: The country was among the seven pioneers in the world that has included Climate Change Action within OGP Action Plan, thus confirming its commitment to put as much as possible open data sets relevant to climate change on the newly established national open data portal. The portal is a good foundational step towards centralizing and sharing knowledge. Recommendations include ensuring that knowledge is easily accessible and consumable, aiming to catch the attention of practitioners, academics, the Scientific and Technical Advisory Panel, and other key organizations.

Awareness: In 2021, UNDP and MOEPP conducted an electronic survey to obtain the latest data on the perception and level of public awareness of climate change. The survey exposed that the biggest social problem placed lack of clean water first, followed by climate change. Around 11% of respondents believe that they are not sufficiently informed about the various impacts and consequences of climate change and 27% stated that they are not informed on how they can adapt to climate change. The results have been used to develop campaign activities and the Climate Change Communication Strategy.

1.9 Gender and climate change

Women are more vulnerable to climate change due to existing gender inequalities and disproportionate levels of poverty, which can become exacerbated from the impacts of climate change. The intersection of gender and climate change recognizes that women are more affected by climate change, but also that their contribution leads the charge on climate change adaptation and mitigation, and builds a more sustainable future for all. As part of this National Communication process, a series of reports and recommendations were developed for dealing with gender and climate change in a cross-cutting manner. Below are the key recommendations:

- Gathering gender-disaggregated data in the area of climate change and creating a register of persons working in the field of gender equality and climate change at the administrative level and ensuring efficient implementation, monitoring and evaluation through designed gender indicators;
- Strengthening the administrative capacities on intersecting gender and climate change
- Appropriate gender-mainstreamed budget reallocation for implementing the policies
- In a gender-mainstreamed manner, new technologies and knowledge, as well as increasing awareness among agricultural producers of adaptive measures to climate change, should be transferred with the active involvement of agricultural advisory services as part of their regular practices in providing advisory services for successful planning and implementation of agricultural production
- Safety nets, antifrost systems, fan installation, protective sheets - to be part of and increase support for Rural Development Financial Support Program – designed in a gender-positive manner;
- Develop a comprehensive policy and strategy for action against the adverse effects of climate change in line with the EU Framework 2030 – including gender mainstreaming into targets
- Take part in all missions, debates on UN action plans to prevent migrant and refugee fluctuations from climate change;
- Undertake more international obligations on human treatment and to provide more funding and action plans to protect more women and children from the adverse effects of climate change;
- Inclusion of gender topics in parliamentary committees holding public hearings on climate change.

2 National Circumstances

2.1 Country profile

2.1.1 Geography

The Republic of North Macedonia is a small, landlocked country that is located in the middle of the Balkan Peninsula in Southern Europe, with a total surface area of 25,713 $km^{2,}$ out of which hills and mountainous terrain cover 79%, plains 19.1%, and water surfaces approximately 1.9%. Macedonia's 246-km southern border is with Greece, a Member State of the European Union (EU), its 148-km eastern border is with Bulgaria (also an EU member state), its 221 km border to the north is with Serbia (Kosovo), and its 151 km border to the west is with Albania.

The Republic of North Macedonia has a diverse topography with high mountains and deep valleys surrounded by mountains, picturesque rivers, large and small natural lakes, and spas. The highest point is the peak of Mount Korab, with a height of 2,764 m. Macedonian cultural sites and resources occupy an important place in world cultural heritage. Land used for agriculture in the form of cropland and pastures is substantial in Macedonia and occupies almost 50% of the surface area of the country. Forested land covers approximately one third of the territory of Macedonia.

The territory of the Republic of North Macedonia is divided into four river basins: Vardar, Strumica, Crn Drim and Juzna Morava. The Vardar river basin is the largest (20,546 km2 or 79.9% of the country's land area) and drains to the Aegean Sea. The Strumica river basin in the South East part of the country (1,520 km2 or 5.9% of the country's land area) also drains to the Aegean Sea. The Crn Drim river basin is in the western part of the country (3.355 km2 or 13% of the country's land area) and gravitates towards Adriatic Sea. The smallest river basin, the Juzna (South) Morava river basin (44 km2 or 0.2% of the country's land area), is in the northern part of the country and drains to the Black Sea. This river basin has no significant impact on the availability of the water resources in the country. Water discharge in Macedonia is performed through the following rivers: Vardar at Gevgelija, Crn Drim at Debar and Strumica at Novo Selo. The largest river, the Vardar, divides the country roughly from north to south into two parts. Macedonia has three large natural lakes in the south of the country: Ohrid, Prespa and Dojran. Lake Ohrid is the deepest lake in the Balkans (286 m).

Several major transport routes connect Macedonia with Central and Eastern Europe, and with Southern and South East Europe and beyond. The basic infrastructure of the country is relatively well established and can be seen as a good foundation for further extension.

2.1.2 Biodiversity

The biodiversity of the Republic of North Macedonia has been relatively well studied and documented in both previous national communications. Macedonia is noted for its species richness and level of endemism, underlining the country's importance of a "hotspot" for biodiversity in Europe. This situation is a result of Macedonia's specific geographic position, climate, geology, geomorphology, hydrography, pedology and other characteristics, such as the changes that occurred during previous geologic periods (e.g., from the end of the Triassic period through the Ice Age, with its glacial and interglacial phases).

To date over 16,000 species have been recorded in Macedonia, including 854 endemics (Petkovski 2010). According to Petkovski (2010), there are more than 10,000 species of animals in Macedonia; Fauna Europaea - lists 10,586 species (although similar, these numbers are based on the elaboration of different groups). With a total of almost 700 endemic animal species, Macedonia represents one of the most important centres in Europe despite its small land area (MOEPP 2004; Petkovski 2010). The centres of endemism in Macedonia are the natural lakes (Ohrid and Prespa in particular) and high-mountain areas, and possibly the Macedonian caves. In terms of climate change analysis, special attention should be paid to high-mountain endemic species, because some of them are restricted only to the subalpine and alpine zones of the mountains. The European Red Data List includes 113 of the vertebrate species present within Macedonia (30 species of fish, 66 birds, 16 mammals and one reptile species). Seventeen of the 20 endemic fish species are globally threatened. The flora of higher plant groups is represented by 210 families (with 67 families of mosses), 920 genera and approximately 3700 species. The most numerous group is flowering (Angiosperm)
plants, with about 3200 species, followed by mosses (about 350) and ferns (42). According to the National Biodiversity Strategy (MOEPP 2004) there were about 1600 species of algae and 1250 species of fungi. Karadelev (2000) proposed a preliminary Red Data List of Fungi of the Republic of North Macedonia that includes 67 species.

Of the nine biomes in the Balkan Peninsula, eight can be found in the Republic of North Macedonia (Lopatin and Mavejev 1995; Filipovski et al. 1996). The diversity of ecosystems has been documented in the National Biodiversity Strategy (MoEPP 2018). Major ecosystems include forest ecosystems, dryland/grassland ecosystems, mountain ecosystems, and aquatic/wetland ecosystems. At present, anthropogenic impacts have affected a range of species and habitats; in particular, aquatic and wetland ecosystems are considered the most endangered, and surviving lowland marsh communities are now only found in fragments (including six sites that are at risk). Within grassland communities, wet meadow communities are considered threatened. Other specific threats affect certain halophytic (saline) communities, and specific forest types. The direct causes of biodiversity loss are many and varied, and they include loss or modification of habitats, fragmentation of habitats, pollution, and unsustainable exploitation.

Four national parks have been recognized in the Republic of North Macedonia: Mavrovo (731 km$^{2)}$, Galičica (227 km^2) and Pelister (125 km^2), as well as part of Shar Mountain (627 km^2), which was declared a National Park in 2021. All four national parks are heritage sites of nature and culture. They offer great possibilities for the development of tourism, the preservation of natural resources, and scientific research. Besides Shar Mountain, two other areas have been declared as protected areas since the last National Communication: Osogovo Mountains and Maleshevo, and the procedures for declaring other protected areas are under way.

2.1.3 Climate

In spite of the relatively small area of the Republic of North Macedonia, the climate is diverse. The climate is influenced by the Mediterranean Sea and by the European continent to a varying extent. The country can be divided into the following eight climatic regions: sub-Mediterranean climate region (50 - 500 m, only in the area of Gevgeija and Valandovo); moderate-continental-sub-Mediterranean climate region (to 600 m); warm continental climate region (600 - 900 m); cold continental climate region (900 – 1,100 m); sub-forest-continental-mountainous climate region (1,100 -1,300 m); forest-continental mountainous climate region (1,300 – 1,650 m); sub-alpine mountainous climate region (1,650 – 2,250 m); and alpine mountainous climate region (> 2,250 m). Figure 2-1 depicts mean annual air temperature in Macedonia.

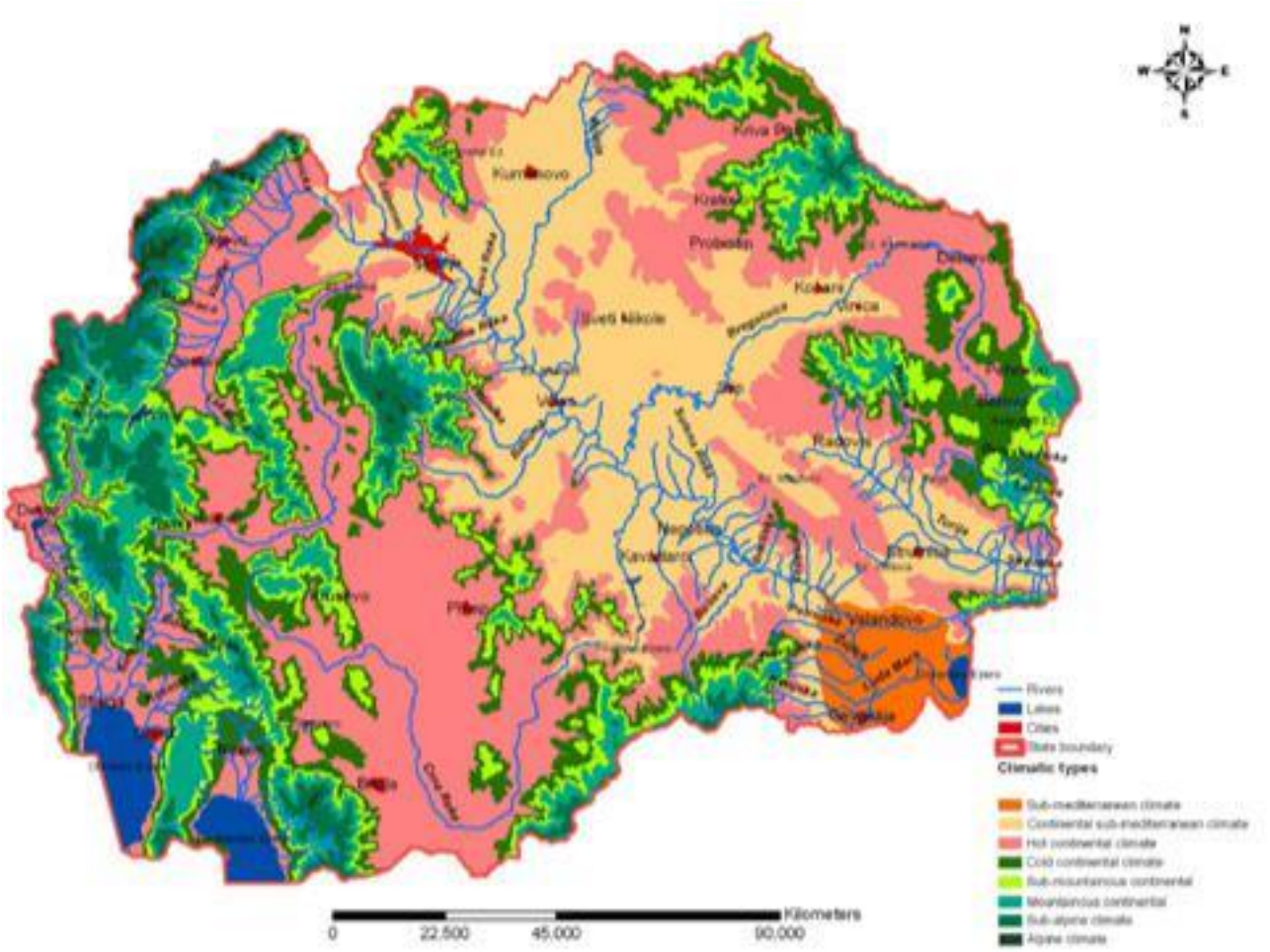


Figure 2-1: Climate Regions in the Republic of North Macedonia
Source: European Environment Agency 2015

The highest values of annual air temperatures in the Republic of North Macedonia are recorded in the Gevgelija and Valandovo Region, where the mean annual air temperature is higher than 14°C. The coldest month in Macedonia is January, and on average July is the hottest month. The highest temperature from 1951 through 2021 was recorded in 2012 at 41.0 °C. The frequency of heat waves[2] has also increased from 1987 onwards. And in contrast to the first half of the period, a heat wave has been recorded in almost every year since 1987. The air temperatures in 2020 in Republic of N. Macedonia continued to reflect trends of a warming planet, with positive anomaly from the normals. The mean air temperatures anomaly in 2020 was from 0.4° to 1.4°C above the reference period 1981-2010. The anomaly of the mean maximum air temperatures in 2020 was from 0.2° to 3.8°C above the reference period 1981-2010, while the mean minimum air temperatures anomaly was from -0.9°C to 1.9°C[3].

Precipitation in the Republic of North Macedonia is unequally distributed. Two basic pluviometric regimes are present in Macedonia: Mediterranean and continental. In the area with the Mediterranean precipitation regime, November, October and December are the months with highest level of precipitation; in the area with a continental climate, the highest amount of rainfall occurs in May and June. The areas with highest precipitation are the mountain ranges in Western Macedonia; the area around the Shar Planina, Bistra and Stogovo mountains; and the mountain ranges of Jakupica, with the summit of Solunska Glava, and Baba, with the summit of Pelister, where annual precipitation totals about 1000 mm. The driest areas of the country are Ovche Pole, Tikvesh and the surrounding of Gradsko, where annual precipitation totals about 400 mm.

2.1.4 Population

According to the most recent census in 2002[4], Macedonia has a population of 2,022,547, with an average density of 78.7 inhabitants per square kilometre, 58% of whom live in urban areas. The western part of the country is the most heavily populated. Most of the population is concentrated in the urban areas. The population estimate for 2020 from the State Statistical Office of North Macedonia is 2,068,808. The average household had 3.58 members in 2002, down from 4.68 members in 1971. The fertility rate has declined from 1.9 births per woman in 1990 to 1.31 in 2020 and is now lower than the EU average of 1.53 (European Commission 2019). The current trend is one of aging.

As in many other countries, people have migrated into the cities, looking for employment. Approximately 25% of the population lives in the capital city of Skopje, which is located in the northern part of the country. Other major cities are Bitola, Kumanovo, Prilep and Tetovo. The country is administratively divided into 84 municipalities and the City of Skopje is a separate entity made up of ten municipalities. Macedonia has also experienced sustained high rates of permanent and seasonal emigration.

Table 2-1: Enumerated and estimated population

Year	Population (thousands)	Year	Population (thousands)
1921	809	1994	1,946
1931	950	2003	2,027
1948	1,153	2005	2,037
1953	1,305	2007	2,044
1961	1,406	2009	2,051
1971	1,647	2012	2,062
1981	1,909	2014	2,069
1991	2,034	2020	2,069

Source: State Statistical Office

[2] In accordance with the recommendations of the World Meteorological Organization (WMO) Working Group for Climate Change Detection and Indices (CCI/CLIVAR), the Heat Wave Duration Index (HWDI) has been used for the analysis of heat waves. This index determines a heat wave as a period of at least 6 successive days with a maximum air temperature (Tx) of 5°C higher than the average maximum temperature (Txavg) for the period 1961–1990.

[3] Hydrometeorological Service of North Macedonia. 2021.

[4] A more recent census was taken near the end of 2021, and the results are still forthcoming.

2.1.5 Health

Life expectancy at birth was 76.7 years (78 for females and 74 for males) in 2018 in the Republic of North Macedonia. The 2020 birth rate was 9.2 per 1,000 population and the crude mortality rate was 12.4 per 1,000, resulting in a natural decrease of 3.2 per 1,000 population (State Statistical Office 2022). The distribution of deaths by age shows the highest proportion of total deaths for age 75 at 43.6 per cent.

Non-communicable diseases present the biggest burden to public health analysed by direct cost to society as well as to the Government based on the disability-adjusted life years (DALYs). Non-communicable diseases are the top 7 causes of death and disability, followed by neonatal disorders, which have fallen by nearly 25% from 2009-2019 (Vos et al. 2020). The most common diseases – cardiovascular diseases, cancer, respiratory diseases, injuries, and non-specific symptoms – have many causes which are often interconnected, including genetics, lifestyle (diet, exercise, etc.), and the environment.

Health care in Republic of North Macedonia is delivered through a system of health care institutions that cover the country's territory relatively evenly. This makes it possible for around 90% of the population to obtain health services in less than 30 minutes. Health care facilities range from primary care stations and centres and specialty-consultative and inpatient departments (including three secondary hospitals), to universities and tertiary-care institutes, whose functions also include research and teaching. The Ministry of Health and the Public Health Institute have introduced an early warning system for communicable diseases surveillance (Early Warning and Response Network – EWARN) based on clinical descriptions in order to detect epidemics. General practitioners from all health care institutions at the primary health care level take part in this system. While there is currently no integrated health information system, the main sources of health-related information include the State Bureau of Statistics (for mortality data); the Institute of Public Health (for morbidity data), the Health Insurance Fund, and regional public health centres and health care facilities.

High-priority environmental health issues in the Republic of North Macedonia include the following: access to safe drinking-water in rural areas, access to sanitation in almost the entire country; inadequate waste and waste water management at the state level; uncontrolled use of chemicals and pesticides; and inadequate air quality indoors and housing generally (in particular associated with poverty and children's exposure to environmental tobacco smoke).

2.1.6 Politics

The Republic of North Macedonia became an independent state on September 8, 1991, following the disintegration of the former Socialist Federal Republic of Yugoslavia. The country became a candidate for EU membership in December 2005.

The political system is a parliamentary democracy. Government is organized on the principle of distribution of powers among the legislative (Parliament), executive (the President of the Republic, the Government), and judicial branches of government. The Parliament consists of 120 members with a four-year mandate. Members are elected by popular vote from party lists, based on the percentage that parties gain of the overall vote in each of six election districts, each district having 20 seats. The Prime Minister is the head of Government and is selected by the party or coalition that gains a majority of seats in parliament. The Prime Minister and other ministers must not be members of parliament. The Government consists of 15 ministries. The General Secretariat of the Government provides logistic and expert support to the government, to the President of the Government, Vice-Presidents of the Government, ministers (members of the government).

The President is elected by general, direct ballot for a term of five years and can serve for a maximum of two terms. The President exercises his/her rights and duties on the basis and within the framework of the Constitution and laws.

The court system consists of a Supreme Court, Constitutional Court, Administrative court, and appeal courts. The Judicial Council of the Republic of North Macedonia governs the ethical conduct of judges and recommends the election of judges to parliament. The Supreme Court is the highest court in the country and is responsible for the equal administration of laws by all courts. Its judges are appointed by parliament without a time limit. The Constitutional Court is responsible for the protection of constitutional and legal rights and for resolving conflicts of power between the three branches of government. An independent public prosecutor with a six-year mandate is appointed by parliament.

2.1.7 Economy

As a small country, the Republic of North Macedonia has a relatively open economy where foreign trade accounts for more than 90% of GDP, making it vulnerable to external events, and since the independence of the country, it has repeatedly suffered the negative impacts of these events. Currently, the country is stabilized and has made good progress in its economic

reform agenda. However, more work needs to be done in building a favourable business climate in order to attract private investors and to create more jobs through private sector growth.

North Macedonia is economically considered as a transition economy. In terms of political proximity to the EU, it is classified as an EU candidate country from 2005 onward. With its Gross Domestic Product (GDP) per capita (Purchasing Power Parity, PPP) of 11,600 Euro in 2018, North Macedonia stood at 37.8 percent of the corresponding EU28 average and ranked third among WB6 countries.

North Macedonia is committed to promoting inclusive economic growth and productive employment for all citizens. Despite the prolonged effects of the global economic slowdown and domestic political crisis in 2016, which further stagnated the economy, the country has successfully kickstarted economic growth — as of the first half of 2019, the economy was growing at a rate of 3.6 percent. Additionally, between 2010 and 2019, GDP per capita grew from 3,459 to 5,460. Growth acceleration is attributed to stable consumption and low inflation, as well as growth in both domestic and foreign investment following the political crisis.

Following the implementation of various strategic and legislative measures, including the National Employment Strategy 2016-2020 and Employment and Social Reform Programme (ESRP), North Macedonia has successfully reduced the unemployment Source: NA Annual Figure 22: GDP per capita in Euros (at current exchange rate) 54 rate (for individuals aged 15-64) from 36 percent in 2005 to 16.6 percent in the last quarter of 2019—a historically low rate. The net nominal salary increased by 7 percent in 2018. As of the first half of 2019, the average monthly salary is approximately 25,200 denars (about 408 Euro). North Macedonia has ratified all key conventions of the International Labour Organization (ILO), including three new conventions ratified last year.

Despite the success in improving wage levels, there is still a significant gender wage gap. Female wage workers receive approximately 18-19 percent less than male wage workers. Further, temporary employment among youth (aged 15-29) is twice as high as among adults because they cannot find permanent employment. The majority of temporary workers are male.

Unemployment and inactivity among youth and women remain high despite success in reducing the overall unemployment rate. The youth unemployment rate was estimated at 35 percent as of the first half of 2019, while young people (aged 15-29) not in employment, education or training (NEET was estimated at 31 percent in 2016. Similarly, as of the first half of 2019, more than 50 percent of women aged 15 and over were not participating in the labor market. North Macedonia recognizes this issue as a long-term structural challenge, and a number of measures are underway to address this, such as the Youth Guarantee Scheme.

Table 2-2: Selected macroeconomic indicators, 2003-2012

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
GDP (million MKD)	258,369	272,462	295,052	320,059	364,989	411,728	410,734	434,730	461,730	462,783
Real GDP growth rate (%)	2.8	4.6	4.4	5	6.1	5	-0.9	2.9	2.8	-0.3
GDP per capita (MKD)	127,478	134,050	144,857	156,874	178,605	201,147	200,292	211,246	224,300	224,439
GDP per capita (EUR)	2,081	2,185	2,363	2,564	2,919	3,283	3,269	3,434	3,645	3,648
Inflation (CPI, average) (%)	1.2	-0.4	0.5	3.2	2.3	8.3	-0.8	1.6	3.9	3.3
Exports f.o.b (million EUR)	1,203	1,345	1,643	1,914	2,472	2,693	1,933	2,530	3,179	3,093
Imports f.o.b (million EUR)	1,956	2,259	2,501	2,915	3,653	4,455	3,492	3,978	4,861	4,877
Current account deficit (% of GDP)	-4	-8.1	-2.5	-0.4	-7.1	-12.8	-6.8	-2	-3	-3.9
Unemployment rate (ILO)	36.7	37.2	37.3	36	34.9	33.8	32.2	32	31.4	31
Employment growth	-2.9	-4.1	4.3	4.6	3.5	3.2	3.4	1.3	1.1	0.8

Source: Ministry of Finance of the Republic of North Macedonia, National Bank of the Republic of North Macedonia

2.1.8 Energy

North Macedonia's power generation mainly relies on lignite and hydropower and is dependent on electricity imports. The gas volumes consumed are modest and imported from Russia through an interconnector with Bulgaria. A second interconnector towards Greece is currently in an advanced stage of planning. North Macedonia was the first country in the Western Balkans to build a sizeable wind facility in 2014. However, no new wind capacities have been built since then. The country is currently tendering for a new pumped storage facility at Cebren as well as additional solar PV capacities (Energy Community Secretariat 2021).

The energy sector in the Republic of North Macedonia has the following main characteristics (International Energy Agency 2020):

- The total annual production of electricity in 2020 was 5,347 GWh, and another 2,326 GWh was imported to satisfy the total domestic electricity demand.
- The production of electricity in 2020 was mainly from coal-fired power plants (49%), hydropower (24%), and natural gas (21%)
- The share of Total Final Consumption (TFC) of energy in 2019 was 38% for transport, 24% for residential, 23% for industry, and 11% for commercial, 3% for non-energy use, and 1% for agriculture and forestry (see Table 23)
- The sources of the Total Final Consumption (TFC) in 2019 came from oil (52%), electricity (27%), biofuels and waste (9%), coal (6%), natural gas (2%), and heat (2%) (see Table 23)
- The sources of the Total Energy Supply (TES) in 2019 came from oil (40%), coal (39%), natural gas (9%), biofuels and waste (8%), hydro (4%), and wind, solar, etc. (1%).

The breakdown of the sectors for final consumption of energy (in TJ) is provided below.

Table 2-3: Energy consumption in the Republic of North Macedonia for 2019 (TJ)

	peat	Crude oil	products	gas	Nuclear	Hydro	solar, etc.	and waste	Electricity	Heat	Total
Total	**5334**	**0**	**43391**	**1807**	**0**	**0**	**184**	**7776**	**22466**	**1800**	**82759**
Industry	5262	0	5894	1483	0	0	0	315	5832	17	18803
Transport	0	0	31649	74	0	0	0	4	51	0	31777
Residential	26	0	435	8	0	0	0	7220	10943	1319	19951
Commercial and public services	22	0	2433	242	0	0	42	180	5497	464	8880
Agriculture/ forestry	23	0	528	0	0	0	143	58	143	0	895
Non-energy use	0	0	2453	0	0	0	0	0	0	0	2453

Source: International Energy Agency (2022)

2.1.9 Transport

Within the transport sector, the road transport has the highest share in the energy consumption (98%) and is dominant in the transport sector in general. The Republic of North Macedonia has relatively well-developed road transport infrastructure though the energy consumption in the sector is small comparing to the EU on a per-capita basis: 650 toe per 1000 inhabitants in the EU-27 compared to 200 toe per 1000 inhabitants in the Republic of North Macedonia. In the last five years there has been a slight increase, but still national figures considerably lag behind European ones.

As to the energy mix, gasoline and diesel have a dominant role in the road transport sector. Since 2000, there has been a significant drop in gasoline consumption and a significant increase in diesel consumption, since diesel vehicles have become more attractive. LPG was introduced after 2000. The total number of the vehicles in the country according to fuel type for the period 2002-2010 is shown in Figure 2-2.

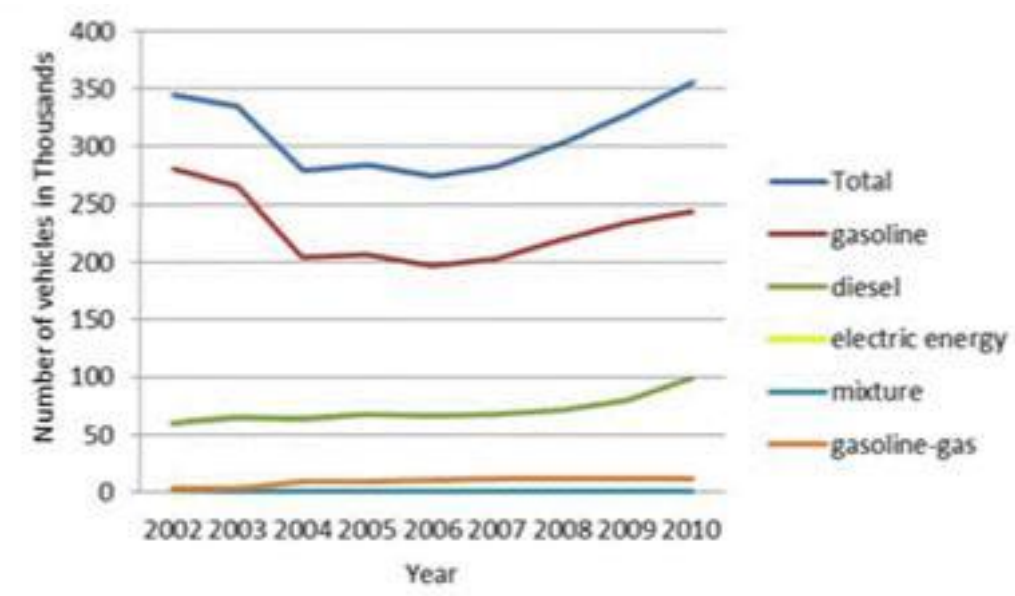


Figure 22: Total number of vehicles in the road transport

In 2019 there were 205 passenger cars per 1000 inhabitants[5] travelling 9.26 billion passenger-km. The vehicle fleet is generally very old with the average age of 19.4 years for passenger cars, 18.2 years for buses, and 16.6 years for goods vehicles in 2020 (State Statistical Office 2021). Transport made up 6.0% of the expenditure of an average household in 2019 (State Statistical Office 2020). Transport infrastructure is the largest contributor to the total value of completed construction works on structures in the public sector, built by business entities (48.8% in 2009, 26.3% in 2014 and 35.9% in 2019).

Participating with 27.7% in 2019, the transport category is the second biggest contributor in the overall energy sector emissions (National Inventory Report 2021). Regarding the fuels, gas/diesel oil (road diesel), motor gasoline, liquefied petroleum gases (LPG), aviation gasoline and natural gas are used. Three subcategories actively contributing to the emissions: Road Transportation, Railways and Domestic Aviation. Road Transportation releases almost all of the emissions (99.6% in 2019), while emissions from Railways are nearly 0.4% and from the Domestic Aviation are close to zero. Unlike the other categories and Energy sector as a whole, the emissions from Transport show an increasing trend, or 26.5% more emissions in 2019 compared to 2014, and 12.4% more in 2019 compared to 2016. Over the period 1990 - 2016 the emission increased by almost 200%.

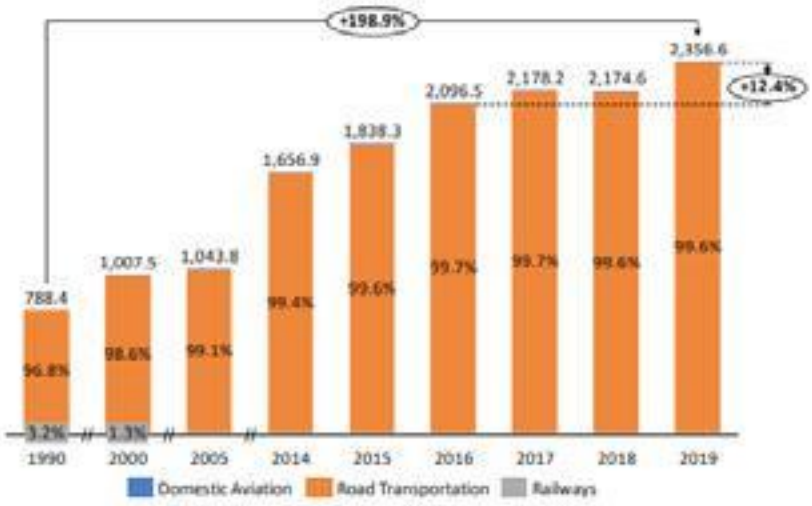


Figure 2-3: GHG Emissions in Transport (in Gg CO_2-eq)

Source: National Inventory Report 2021

[5] United Nations Economic Commission for Europe (2022). Transport Statistics Database.

2.1.10 Industry

Industry is important in the development of the Macedonian economy. Industrial activities comprise 18% of (GDP). According to the value added data for 2010, industrial production was dominated by the following divisions (State Statistical office of the Republic of North Macedonia 2013):

- Manufacture of food products (11.7%);
- Electricity, gas, steam and air conditioning supply (14.6%);
- Manufacture of basic metals - steel, lead, zinc, ferro-alloys (9.34%);
- Manufacture of wearing apparel (textiles) (10.2%);
- Manufacture of other non-metallic products (5.9%);
- Manufacture of tobacco products (4.5%); and
- Manufacture of beverages (6.2%).

2.1.11 Agriculture

Agriculture is one of the key economy sectors and plays a critical role in the social and economic stability of North Macedonia. Agriculture's contribution to the nation's GDP has slightly declined in the past decade due to a shift of economic structure. At present agriculture contributes 10 percent to GDP (2017) and accounts for 18 percent of total employment (State Statistical Office, 2019). About 42% of country's population live in rural areas where off-farm employment opportunities are limited. Therefore, official figures are considered to underestimate the importance of the agriculture sector, because they include only a fraction of the value of smallholders' outputs and do not measure all family labour inputs (which are the dominant type of informal employment arrangements on family farms).

Agriculture suffers from low productivity and does not reach to its potential due to several structural constraints. The average farm size is less than two hectares, more than 60% (106,875 farmers) of all farmers use up to 1 ha of agricultural area (State Statistical Office, 2017). Half of the agricultural producers are semi-subsistent with limited opportunities to produce at scale and higher quality and introduce innovation. In addition, smaller agricultural producers and agri-businesses lack access to new technologies and market opportunities, as well as agricultural knowledge and skills in climate resilient technologies. In addition, farmers also have limited capacities in business management, logistics, financial literacy, and domestic and international marketing.

Agricultural land is fragmented and unproductive. More than 40% of the total area of arable land (approximately 240,000 hectares) and 80% of the pastureland (approximately 570,000 hectares) in North Macedonia is owned by the State. Nearly one third of the total arable land is either abandoned or not utilized for agricultural production. Out of the total territory of the country, 50.1% (1,261,000 ha) is agricultural land (cultivated land, permanent pasture and meadow, land used for permanent crops and kitchen gardens), 44.3% are under forests and the rest are water and other land use. The cultivated land covers about 40% (509,000 ha) of total agricultural land (State Statistical Office, 2017). From the total cultivated land 81% are under arable land and gardens, 3% are under orchards, 4% under vineyards, while the meadows represent 11 % from total cultivated land (State Statistical Office, 2017). Pastures are represented on 751 187 ha or 60% of total agricultural land.

In North Macedonia, irrigation is a significant factor for stable and competitive agricultural production. Some crops cannot be commercially grown without irrigation. Water demand for irrigation is estimated to 62.6% of the total water demand in the country. The existing irrigation systems (area equipped for irrigation) cover about 120,000 ha of arable land. However, in reality, irrigated area is about 30,000 ha or only 10% of the arable land (Government of North Macedonia, 2014). With the exception of the western parts of the country, water deficiencies occur in summer, resulting in significant moisture stress for summer and annual crops.

Cereals are the major crops in the country, usually not irrigated because their growing period is during the humid season. However, their yield is only about 3 t/ha. Cereal crops were sown on about 41% of the arable land area or in total 166,664 ha for 2018. Fodder crops covered about 40,749 ha in year 2018. The most important fodder crop is alfalfa planted on more than a half of fodder crops area. Industrial crops in 2018 were planted on about 19,878 ha. Tobacco is the major industrial crop produced exclusively by small farmers and planted on about 80% of industrial crops area. In 2018 vegetables were

produced on a total area of 51,617 ha. The most important vegetable crops are: potato (which is grown on 12,000 ha), pepper (9,200 ha), tomatoes (5,600 ha), and cabbage (4,500 ha). The total area for fruit production is about 17,000 ha (apples, plums, sour cherries, pears, and peaches). The most important fruit is apple – 4.8 million fruit trees in 2018. Furthermore, melon and watermelon were grown on 5,300 ha.

Grapes and viticulture are one of the most important sectors with wine being a significant export commodity, grown on approximately 24,000 ha with more than 2/3 being for wine production. Viticulture and wine production comprise 17-20% of agricultural GDP. Wine (after tobacco) is the second most important product related to the export value of agricultural commodities in the country. Most vineyards are situated in Povardarski and South East region. The cultivated varieties and the overall wine style that a region produces is a direct result of the average climatic conditions, while climate variability determines vintage quality differences.

The livestock sector is characterized by a large number of small, subsistence-oriented farms, and commercially oriented family farms. However, intensive production systems are major market suppliers in cow milk, pork and egg production. In last decade, there has been rapid development in pig and poultry farms, which have adopted the latest technologies, resulting in high productivity. Pastureland, is the dominant category of agricultural land use, covering and area of more than 748,413,00 ha under pastures in 2017, more than 77.69% are managed by agricultural enterprises and cooperatives, while only 22.31% are managed by farm holdings. The total production of hay is 512,518 tons/year with average production of 685 kg/ha. Although a very modest yield, this production of fresh forage is still used as a solid base for grazing animals during summer months. There is no organized management of pastureland in terms of clearance of bushes and tree species and increase of passive area, improvement of degraded natural grasslands. This leads to a gradual decrease in their productivity.

Measures to improve resilience against climate impacts are imperative to protect the agricultural sector in the country and ensure a climate resilient and low-carbon economic development and accession to the European Union. North Macedonia's climate is highly influenced by the great variance in elevation across the country. It is already experiencing changes in mean temperature and precipitation and increase in the frequency and the intensity of climate extremes such as floods and droughts in the past decade. With respect to crop production, the seasonal distribution of temperature and precipitation is more important than the annual average. The following table shows the projected climate impacts on crop yields by 2050.

Crops	Projected Climate Impacts
Wheat	Rainfed yield will increase by up to 15% especially in the Continental area but will decrease by up to -33% in the Mediterranean area by 2040. The yield will then decrease with up to 26% per 25% 2040 and 2050.
Maize	Irrigated maize may increase yield by 23% in the Continental area but reduce yield by 11% in the Mediterranean area. Rainfed maize is likely to decrease yield in both areas by up to 77%. For the South-East region, maize yield is expected to be reduced by 54% in 2025 and even 84% in 2050.
Grapes	Reduction in yield of irrigated grapes will be between 3% - 39%, while the reduction of rainfed grapes may reach up to 53%.
Apples	Irrigated apples will increase yield by 15% especially in the Continental area, while the rainfed apples will likely decrease yield by up to 63%.
Vegetables	Irrigated vegetables may likely increase yield by 18%, while rainfed vegetables will decrease yield by up to 21%.

2.1.12 Forestry

The Republic of North Macedonia's forests are growing in size. From 2010 to 2018, forest area increased by 46,664 ha to a total of 1,007,095 ha (State Statistical Office 2022). The total wood stock is estimated at around 75,000,000 m^3, and the annual in-crement is around 1,830,000 m3. The most dominant species are beech (Fagus moesiaca), and several oak species (Quercus spp.), which make up to 90% of all native forest types. Forests are mostly covered with deciduous tree species, and conifers comprise around 11% of all forests. Around 550,000 ha are categorized as low-quality coppice forests, and around 390,000 ha are categorized as high forests, out of which around 140,000 ha are plantations (artificially planted), mostly with coniferous tree species (Pinus nigra, Cupressus arizonica, and others).

Regionally, the richest forest region is Southwest Macedonia, with around 180,000 ha, and the poorest is the Skopje region, with around 125,000 ha. Distribution of forest cover throughout the country is uneven in terms of quantity and quality. High forests with good quality are located along state borders, far from the industrial and inhabited places and human influence. Low-quality coppice forests are located in the central parts of the country, and their condition has resulted partly from climate conditions and partly from human activities.

Around 90% of the forests are in state ownership, and state-owned forests with commercial value are managed by the special public enterprise "Makedonski sumi." State-owned protected forests are managed by the national parks (public enterprise) or

by local government offices. The remaining 10% of forests are in private or other forms of ownership (e.g. church lands). There are more than 200,000 parcels of forests owned by around 65,000 households, averaging 0.6 ha.

In the terms of assignation, around 92% of total forest area has an economical character, and around 8% are protective and protected forests. Annual allowed logging volume, according to approved management plans, is set at around 1,200,000 m3, and is around 2/3 of the annual increment that is totally acceptable in terms of its sustainability. Most of this cut comes from the state-owned economic forests, and a very small part comes from protective and protected areas. Annual actual logging volume is between 550,000 m3 and 750,000 m3, and is mostly firewood (80- 85%), which is used by households. Logs are used mostly by domestic industry, and only a small part is exported.

The health condition of the forests of North Macedonia in the period between last National Communication on climate change and this one (2014-2021 year) is in a declining trend. Generally, there are no significant changes in terms of the percentage of the crown transparency but there has been a small transition from lower to higher categories. More precisely, 50% of assessed trees in 2011 didn't have signs of crown transparency, and this proportion fell in 2018 and 2019 to around 45%. Also, there was an increase in the proportion of the second class of trees from around 27 % in 2011 to around 33.5% in 2018 and 2019. It is sign that the health condition of these trees shows negative trend. Finally, the tree mortality is higher, too. In 2011 the percent of dead trees had been 0.7 % and in 2019 it more than doubled to 1.6% of the estimated trees. The other parameter of concern is the water availability for the trees as measured by soil moisture. In the year 2019 around 75% of the assessed trees were almost in drought conditions.

Using these observations along with future climate models of North Macedonia, it is apparent that the health condition of the forests are predicted worsen, with more significant dieback processes and a higher percentage of tree mortality. Because of the weak health condition of the trees, this process will be followed and accelerated by insect and fungi infestations.

2.1.13 Tourism

North Macedonia has an interesting mix of tourism products ranging from history and culture to modern winter adventure sports and skiing. Tourism has not traditionally played a significant part in Macedonia's economy and as such was somewhat neglected. However, recent government actions (starting with a revision to the 2009-2011 tourism strategy and subsequent attention to rural tourism) have given the sector a higher priority. However, Macedonia's tourism is not seen as particularly competitive by global standards and underperforms in comparison to its regional competitors.

Tourism in the 2009-2013 Strategy was identified as comprising the following sub-sectors:

i. **Wine tourism** taking advantage of high quality viticulture in the Tikveš region of central Macedonia.

ii. **Nature based tourism (summer)** primarily hiking found mainly in Branjo with emerging developments in Zrnovci, Pehcevo, Berovo, Kolesino, Bansko, Mokrino, Smolare, Vevcani and Galichnik

iii. **Nature based tourism (winter)** primarily skiing with a nascent snowboarding sector. The largest is Popova Sapka and is also present in Krusevo, Mavrovo/ Zare Lazarevski, Mount Kozuf, Oteshevo, Pelister, and Ponikve

iv. **Cultural tourism (tangible)** comprising handicrafts, the built heritage (especially Skopje) archaeological, monasteries, churches and religious monuments found throughout the country

v. **Cultural tourism (intangible)** comprising museums, arts, drama, cultural heritage, and festivals

The total number of tourists in 2019 was 1,184,963, of which 36.1% were domestic tourists and the other 63.9% were foreign tourists (State Statistical Office 2020). Compared to the previous year, the number of foreign tourists increased by 7.1%. The number of nights spent in 2019 was 3,262,398, of which about 51.6% by domestic and the other 48.4% by foreign tourists. Compared to the previous year, the number of nights spent by foreign tourists increased by 5.8% (State Statistical Office 2020). Most foreign tourists to the Republic of North Macedonia come from Turkey, followed by Serbia, Greece, Bulgaria, Poland, and Germany.

2.2 Climate change-related institutional and policy framework

The Republic of North Macedonia is a party to the United Nations Framework Convention on Climate Change (UNFCCC) as a non-Annex I country and party to the Kyoto Protocol without a quantified emissions limits and reduction commitment (QELRC). However, the country has acceded to the Copenhagen Accord, and it submitted a list of mitigation actions (without quantifying the associated emission reductions) based on these actions.

The **Ministry of Environment and Physical Planning (MOEPP)** is the key governmental body responsible for development of climate change policies. MOEPP has been designated as the National Focal Point to the UNFCCC and as Designated National Authority (DNA) for Kyoto Protocol implementation and is therefore the key governmental body responsible for coordinating implementation of the provisions of the Convention and the Protocol. The UNFCCC Gender and Climate Change Focal point has been nominated from the **Ministry of Labour and Social Policy**. Other ministries that have responsibilities related to climate change are: Ministry of Agriculture, Forestry and Water Management, Ministry of Economy, Ministry of Transport and Communication, and Ministry of Finance. Most of these ministries have appointed Climate Change Focal Points, who are responsible for mainstreaming climate change into respective policies, strategies and programmes. In addition, the Ministry of Health established a National Committee for Climate Change and Health in 2009 to serve as the responsible body for surveillance activities and decision-making in that area.

In January 2000, the **Climate Change Project Office** was set up within MOEPP. In addition, a **National Climate Change Committee (NCCC)** was established by the Government consisting of representatives of all relevant stakeholders: government bodies, academia, private sector and civil society. The NCCC is a participatory platform aimed at providing high-level support and guidance for overall climate change policies in the country. Moreover, a **National Council for Sustainable Development** has also been established under the auspices of the Deputy Prime Minister in charge of economic affairs.

At the legislative level, climate change issues are incorporated into the Law on Environment, including details on the preparation of GHG emissions inventories as well as an action plan on measures and activities to abate the increase of GHG emissions and to mitigate the adverse impacts of climate change. The **Law on Environment** stipulates that a National Communication for climate change is to be adopted for the purpose of stabilizing GHG concentrations at a level that would prevent any dangerous anthropogenic impact on the climate system within a timeframe sufficient to allow ecosystems to naturally adapt to climate change, in accordance with the principle of international cooperation and the goals of the national social and economic development. In July 2013, changes in the Law on Environment were adopted, and a new article (188) was added regarding the national system of GHG emissions inventories. This article called for a national system of inventories of GHG emissions to be established to provide a database of relevant information for the preparation of GHG inventories as well as to monitor the implementation of agreements regarding climate change. This system incorporates collection, processing, assessment, verification and quality assurance and management of uncertainty, as well as storage, use, distribution and presentation of data and information derived from entities holding data for anthropogenic emissions by sources and sinks of greenhouse gases in the atmosphere.

Recognizing the important steps forward in the institutionalization of climate change issues and the mainstreaming of climate change in the national and sectorial development policies, the development of three National Communications to the UNFCCC has contributed to strengthening these integration processes as well as to informing the international community on the actions taken by the country to address climate change issues. The First, Second, and Third National Communication on Climate Change were adopted by the Government of North Macedonia and submitted to the UNFCCC Secretariat in 2003, 2008, and 2014 respectively. This Fourth National Communication (NC4) represents a further step forward in the process.

In addition, three Biennial Update Reports (BURs) have been carried out (BUR 3 was submitted in June 2021) to build on the findings and recommendations of the National Communications, as well as the outcomes of the ongoing complementary projects in the country. In order to fulfil the obligations arising from Cancun and Durban Conference of Parties (COP) decisions related to the submission of national communications and biennial update reports, further support is needed to continue to develop and consolidate the existing technical and institutional capacity and to continue the efforts of integrating climate change into national policies, plans and programs.

It should also be noted that in the context of the EU accession process, the Republic of North Macedonia has already initiated the process of harmonising of its approach towards EU commitments to the UNFCCC and sections of the EU *acquis communautaire* related to climate change. While the Republic of North Macedonia is not currently under any obligation to enter the EU emission trading system (ETS) or have a national ETS, the Enhanced Nationally Determined Contribution includes a goal to align with the EU Emissions Trading System (ETS) carbon price by 2027. Additional details related to the EU accession process are included below.

2.3 National and regional development priorities and objectives

The driving forces for creation and implementation of environmental policy in the Republic of North Macedonia can be grouped into two major categories: national and international, which includes regional cooperation, bilateral activities, and multilateral activities.

2.3.1 National context of climate change policy

At the national level, the Republic of North Macedonia focuses on several types of objectives in the areas of environment and climate: strategic, legislative, and institutional/organizational. A cross-cutting priority is accession to the EU, which is at the core of the development goals of Macedonia and a main driving force behind its objectives. The EU integration agenda has generated momentum for political, economic and social reforms and contributed to building consensus on important policy issues across sectors. While EU accession poses great challenges in terms of human capacity at the national and local level and identifying financial means for investments in key sectors, it also provides opportunities for the creation of more integrated, cross-cutting policies and better utilization of available resources.

At the strategic level, environmental policy (as a component of sustainable development policy and in and of itself) is covered by the National Strategy for Sustainable Development (in which the energy sector and climate change are identified as the main contributors towards national sustainable development, adopted in 2010) and the Second National Environmental Action Plan (2006). A number of relevant laws, regulations and strategies that incorporate climate change considerations have been adopted, such as the Strategy for Energy Development in the Republic of North Macedonia Until 2040 (2020); National Environmental Investments Strategy (2009); National Environmental Approximation Strategy (2008); National Strategy for Nature Protection 2017-2027 (2017); National Health Strategy for Adaptation in Health Sector (2010); a National CDM Strategy, 2008-2012 (2007); the National Agriculture and Rural Development Strategy 2007-2013; and the National Strategy for Climate Change Adaptation in Agriculture (under development).

The Strategy for Energy Development (2020) offers a set of ambitious and specific numerical targets for 2040 following the EU climate change policy track, i.e. aligning with EU's 2030 climate and energy framework and its 2050 Energy Roadmap. The Strategy for Energy Development of the Republic of North Macedonia until 2040 has the following vision: Secure, efficient, environmentally friendly and competitive energy system that is capable to support the sustainable economic growth of the country. The Strategy defines six strategic goals for North Macedonia, mapped along five energy pillars:

1. **Energy efficiency:**the Strategy maximizes energy savings up to 51.8% of primary and 27.5% of final energy.
2. **Integration and security of energy markets:** the Strategy is aiming to ensure that North Macedonia is even stronger integrated into European markets, protect today's levels of energy dependence and provide necessary flexibility for higher RES integration
3. **Decarbonisation:** In the Green scenario in 2040 the Strategy decreases GHG emissions up to 61.5% vs. 2005 or 72.8% vs. BAU, while strongly increasing the usage of RES in a sustainable manner up to 45% in gross final energy consumption
4. **R&I and competitiveness:** the Strategy minimizes total system costs based on least cost optimization taking into consideration country specific situation
5. **Legal and regulatory aspects:** the Strategy emphasizes full compliance with EnC acquis

The strategy outlines three different scenarios – reference, moderate transition, and green. The Government has confirmed that it plans to implement the most ambitious, green scenario, which involves phasing out coal completely by 2040. Additionally, 45% of total energy production would come from renewable sources. The strategy predicts phasing out coal by 2025, which would make North Macedonia the first country in the Western Balkans to set a concrete goal to eliminate coal power before 2030. The strategy also predicts solar and wind power plants to be the fastest-growing technologies for electricity production.

The Government has adopted 5 Laws on Ratification of 5 Protocols under the United Nations Economic Commission for Europe (UNECE) Convention for Trans-boundary Effects of Air Pollution and they are in parliamentary procedure at the moment (National Programme for Adoption of the *Acquis Communautaire 2012). In previous years, work was aimed at increasing the reliability of data in order to enable a gradual transition to a more sophisticated inventory with a higher tier of analysis. The differences in terms of data collection have been analysed, and a proposal for a legal solution has been submitted.*

2.3.2 International context of climate change policy

As previously stated, accession to the European Union is a priority for the Republic of North Macedonia. It was the first country in the region to sign a Stabilization and Association Agreement (SAA) with the EU in April 2001, and in December 2005 the Presidency of the European Council granted North Macedonia candidate status for the EU. Legislative and regulatory activities related to the accession process include the Ohrid Framework Agreement, the Law on Local Self-Government, the Action Plan on Accession Partnership, and the National Programme for Adoption of the *acquis communautaire in the environment sector.*

In the process of harmonisation of the country's environmental legislation with the *Acquis Communautaire,* new laws on Environment, Nature, Water, Air Quality and Waste Management have been adopted and regularly updated. In the field of Climate change the process of harmonisation with the EU Acquis is at an early stage. Currently, only few provisions from the EU Climate Acquis are transposed in to the Law on environment (LE). These provisions from the Law on environment are related to planning documents on climate change, the GHG inventory preparation system and the assessment, approval of the projects for funding through the Clean Development Mechanism (CDM) and ozone deplete substances. As such, the legal framework is not sufficient to regulate the topic Climate change in the country. This situation has been noted by different assessments and studies. Moreover, the lack of legal framework has been reported as well by the European Union in the yearly Progress Reports for the country.

Oriented to step forward the process of alignment with the EU Acquis, the national institutions are making efforts to improve the situation in the climate action sector. As part of mutual efforts together with EU institutions, is the project "Preparation of Long-term Strategy and Law on Climate Action". The project represents an important intervention to support the processes in the country establishing a comprehensive legal and long-term strategic framework.

As a member of the EU, North Macedonia would be obligated to participate in the EU Emissions Trading System (EU ETS). In 2012, there were a series of coordinated activities with stakeholders to develop a roadmap for implementation of the Directive on Emissions Trading and EU decision for monitoring, reporting and verification, using the experience of the Republic of Bulgaria for monitoring, reporting and verification of greenhouse gases required for participation in European scheme for emissions trading. The Enhanced Nationally Determined Contribution of the Republic of North Macedonia (2021) now has a goal to align with the EU Emissions Trading System (ETS) carbon price by 2027.

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3 National Greenhouse Gas Inventory

This chapter is a summary of a report developed for the TNC. The full report is available at: http://www.unfccc.org.mk/Default.aspx?LCID=246

The Republic of Macedonia ratified the UN Framework Convention on Climate Change (UNFCCC) in December 1997 and the Kyoto Protocol in 2004. Responding to the obligations incurred by signing the Framework Convention as a non-Annex I Party, the country prepared and submitted the First National Communication (NC) on Climate Change in 2003, the Second NC in 2008, and the Third NC in 2014. So far, the country has submitted to the UNFCCC three National Communications and three Biennial Update Reports.

The aggregate GHG emissions and removals (net emissions) in 2019 are estimated to be 12,902 Gg CO_2-eq (including the FOLU sector). The net GHG emissions in 2019 increased by 18.7% compared to 1990, or 48.2% compared to 2016, mainly because instead of sinks, emissions occur from the forestry sector.

This chapter provides information on the sources of data used for calculating emissions, the methods applied, emission factors, GHG emission trends, and the quality control and assurance procedures.

3.1 Methodological approach

Within the three previous National Communications, GHG inventories were developed for the period 1990–2009, estimated following the 1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories and the 2000 IPCC Good Practice Guidance. In the First Biennial Update Report (BUR1), the inventory was produced using the IPCC Inventory Software, in compliance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Due to the improvement of the method used for emissions estimation (from 1996 to 2006 IPCC Guidelines), the time series reported in the previous inventories (for period 1990 - 2009) were recalculated and extended to consider the period 2010 – 2012. The same approach was used in the subsequent Biennial Update Reports (BURs), expanding the GHG inventory to include the years 2013 and 2014 under the Second BUR (BUR2) and the years 2015 and 2016 under the Third BUR (BUR3). In BUR2, the emissions for 2012 were recalculated using the most recent available data. In BUR3, the data sources were revised due to some gaps identified in the previous BUR, and the whole time series were recalculated to maintain consistency.

The inventory activities under the Fourth National Communication (NC4) continue the work done in the previous BURs and include developing the GHG inventory for 2017, 2018, and 2019. The inventory was prepared following the 2006 IPCC Guidelines and using the IPCC Inventory Software (version 2.691 – from January 23, 2020).

In the IPCC Guidelines, the GHG estimation methods are divided into three tiers: Tier 1 is for the “default method”, which is the simplest and is usually applied when no country-specific emission factors are available; Tier 2 method uses the same procedure as Tier 1 methods, but incorporate emission factors and/or parametric activity data that are specific to the country or at least one of its regions and Tier 3 is reserved for country-specific methods (models, censuses, and others). In the preparation of Macedonia’s National Inventory, the Tier 2 method was applied for CO_2 emission factors for lignite, residual fuel oil and natural gas for Fuel combustion activities in Energy sector. Tier 2 was also used in IPPU sector for emission factors in Mineral industry, for cement production and in Metal industry, for Iron and steel production and Ferroalloys production. The Waste sector is another sector with Tier 2 application, through IPCC FOD method and considering the country-specific activity data on waste disposal at solid waste disposal sites (SWDS) and the historical data on GDP and population. For the other sectors the default method, Tier 1, was used.

The inventory covers sources of greenhouse gas emissions and removals by sinks grouped under four main sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste, disaggregated by categories and subcategories. It includes a database for the major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs). The inventory also covers the indirect greenhouse gases: carbon monoxide (CO), oxides of nitrogen (NOX), and non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO_2), and ammonia (NH_3). The emissions of sulphur hexafluoride (SF6) are not estimated for Macedonia due to the lack of activity data.

The data used for the preparation of national inventory are primarily taken from official national documents such as statistical yearbooks, energy balances, sectoral reports and MAKSTAT database from the State Statistical Office (SSO), various strategies and annual reports from relevant institutions, like the Ministry of Environment and Physical Planning (MOEPP), Ministry of Agriculture, Forestry and Water Economy (MAFWE), etc., and various international databases such as UN projections for population and FAOStat.

The national inventory process (see the figure below) includes the following key players:

1. **Ministry of Environment and Physical Planning**, responsible for supervising the national inventory process and reporting the emissions to UNFCCC and for other international reporting.

2. **GHG Inventory Development Team**, composed of the team from the Macedonian Academy of Sciences and Arts (MANU) and AFOLU team from the University of Ss. Cyril and Methodius (UKIM) - Institute of Agriculture, Hans Em Faculty of Forest Sciences, Landscape Architecture and Environmental Engineering, Faculty of Agricultural Sciences and Food.

3. **Verification Team**, who includes experts working on Quality Control, as well as experts working on Quality Assurance. The last is also ensured by multilayer structure involving CTA, NCCC and GSP.

During the development of this NIR, the Ministry of Environment and Physical Planning has been developing new legislation (i.e., The Law on Climate Action and its secondary legislation – the Decree on GHG Inventory System and the Rulebook on GHG reporting), that should establish a legally binding inter-institutional coordination mechanism for reporting of GHG emissions. The draft versions of legal acts had been prepared but not officially adopted when this NIR was finalized.

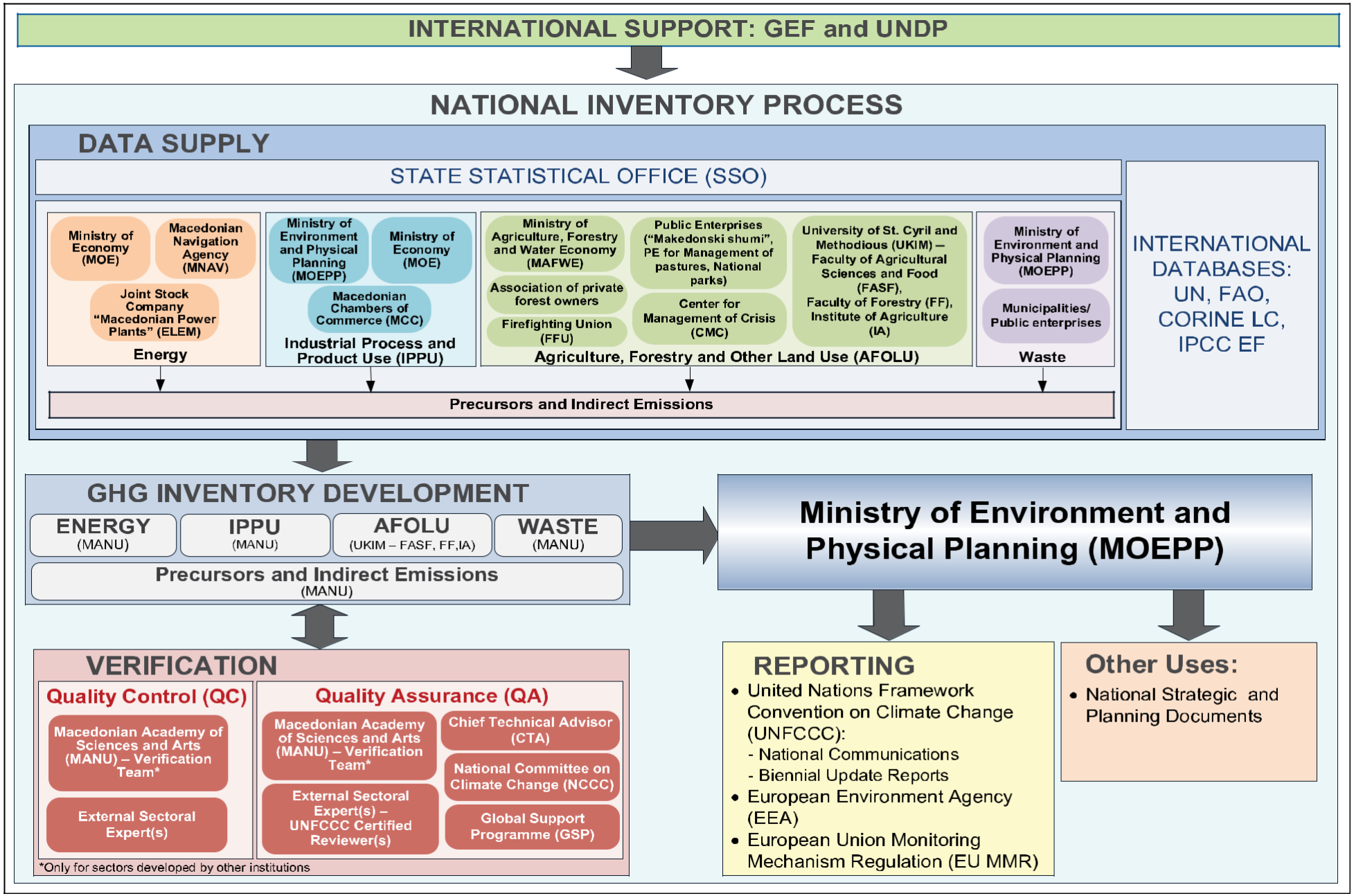


Figure 3-1: National inventory process

3.2 Summary of GHG emissions

The aggregate GHG emissions and removals (net emissions) in 2019 are estimated to be 12,902 Gg CO_2-eq (including the FOLU sector). Table 2 shows the time series of emissions and removals (given in Gg CO_2-eq) from 1990 to 2019. There are significant fluctuations in the net emissions in 2000, 2007, 2012, 2017, and 2019, where one can notice increased emissions in the FOLU sector (instead of removals) due to the intensified forest fires/wildfires. The net GHG emissions in 2019 increased by 18.7% compared to 1990, or 48.2% compared to 2016, mainly because instead of sinks, emissions occur from the forestry sector. However, in recent years, minor variations in the emissions are noticeable for the other sectors, explained more in the subsequent chapters for each sector.

Table 3-1. GHG emissions and removals by sector (in Gg CO_2-eq)

Sector	1990	2000	2005	2014	2015	2016	2017	2018	2019
Energy	9,608	9,744	9,247	8,045	7,697	7,447	7,964	7,430	8,501
Industrial Processes and Product Use	932	888	862	836	734	768	588	651	763
Agriculture (without FOLU)	1,468	1,244	1,203	1,127	1,164	1,203	1,755	1,704	1,368
FOLU	-1,546	10,056	-2,028	-3,252	-890	-1,321	1,360	-1,763	1,634
Waste	407	413	435	574	595	607	611	622	635
Total (incl. FOLU) – Net emissions	10,870	22,346	9,719	7,330	9,299	8,704	12,278	8,644	12,902
Total (excl. FOLU)	12,415	12,290	11,747	10,582	10,190	10,024	10,918	10,407	11,268

If the removals (or emissions, in years with forest fires) from the FOLU sector are not accounted for, the total GHG emissions in 2019 are 11,268 Gg CO_2-eq (Figure 3-2). The most significant share of emissions is from the Energy sector, accounting for 75.4% in 2019, followed by the Agriculture (excluding FOLU) with 12.1%, IPPU sector with 6.8% and the Waste sector with 5.6% share. The dominant share of emissions for the Energy sector is evident throughout the whole time series. When excluding FOLU, the emissions in 2019 are reduced by 9.2% competed to 1990. In general, since 2012, a decreasing trend of emissions is evident, reaching the lowest level of 10,024 Gg CO_2-eq in 2016, despite minor variations in 2017 and 2019, due to increased domestic electricity production instead of import.

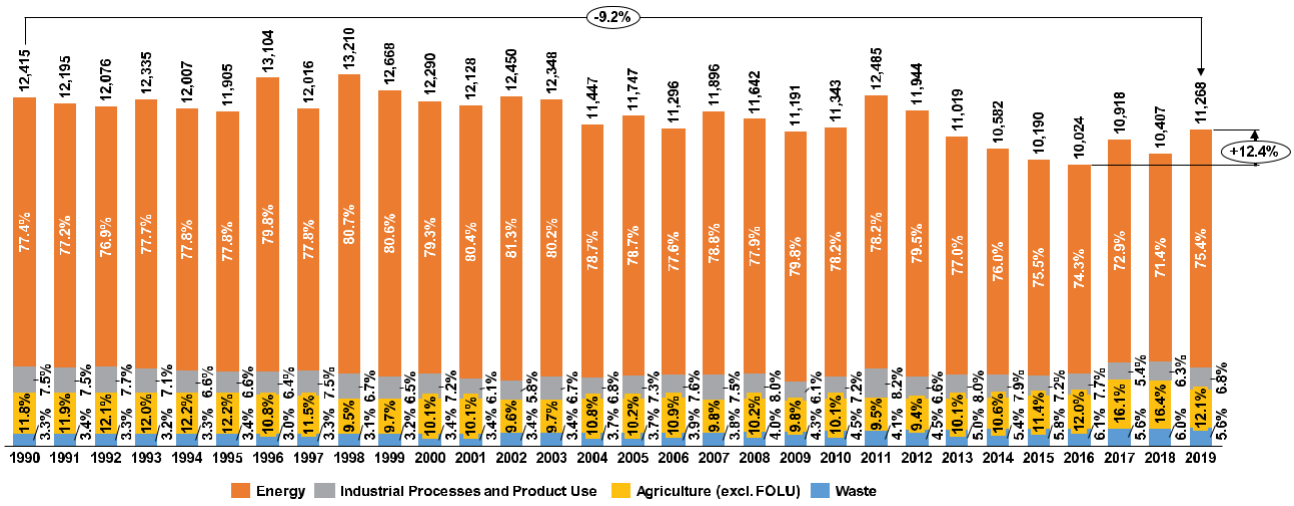


Figure 3-2. Total GHG emissions by sector, excluding FOLU sector (in Gg CO_2-eq)

Analysing the GHG emissions by gas (excluding the FOLU sector), it is evident that the most dominant are the CO_2 emissions (See the table and figure below). Their share accounts for 77.2% in 2019, followed by the CH_4 emissions with 13.7%, then N_2O emissions with 6.6%, and all F-gasses with 2.5%.

Table 3-2. GHG emissions by gas (in CO_2-eq)

Gas	1990	2000	2005	2014	2015	2016	2017	2018	2019
CO_2 (incl. FOLU)	10,147	10,237	9,689	8,411	7,971	7,717	8,123	7,621	8,698
CO_2 (excl. FOLU)	1,713	1,572	1,509	1,562	1,594	1,586	1,640	1,636	1,546
CH_4	463	414	446	451	459	487	1,000	952	744
N_2O	0	5	103	158	166	234	154	198	279
HFCs	92	63	0	0	0	0	0	0	0
PFCs	0	0	0	0	0	0	0	0	0
SF_6	10,147	10,237	9,689	8,411	7,971	7,717	8,123	7,621	8,698
Total (incl. FOLU) - Net emissions	**10,870**	**22,346**	**9,719**	**7,330**	**9,299**	**8,704**	**12,278**	**8,644**	**12,902**
Total (excl. FOLU)	**12,415**	**12,290**	**11,747**	**10,582**	**10,190**	**10,024**	**10,918**	**10,407**	**11,268**

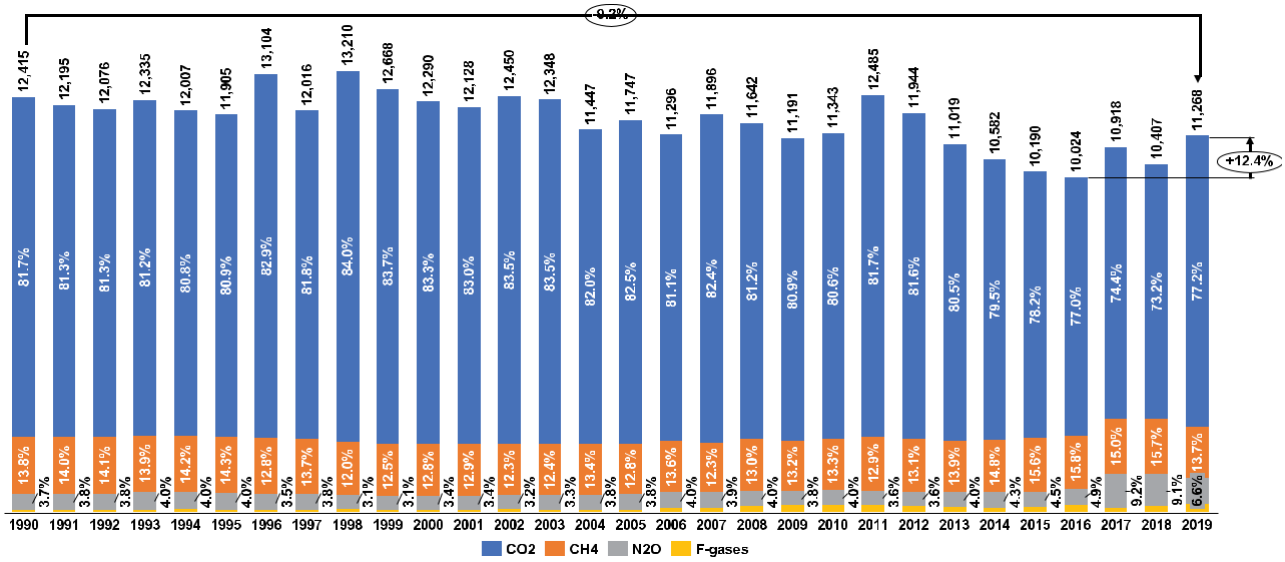


Figure 3-3. Total GHG emissions by gas, excluding FOLU (in Gg CO_2-eq)

Despite the small share of the F-gases in the total emissions, only HFCs and PFCs are reported in the inventory (Table 3-2). The SF_6 emissions are not estimated for Macedonia due to the unavailability of activity data. As shown in Figure 3-4, the emissions of HFCs start in the year 2000, achieving 279 Gg CO_2-eq in 2019, fluctuating over time, depending on the activities in the IPPU sector, while the PFCs emissions are considerably decreasing after 2003. The significant growth in the import of gases (blends) used for refrigeration and air-conditioning has increased HFCs emissions in recent years.

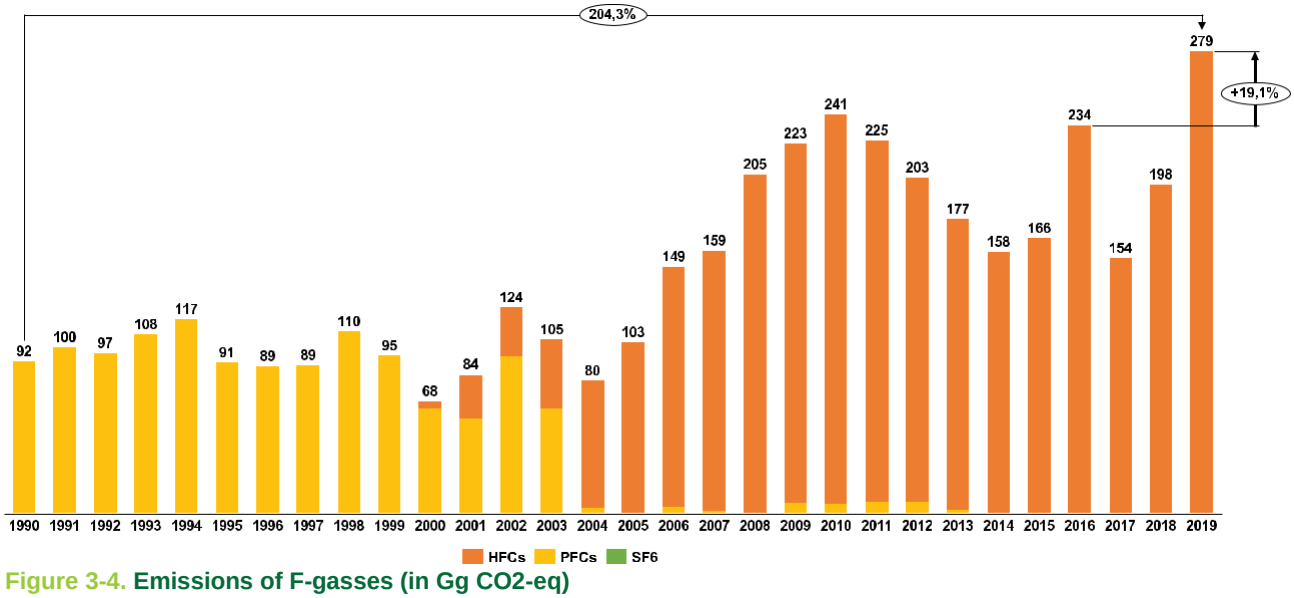


Figure 3-4. Emissions of F-gasses (in Gg CO2-eq)

3.3 Sectoral inventories

3.3.1 Energy sector

The Energy sector is the main source of GHG emissions in the Republic of Macedonia, accounting for 8,501 Gg CO_2-eq in 2019, 65.9 % of overall direct GHG emissions. The gross inland consumption in Macedonia is still dominated by fossil fuels, although their share is decreasing over the reported period, from 92% in 1990 to 84% in 2019 (Figure 35). At the same time, the share of renewable energy sources has doubled (7.5% in 1990 to around 14% in 2016 and 2018). The rest of the gross inland consumption is covered by the electricity import, which increased from insignificant 0.2% in 1990 to 6.5% in 2016, or 5.6% in 2019. The gross inland consumption in total in 2019 is 7% lower compared to the consumption in 1990.

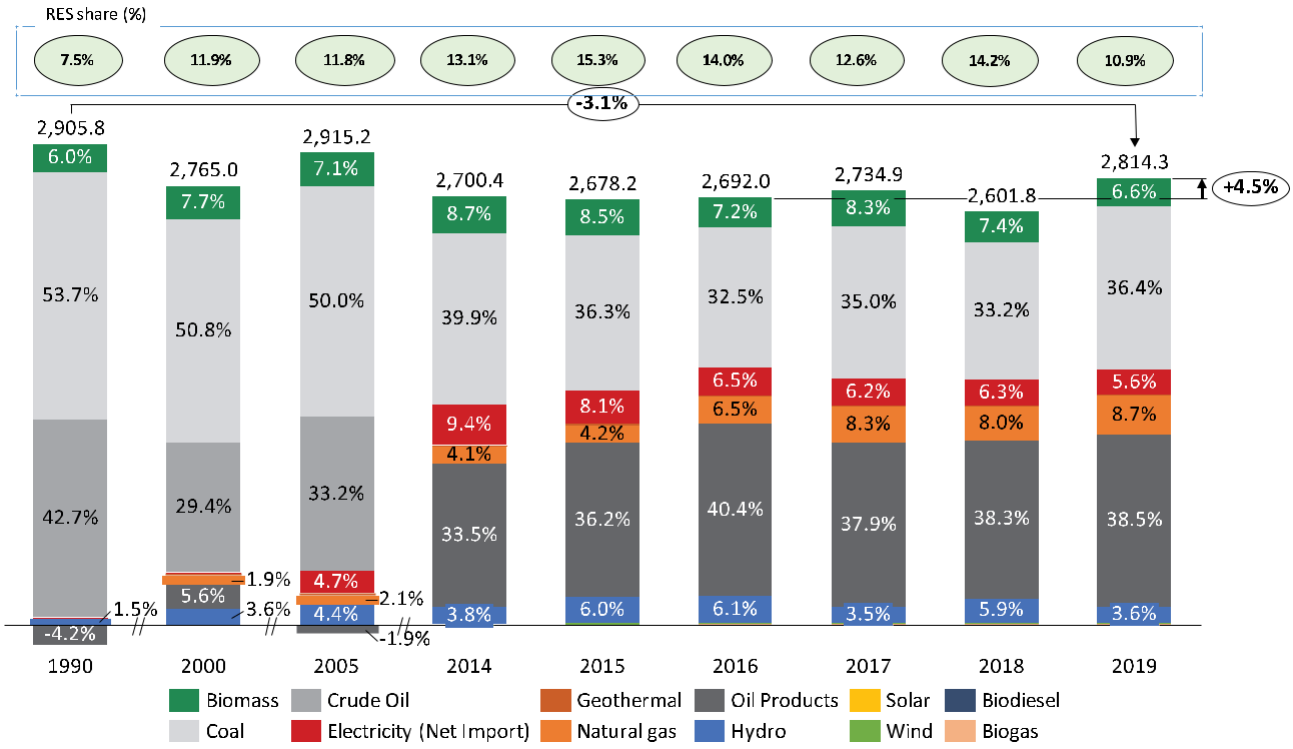


Figure 3-5. Gross inland consumption (in ktoe)

The choice of Tier for each calculation of the GHG emissions from the Energy sector was determined by the accessibility of the corresponding national data. In the inventory report the following Tiers have been used:

- **Tier 1:** data on the amount of fuel combusted in the source category; default emissions factor
- **Tier 2:** data on the amount of fuel combusted in the source category; a country-specific emissions factor for the source category and fuel for CO_2 emissions

The State Statistical Office issues annual Energy balances with information on fuel consumption both in natural units and kilotons of oil equivalent (ktoe). These data were used to calculate the NCV of each fuel in a certain year. It should be noted that the variations of fuels' NCV from one sector to another were considered in this inventory.

The main data sources for the Energy sector are the Energy balances from the State Statistical Office as the most relevant institution for gathering accurate information and the Energy Balances and Statistics from the International Energy Agency (IEA) as a secondary data source. For a source of information for vehicle type activity data, the National Road Transport Emission Inventory was used based on the data from the COPERT database.

The Sectoral approach of the inventory for the Energy sector accounts for the GHG emissions released because of Fuel combustion activities, as well as the fugitive emissions from extraction of solid fuels and transmission and distribution of liquid and gaseous fuels.

The total Energy sector emissions by category can be observed in Table 33 and Figure 36. One can notice a decreasing emission trend due to reduced electricity production from the Energy Industries, replaced mainly with electricity import. Although the emissions in 2018 have nearly the same values as in 2016 (as the lowest level), in 2019, the emissions increased by 14% relative to the 2016 level due to increased domestic production and reduced import. But, compared to 1990-level, in 2019, the emissions are lower by 11.5%.

Most of the GHG emissions in 2019 occur in the category Energy Industries (54%), followed by Transport (27.7%) and Manufacturing Industries and Construction (12.6%). The other two categories together account for nearly 4% of the total emissions in 2019 and the remaining less than 2% are Fugitive emissions.

Table 3-3. GHG emissions in Energy sector, by category (in Gg CO_2-eq)

Categories	1990	2000	2005	2014	2015	2016	2017	2018	2019
Energy	**9,608**	**9,744**	**9,247**	**8,045**	**7,697**	**7,447**	**7,964**	**7,430**	**8,501**
Fuel Combustion Activities	**9,415**	**9,537**	**9,057**	**7,866**	**7,533**	**7,304**	**7,824**	**7,292**	**8,350**
Energy Industries	6,197	6,987	5,941	4,747	4,261	3,801	4,401	3,839	4,588
Manufacturing Industries and Construction	1,771	1,080	1,356	1,128	1,063	1,035	876	941	1,071
Transport	788	1,008	1,044	1,657	1,838	2,097	2,178	2,175	2,357
Other Sectors	635	326	303	158	162	149	159	142	138
Non-Specified	23	136	414	177	209	222	211	195	196
Fugitive emissions from fuels	**193**	**208**	**191**	**179**	**164**	**142**	**141**	**138**	**151**
Solid Fuels	193	208	190	179	164	142	141	138	151
Oil and Natural Gas	1	1	1	0	0	0	0	0	0

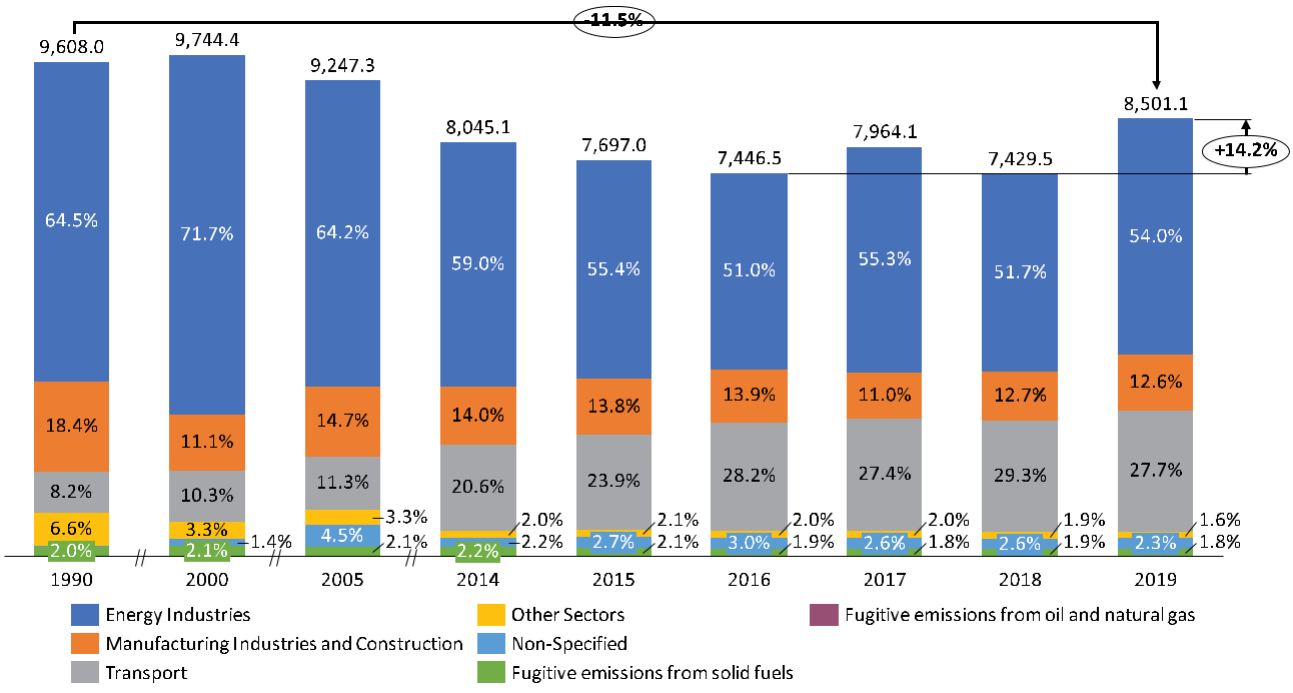


Figure 3-6. GHG emissions in Energy sector, by category (in Gg CO_2-eq)

The three major sectors on emission release are Energy industries, Transport, and Manufacturing Industries and Construction, with almost 95% of the direct emissions in 2019.

The Energy Industries cover the following subcategories: Electricity Generation, Combined Heat and Power Generation (CHP), Heat Plants, and Other Energy Industries. Electricity Generation contributes the most to the category's emissions, i.e., almost 90% in 2019 or 48.5% to the total Energy sector emissions in 2019. Lignite (as a domestic source) and natural gas are

the primary energy sources for electricity production in the country. In the previous years, residual fuel oil was one of the main energy sources used in the Energy Industries. Still, it was gradually replaced by natural gas, especially for electricity and heat production. Due to fuel switch and reduced electricity production from lignite, the emissions from this category in 2016 are lower by 19.9% compared to 2014. But the emissions grow again in 2019 (by 21% relative to 2016) due to the increased domestic production and reduced import. However, compared to 1990-levels, the emissions in 2019 decreased by 26%.

Participating with 27.7% in 2019, the transport category is the second biggest contributor in the overall Energy sector emissions. Regarding the fuels, gas/diesel oil (road diesel), motor gasoline, liquefied petroleum gases (LPG), aviation gasoline and natural gas are used. Road Transportation releases almost all the emissions 99.6% in 2019, while emissions from Railways are nearly 0.4% and from the Domestic Aviation are close to zero.

Manufacturing Industries and Construction as an Energy category had a portion of 12.6% in the overall Energy sector emissions in 2019. The top three most intensive subcategories in 2019 are Iron and Steel (48.3% of the category emissions), Non-Metallic Minerals (32.6%) and Food Processing, Beverages, and Tobacco (6%). The declining trend over the reported period resulted in lower emissions in 2019 by nearly 40%. However, due to the intensified activities in the Iron and steel industry in recent years, the emissions are slightly higher (3.5%) when compared to the 2016-level.

The overall GHG emissions in Energy sector by gas (in Gg of CO_2-eq) for the reporting years, are given in Figure 37. Notably, almost all the GHG emissions in 2019 are actually CO_2 emissions (96.5%), and CH_4 and N_2O emissions amount to only 2.8% and 0.7%, respectively.

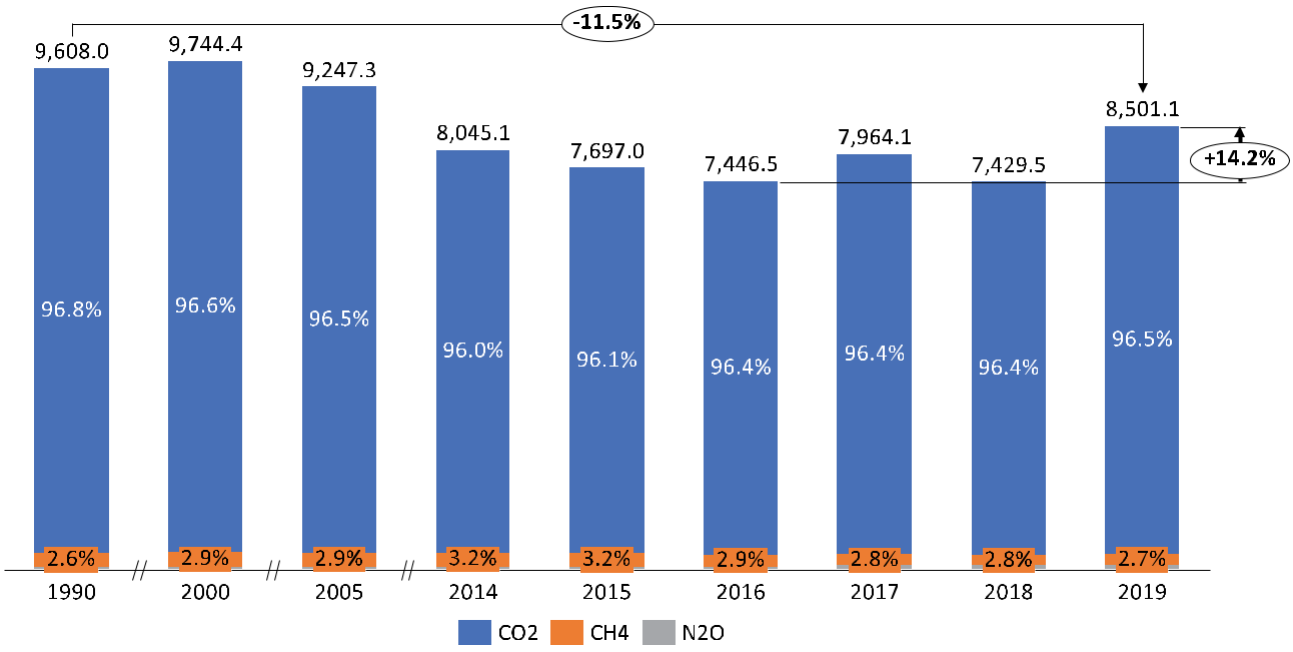


Figure 3-7. GHG emissions in Energy sector, by gas (in Gg of CO_2-eq)

3.3.1.1 Biomass combustion for energy production

According to the IPCC Guidelines, the CO_2 emissions that occur because of biomass combustion for energy production are reported as information items. These emissions have decreased over the period 1990 – 2019 for 4.4% (Figure 3-8).

CO_2 emissions from biomass in the Republic of Macedonia arise from the combustion of wood biomass. This energy source is generally used by households and usage is very difficult to quantify precisely due to widespread illegal logging.

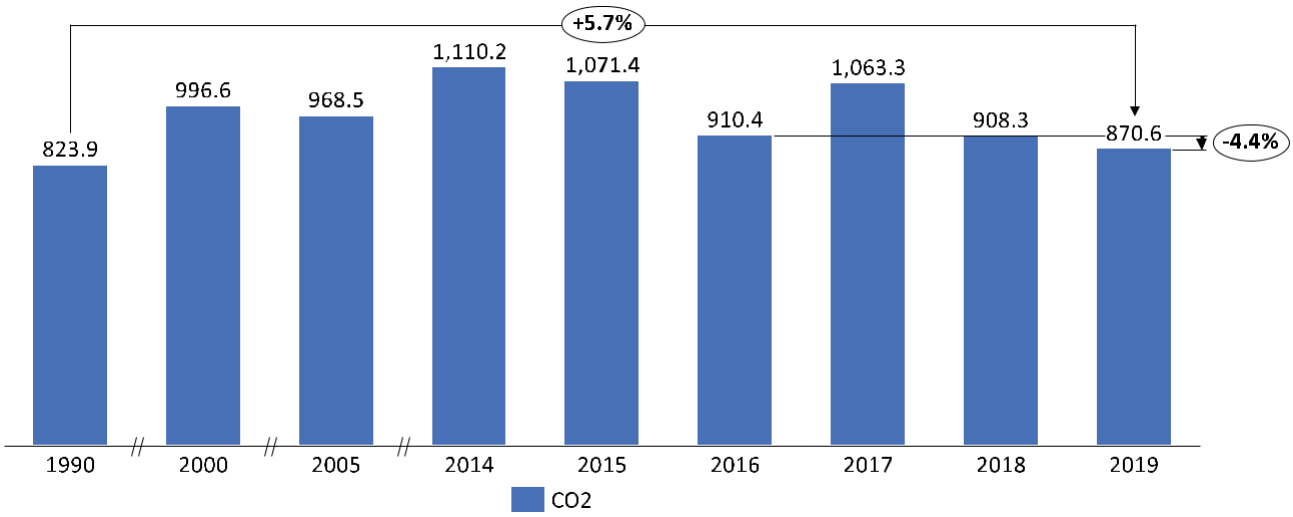


Figure 3-8. CO_2 emissions from biomass burning for energy production (Gg)

3.3.2 Industrial processes and product use

The industrial production in Macedonia has slowed down after the economic transition period in the '90s. Many industrial plants in the country have either lowered the volume of manufacturing or entirely shut down. However, several industries that continued their production have become the largest contributors of GHG emissions in the Industrial processes and product use (IPPU) sector. Most of the GHG emissions come from the metal industry (from steel and ferroalloys production) and the mineral industry (from production of cement production). The rest of the greenhouse emissions in the country come from usage of substitutes for ozone-depleting substances (ODS) for refrigeration and air-conditioning.

The estimation of the greenhouse gases from all the categories in the IPPU sector was done in accordance with the 2006 IPCC guidelines (Tier 1, Tier 2) and with the usage of the IPCC Inventory Software. The data for preparation of the greenhouse gases inventory for the IPPU sector was generally collected from three main sources: the State Statistical Office, the Ministry of Environment and Physical Planning or directly from the industrial plants.

Over the reported period, the emissions from this sector had slightly changed, however the participation of different categories had significantly changed. In the 2019, the overall emissions from IPPU sector achieved 763 Gg CO2-eq, which represent a decrease of 18.2% relative to 1990, or a minor decrease of 0.7% compared to 2016 (Figure 3-9).

Until 2000, the metal industry was prevailing source of the emissions, mostly from the ferroalloy production. After 2000, when ODS substitutes usage in the country have started to increase, the share of the GHG emissions from the Metal industry have decreased considerably (from 64% in 1990 to 21% in 2016, and nearly 12% in 2019). At same time, the emissions from the Mineral industry have been fluctuating over the inventory period, showing slightly increasing trend, in the last years. In the last three reporting years the product uses as substitutes for ODS had grown for around 20% (relative to 2016), resulting with share of around 36% of the IPPU sector emissions in 2019. However, the dominant share had the Mineral industry with 48%, in 2016, 64% in 2017, 58% in 2018 and around 52% in 2019. Emissions from the other categories, like Chemical industry, Non-Energy Products from Fuels and Solvent Use, Electronics Industry and Other Product Manufacture and Use do not occur in the country (Table 3-4).

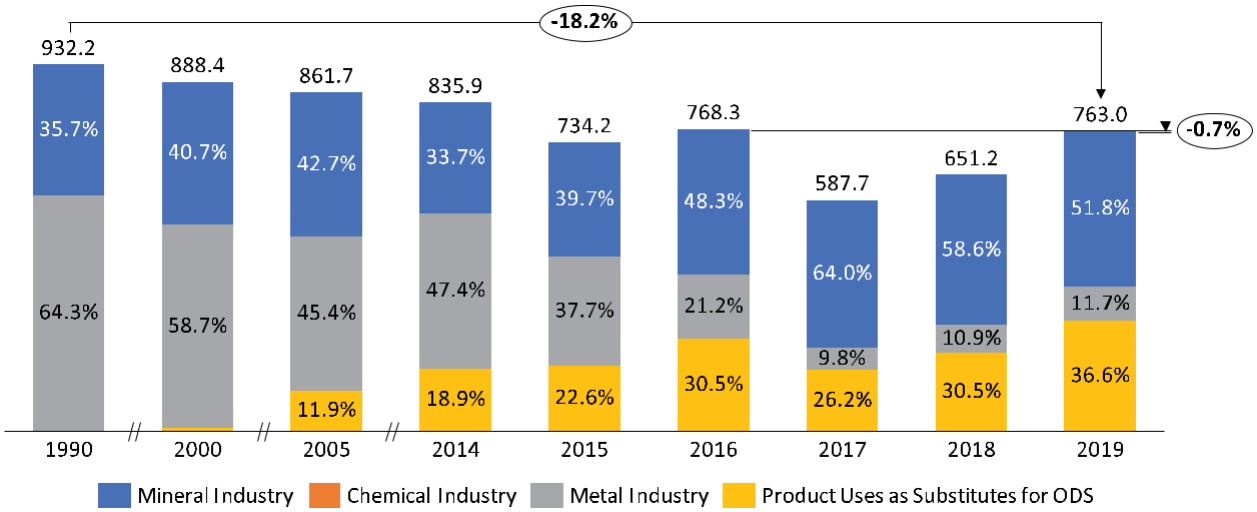


Figure 3-9. GHG emissions from the IPPU sector, by category (in Gg CO_2-eq)

Table 3-4. GHG emissions from the IPPU sector, by category (in Gg CO_2-eq)

Categories	1990	2000	2005	2014	2015	2016	2017	2018	2019
Industrial Processes and Product Use	**932**	**888**	**862**	**836**	**734**	**768**	**588**	**651**	**763**
Mineral Industry	**333**	**362**	**368**	**282**	**291**	**371**	**376**	**382**	**395**
Cement production	294	349	355	274	285	365	374	377	377
Lime production	34	11	11	6	5	5	1	4	17
Glass Production	0	0	0	0	0	0	0	0	0
Other Process Uses of Carbonates	5	2	2	1	1	1	1	1	1
Ceramics	3	0	0	0	0	0	0	0	0
Other Uses of Soda Ash	3	1	1	1	1	1	1	1	1
Other	NO, NA								
Chemical Industry	**NO,NA**								
Metal Industry	**599**	**522**	**391**	**396**	**277**	**163**	**58**	**71**	**89**
Iron and Steel Production	25	15	58	17	11	15	25	24	22
Ferroalloys Production	266	196	332	379	265	145	29	41	62
Aluminium production	100	69	0	NO	NO	NO	NO	NO	NO
Lead Production	22	23	NO	NO	1	2	4	6	6
Zinc Production	186	218	NO	NO	NO	NO	NO	NO	NO
Non-Energy Products from Fuels and Solvent Use	**NA, NO**								
Electronics Industry	**NA, NO**								
Product Uses as Substitutes for ODS	**0**	**5**	**103**	**158**	**166**	**234**	**154**	**198**	**279**
Refrigeration and Air Conditioning	0	5	103	158	166	234	154	198	279
Refrigeration and Stationary Air Conditioning	0	5	103	158	166	234	154	198	279
Mobile Air Conditioning*	IE								
Foam Blowing Agents									
Fire Protection									
Aerosols									
Solvents	**NA, NE**								
Other Applications									
Other Product Manufacture and Use									
Other									

Note: *Emissions from Refrigeration and Air Conditioning are calculated based on imported substitute of ODS and all are reported under Stationary Air Conditioning

NO - Not occurring, NA – Not Applicable, NE – Not Estimated, IE – Included Elsewhere

In 2019, the CO_2 emissions accounted for 63.4% of the overall greenhouse emissions from IPPU. The HFCs were second highest contributor and accounted for 36.6% of the total emissions. CH_4 emissions were negligible (accounting for less than 0.001% of the greenhouse emissions from this sector. The emission of SF6 were not estimated due to unavailability of activity data. The emissions segregated by gas are presented in Figure 3-10.

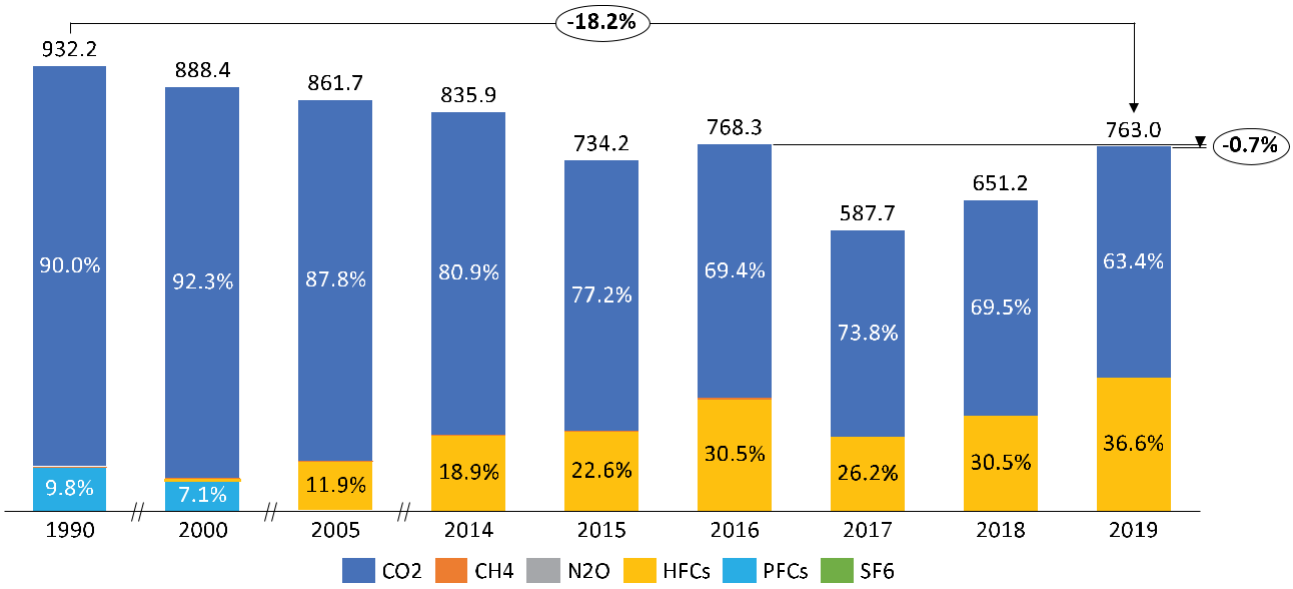


Figure 3-10. GHG emissions from the IPPU sector, by gas (in Gg CO_2-eq)

Among the subcategories, the three main sources of emissions are cement production, products used as substitutes for ODS, and ferroalloys production.

There is only one cement production factory in the country. Marlstone is used as basic mineral raw material and is obtained from the open-cast mine, located within the factory. Marlstone, as a non-metallic mineral raw material, is a basic component in the production of clinker, i.e., cement. The emissions from the cement production were influenced by the volume of industrial activity and their fluctuation were observed over the inventory period. However, an increasing trend can be seen in the last three years, resulting with 28% higher emissions in 2019 relative to 1990, or 3.4% higher relative to 2016.

Hydrofluorocarbons (HFCs) and, to a very limited extent, perfluorocarbons (PFCs), are serving as alternatives to ozone depleting substances (ODS) being phased out under the Montreal Protocol. HFCs and PFCs are not controlled by the Montreal Protocol because they do not contribute to depletion of the stratospheric ozone layer. In Macedonia these gasses are mainly used for refrigeration and air conditioning. The HFC emissions from this sector follow an increasing trend in the reported years, reaching the highest level of 279 CO_2-eq in 2019, and 234 CO_2-eq in 2016.

In North Macedonia, electricity is mainly used to produce ferro-alloy. In the electric furnaces, heating is realized by passing current through graphite electrodes suspended in a cup-shaped, refractory-lined steel shell. Carbon reduction of the metallic oxides occurs as both coke and graphite electrodes are consumed. This process results in both CO_2 and CH_4 emissions. The trend of the GHG emissions from ferroalloy production is fluctuating over the observed period, mainly because of the financial crises (locally and globally). In 2019, the GHG emissions amount have decreased for 77% from 1990 level, and for 58%

3.3.3 Agriculture, forestry, and other land use

Agriculture, Forestry, and Other Land Use (AFOLU) is unique among the sectors considering the numerous processes leading to emissions and removals of greenhouse gases, which can be widely dispersed in space and highly variable in time. The AFOLU sector covers Livestock production activities; Land use in particular Forestland, Cropland, Grassland, Wetland, Settlements, and other land; Aggregate sources and non-CO2 emissions sources on land; and Other.

As one of the primary sources of GHG, the AFOLU sector produced total emissions of CO_2-eq varying in a range from 11,300 Gg in 2000 to the lowest -2,125 Gg in 2014, followed by an significant variations for the period 2015 to 2019, which is mostly result to the year to year changes of emissions in forestland (Figure 3-11 and Table 3-5). Main emissions are produced in livestock sector. Cattle are the primary source of GHG among the ruminants. Most of the methane emission arouses from enteric fermentation (approx. 80%), while manure management contributes with only 15-18% of the total CH_4 emissions.

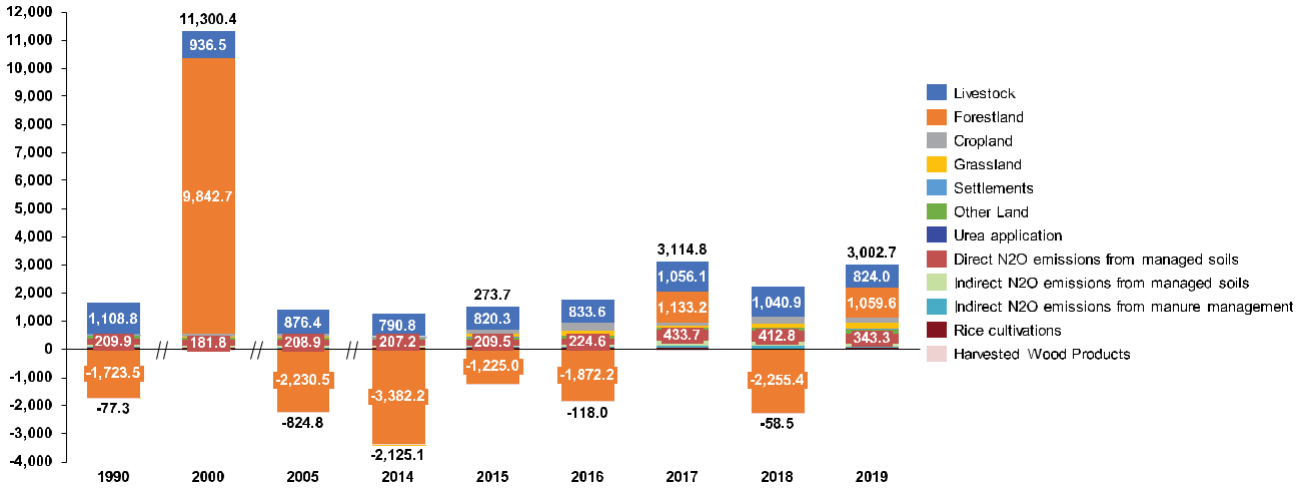


Figure 3-11. GHG emissions (and removals) from AFOLU sector (in Gg CO_2-eq)

Table 3-5. GHG emissions and removals from AFOLU sector, by category (in Gg CO_2-eq)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
AFOLU	**-77**	**11,300**	**-825**	**-2,125**	**274**	**-118**	**3,115**	**-59**	**3,003**
Livestock	**1,109**	**937**	**876**	**791**	**820**	**834**	**1,056**	**1,041**	**824**
Land	**-1,545**	**10,057**	**-2,027**	**-3,251**	**-889**	**-1,319**	**1,361**	**-1,761**	**1,634**
Forestland	-1,724	9,843	-2,231	-3,382	-1,225	-1,872	1,133	-2,255	1,060
Cropland	52	93	75	78	140	257	123	266	199
Grassland	-4	7	41	-3	110	163	27	104	196
Settlements	10	18	14	23	18	6	7	7	17
Other Land	121	96	74	33	68	127	71	118	163
Aggregate sources and non-CO_2 emissions sources on land	**359**	**308**	**327**	**336**	**344**	**369**	**699**	**664**	**544**
Urea application	4	4	1	2	2	2	3	3	3
Direct N_2O emissions from managed soils	210	182	209	207	210	225	434	413	343
Indirect N_2O emissions from managed soils	81	68	76	75	75	81	148	140	114
Indirect N_2O emissions from manure management	35	32	29	29	35	39	98	94	68
Rice cultivations	29	23	12	24	23	23	16	15	17
Harvested Wood Products	**-1**	**-1**	**-1**	**-2**	**-2**	**-2**	**-2**	**-2**	**0**

The forestry sector is a major contributor of GHG sinks in the Republic of Macedonia within the Land subsector of AFOLU, except for several years when because of forest fires (burned areas), emissions from this category of land use were significantly above the annual average. The area of forestland, the species composition (conifers, broadleaved, mixed), as well as the annual increment and removals from the forests are relatively stable. Land as a part of AFOLU, and more specifically, Forestland, in most cases are significant sinks of GHG. In some years of the reporting period, like in 2005 (-2,230 Gg CO_2-eq), 2014 (-3,382 Gg CO_2-eq), and 2018 (-2,255 Gg CO_2-eq) removals are notable. At the same time, years with significant numbers of forest fires and large burned areas of forest, contribute to increase of the GHG emissions (2000 with 9,843 Gg, 2017 with 1,133 Gg, and 2019 with 1,060 Gg).

For the non-CO_2 sources of GHG, it can be concluded that numerous management practices and inputs are resulting in a significant amount of GHG emissions, which total emission when summed up, differ in a wide range for specific periods. If we compare the period 1990-2016 where total emission of GHG are in ranges of from 308 Gg CO_2-eq in the year 2000 up to 369 Gg CO_2-eq, in 2016. In the last three years of the analysed period (2017-2019), there is a severe increase of the emissions from non-CO_2 sources, especially in the categories: direct and indirect emissions from managed soils and manure management. There are no severe changes in the overall emissions trend for the other two types of non-CO_2 emissions urea application and rice cultivation. A significant source of non-CO_2 gases is managed soils, which contribute with a total AFOLU CO_2- equivalent emissions (excluding sinks from Forestry) in a range of 17.11% in 2000, up to 29.37 % in 2017

3.3.3.1 Livestock

GHG emissions from livestock activities result from their physiological and activity concerning their production and manure management on the farms. There are differences in emissions in different species and types of production, production system, productivity level, farm-specific management, etc. National livestock production of cattle, sheep, goats, and horses is mainly characterized by production systems with low to moderate intensity. However, a part of dairy cows and most swine and poultry production systems are very intensive where emissions from manure management can be closely monitored. Tier 2 was used in dairy cattle and swine for emissions from enteric fermentation and manure management in this report. Simultaneously, as was the case in previous reports, Tier 1 methodology was applied for other species.

The total emissions due to livestock activity in 2017 were 1,056 Gg CO_2-eq, while dropping in 2019 to 824 Gg CO_2-eq. The direct comparison with previously reported emissions is not applicable due to improvement of methodology used, and increased use of manure into biogas production.

Ruminants are the primary source of GHG emissions from livestock. In particular, dairy cows and other cattle are emitting the majority of GHGs. Sheep and goats (ruminants), horses, swine, and poultry, contribute significantly less to the sector's emissions. In 2017- 2019, CH_4 emissions were from 34 Gg (2017-18) to 29 Gg in 2019 (Table 3-6). On average, most CH_4 emissions were from the enteric formation (88%), while manure management was contributing with 12%. Most CH_4 is produced by enteric fermentation and manure management in cattle (29 Gg enteric and 2 Gg manure), accounting for 80% of livestock's total methane emissions. Enteric fermentation from all other species (sheep, goat, horses, and swine) contributed about 16% of total CH_4 emission in the sector. On average, for the period, 55% of CH_4 emissions from manure management were produced in cattle, and 40% were coming from swine. All other species contributed for only 5% to CH_4 emission from manure management. In the assessment, emissions of CH_4 were transferred into CO_2 equivalents. The CH_4 emissions in 2017, 2018 and 2019 were 814.44; 838.16 and 715.47 Gg CO_2-eq, respectively.

Table 3-6 Emissions of CH_4 (in Gg) due to activities in livestock production

Categories	1990	2000	2005	2014	2015	2016	2017	2018	2019
Enteric Fermentation	36	30	28	25	26	26	30	30	25
Manure Management	6	6	5	5	5	6	4	4	4
Total emissions	**42**	**36**	**33**	**30**	**31**	**32**	**34**	**34**	**29**
Total emissions (Gg CO_2-eq.)	**1,060**	**893**	**836**	**752**	**782**	**792**	**841**	**838**	**715**

N_2O emissions were solely due to manure management. The emissions for the period 2017- 2019 were about 0.7 Gg in 2017 and 2018 and drop to 0.36 Gg in 2019 (Table 3-7). The main emitters were swine farms, 84%, followed by cattle farms contributing with 13%. In previous reports, the emission of N_2O was 3-4 times lower when the Tier 1 methodology was applied.

Emissions of N_2O were also transferred into CO_2 equivalents. The emissions of N_2O over the years are relatively stable, around 41 Gg CO_2-eq until 2016. In the reporting period Tier 2 was applied for estimation of emissions in dairy cattle and swine, so the N_2O emissions were form 215 in 2017 to 109 Gg CO_2-eq in 2019.

Table 3-7 Emissions of N_2O (in Gg) due to activities in livestock production

Categories	1990	2000	2005	2014	2015	2016	2017	2018	2019
Enteric Fermentation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manure Management	0.2	0.1	0.1	0.1	0.1	0.1	0.7	0.7	0.4
Total emissions	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.7**	**0.7**	**0.4**
Total emissions (Gg CO_2-eq.)	**49.3**	**43.1**	**40.4**	**38.8**	**38.6**	**41.4**	**214.6**	**202.7**	**108.5**

3.3.3.2 Land

The category Land contents Forest land, Cropland, Grassland, Settlements and Other land. Nevertheless, some of the categories are significant contributor to GHG emissions, but other like Forest land can be major CO_2 sink. For this report need, they were deeply analysed separately.

Forest land

Forests and forest land in Republic of Macedonia cover around 1,1 mil. ha and are characterized with great species diversity, but low quality and small annual growth. More than 70% of the forests are coppice, 90% are deciduous and almost 90% are state owned. The most dominant species is Beech, and then various oak species. Total wood reserve is estimated on around 70 mil m3, and total annual growth is around 1,7 mil m3. Very large part of the land considered as forest, are Mediterranean type of forest, characterized with small trees and bushes.

Data for the total forest area were found in the Statistical Yearbooks, from the State Statistical office, Forestry management plans (PE "Makedonski sumi", other subjects that manage forests, Ministry of Agriculture, forestry, and water economy) and Faculty of Forestry (different experts). All those different data were compared between themselves, and they all differ due to their different update year.

To improve the quality and consistency of data for areas under forestland, in this report additional data sources were used. In the previous report, the digital LU/LUC data from CORINE LC were used for calculation of areas under forestland and were checked against the official state data; while for the period before 2000 (when CORINE did not exist) SSO data were used. For this up-dated report, additional effort has been done to improve the land use land use change with developing of methodology for photointerpretation of satellite images from various sources (LandSAT, SENTINEL etc.). Based on this analysis, total forestland area increased from 958,388 ha in 1990 to1,042,534 ha in 2019. Land use changes from forestry are shown in Table 3-8.

Table 3-8. Forestland area (ha)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Forest remaining forest	953,863	973,487	991,016	1,020,437	1,024,564	1,026,558	1,031,084	1,033,295	1,037,179
Land converted to forest land	4,525	6,789	5,729	5,210	3,948	5,807	3,916	5,841	5,354
Total	**958,388**	**980,277**	**996,745**	**1,025,647**	**1,028,512**	**1,032,365**	**1,035,000**	**1,039,136**	**1,042,533**

Emissions in Republic of Macedonia from forestry sector are product of firewood consumption as well as the forest fires. The most constant producer of CO_2 emission are households that use firewood for heating. Forest fires are the second emitter of CO_2, but they are not constant, and their contribution varies greatly from year to year, depending on their number, and the area that they cover, as well as the species composition in burned areas. There are several years (2000, 2008, 2012, 2017 and 2019) where due to the huge number of forest fires and great burned area, forestry sector instead of removing, contributed into increase of the GHG emissions in the country.

Methodology used for estimation of the emission is Tier1, since there are no accurate data on annual level, improved using CORINE Land cover maps to establish annual land use changes. Also, the annual increment of different types of forests, were changed and used national averages for different categories of forests, provided by the experts from UKIM Faculty of Forestry, Department of Forest growth and yield. Default emission factors were used from the software

Trend of the emissions from this sector is shown in the time series in the table and figure below.

Table 3-9. **Emissions from forestry sector (CO_2-eq)**

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Forestry	-1,724	9,843	-2,231	-3,382	-1,225	-1,872	1,133	-2,255	1,060

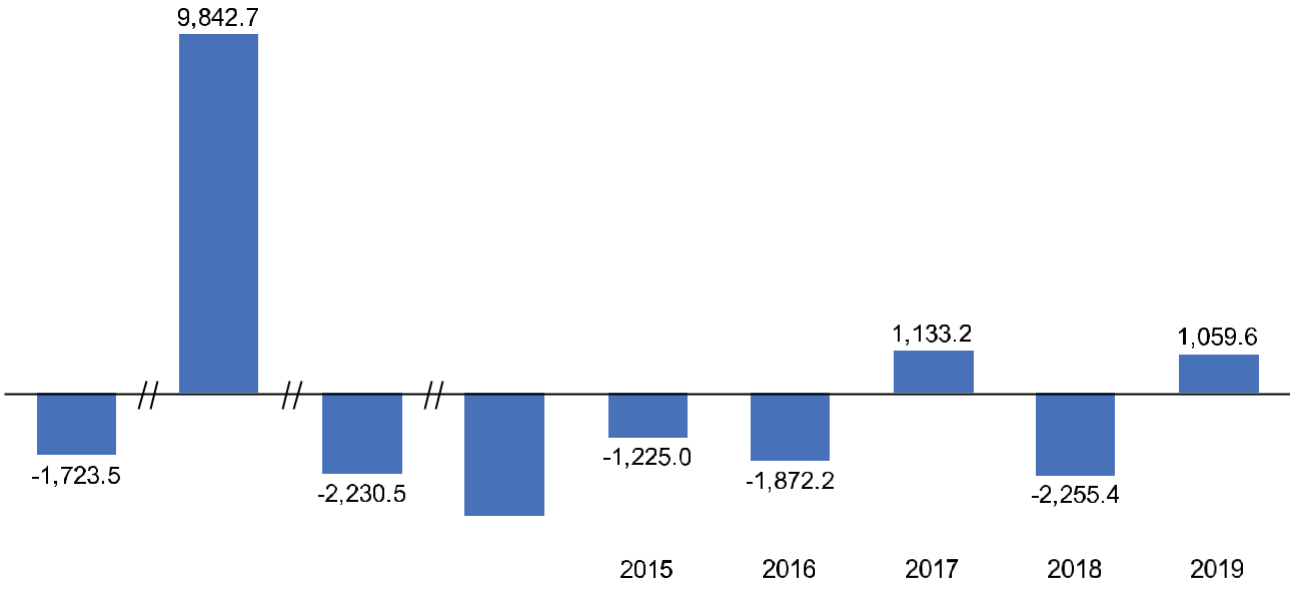


Figure 3-12. **GHG emissions and removals from Forest land (in Gg CO_2-eq)**

Crop land

According to the National Statistical Office (NSO) methodology, cropland refers to cultivated land used for performing agricultural activities for producing of annual yields. In fact, land-use class Cropland covers the category of arable agricultural land, referring to a land where crop production takes place and which is sown with annual field crops: cereals, industrial crops, vegetables, and fodder crops, and perennial crops, like vineyards, orchards, and grasses (meadows and loans). This category includes fallow and uncultivated arable land. The categories Cropland and Pastures are the two components compiling the agricultural land.

Estimations of cropland areas were done based on data available within several sources, like national data published in State Statistical Office (SSO) Year Books for the period 1990-2016, and the special publications of the SSO, "Field crops, orchards and vineyards" and "Macedonia in numbers" (2004-2016) and the digital database, MakStat (http://makstat.stat.gov.mk/PXWeb/pxweb/en/MakStat/?rxid=46ee0f64-2992-4b45-a2d9-cb4e5f7ec5ef) for the period 2014-2018. For this updated inventory, an additional effort has been to improve the land use and land-use change data, by developing a methodology for photointerpretation of satellite images from various sources (LandSAT, SENTINEL, etc.).

Based on this analysis, the total area of cropland in 1990 is estimated at 590,833 ha and slightly decrees in the past 30 years up to 526,765 in 2019, which is a decrease of more than 64,000 ha of Cropland. It should be noted that the trend of decreasing is random, mining that Cropland is gradually lost in the past 30 years, which is probably the result of migration and abandonment of arable agricultural land that is occupied with bushes and forest vegetation.

Table 3-10. Cropland (ha)

Cropland	**590,833**	**580,381**	**565,252**	**543,030**	**538,036**	**535,904**	**533,692**	**530,455**	**526,765**
Cropland Remaining Cropland	587,231	578,265	563,841	541,972	536,198	533,592	531,458	528,163	525,441
Land Converted to Cropland	3,602	2,115	1,411	1,058	1,838	2,312	2,235	2,293	1,324

Emissions from cropland are mainly result to the conversions and changes in perennial plantations. Giving though that the converted areas, as previously explained, are changing in a very narrow boundaries over the analysed periods, the emissions of CO_2 are varying in a narrow range as well. The intensity of emissions is mostly due to the conversion of areas under Forest land to Cropland, when huge quantities of CO_2 are released from the above and belowground forest biomass. Such trend is more significant in the period after 2015, when more accurate graphical datasets become available, like SENTINEL products. The total yearly emissions with conversions vary in ranges of almost 266 Gg CO_2-eq. in 2018 up to only 52 Gg CO_2-eq. in 1990 which is more than 5 time increasing over the analysed period (Table 3-11).

Table 3-11. Emissions from cropland (CO_2-eq)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Cropland, Gg CO_2-eq,	**52**	**93**	**75**	**78**	**140**	**257**	**123**	**266**	**199**
Cropland Remaining Cropland	0	0	0	0	0	0	0	0	0
Land Converted to Cropland	52	93	75	78	140	257	123	266	199
Forest Land converted to Cropland	44	86	65	71	129	250	106	259	190
Grassland converted to Cropland	8	7	9	6	11	7	16	7	8
Wetlands converted to Cropland	0	0	0	0	0	0	0	0	0
Settlements converted to Cropland	0	0	0	0	0	0	0	0	0
Other Land converted to Cropland	0	0	0	0	0	0	0	0	0

Grassland

Grassland together with the cultivated land represent the total agriculture land. Pastures covers areas on higher altitudes above the forests, known as high mountainous pastures, and areas in the lower parts used for grazing of animals during the winter period. In the process of the photointerpretation of the satellite, images as a Grassland were considered all areas covered with the following categories of land use according CORINE LC: Pastures, Complex cultivation patterns and Natural land with significant areas of natural vegetation.

In terms of emissions of GHG, according to IPCC methodology, due to the low inputs and management practices for the areas designated as Grassland Remaining Grassland, in Tier 1 approach, grassland is considered as a system in equilibrium in terms of emissions/removals, due to what emissions are not reported. The only inputs on these areas are the urine and excrement deposition from grazing animals.

According to the results from the analysis, it can be noted that the total area of Grassland similarly like with the Copland, fluctuates in a very narrow ranges from slightly above 627 thousand ha. in 1990 to around 626-628 thousand ha. for the period 2014-2019 (Table 3-12).

Table 3-12. Grassland area, ha

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Grassland	**627,047**	**632,048**	**631,364**	**626,207**	**628,085**	**627,484**	**627,483**	**628,355**	**626,879**
Grassland Remaining Grassland	623,843	629,701	627,239	622,093	623,437	625,425	623,927	624,772	623,234
Land Converted to Grassland	3,204	2,347	4,125	4,114	4,648	2,059	3,555	3,583	3,645

Emissions from the areas of Grassland Remaining Grassland are not reported since removals and emissions, according to Tier 1 approach, are in equilibrium (carbon neutral) in all CO_2 pools, like above and below ground biomass, dead wood, and SOC. There are certain sources of non-CO_2 emissions coming from the burned areas of Grassland, but due to the absence of exact data of the burned areas, these emissions are not reported. The emission from the grassland is mainly caused by

land use changes. Emissions trends from Grassland similarly like the area under this category significantly differ from -3.46 Gg-CO_2-eq in year 1990, up to 195,94 Gg- CO_2-eq. The values of CO_2 emissions, within the period 2014-2019 are significantly higher than to the previous period (1990-2014), which is result to the higher emissions coming from the conversions of areas under Forestland. Having in mind that the analysis of the conversions of LU were done on the base of remotely sensed data, it should be emphasized that in some cases burnt forest areas might be mistakenly reported as Grassland. This might be the explanation for the appearance in some years of a newly converted 100-190 ha of Forestland to Grassland (Table 3-13).

Table 31-3. Emissions from grassland (CO_2-eq)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Grassland	**-3**	**7**	**41**	**-3**	**110**	**163**	**27**	**104**	**196**
Grassland Remaining Grassland	0	0	0	0	0	0	0	0	0
Land Converted to Grassland	-3	7	41	-3	110	163	27	104	196
Forest Land converted to Grassland	*11*	*17*	*41*	*0*	*118*	*175*	*33*	*116*	*198*
Cropland converted to Grassland	*6*	*4*	*14*	*12*	*12*	*1*	*10*	*7*	*10*
Wetlands converted to Grassland	*0*	*0*	*0*	*-1*	*0*	*0*	*0*	*0*	*0*
Settlements converted to Grassland	*0*	*0*	*0*	*-1*	*0*	*0*	*0*	*0*	*0*
Other Land converted to Grassland	*-21*	*-15*	*-14*	*-13*	*-19*	*-13*	*-16*	*-19*	*-11*

Wetland

Wetlands as a land use category in these reports, were identified and delineated from the satellite images used, taking in consideration the CORINE LC classification. The CORINE classes encompassed in the Wetland category of land use, are peat bogs and inland marches. The national Statistic does not report wetlands as a particular type of land use; due to what CLC is the only source of information for identifying categories of LU which falls within Wetland area.

Estimation of total area of Wetland were accomplished with photointerpretation of satellite images and the classification adopted from CORINE LC. The total area of wetlands is varying in a narrow range from 53,394 ha in 1990 to 54,209 ha. in 2005, or a maximum difference of 815 ha.

Table 3-14. Wetland area, ha

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Wetland	**53,394**	**53,722**	**54,209**	**53,476**	**53,461**	**53,607**	**53,566**	**53,626**	**53,626**
Wetland Remaining Wetland	**53,308**	53,685	53,854	53,315	53,300	53,291	53,358	53,473	53,626
Land Converted to Wetland	**86**	37	355	161	161	316	208	153	0

Unfortunately, as already reported due to some unexpected malfunction of the IPCC software or the database, we were not able to run calculations for the emissions or sinks from the wetlands.

Settlements

Settlement is another category of land use that is not reported within the official national statistics of land use. For this reason, satellite images (LandSAT and Sentinel 2) data source were used to estimate the spatial distribution of the area of this category as well as its temporal dynamics. Similarly, like with the Wetlands, to identify which areas from the satellite images should be included within the category of Settlements, CORINE LC classification was used as an auxiliary dataset for this purpose. Several land uses classes, out of in total 31 CORINE LU class, were identified to outline the area under Settlements, like: Continuous and Discontinuous urban fabric, Green urban areas and Sport and leisure facilities.

Total area under this category of land use is estimated on approx. of over 30 thousand ha, which significantly increases over time, especially in the period 1990-2014. Whiten this time frame the total areas of settlements is enlarged from 28,702 ha in 1990 up to 42,941 in 2014, which is increasing of more than 14,2 ha. (almost 50%), which is result to the intensive urbanization and conversion of other categories of land use into urban areas. This process of conversion is becoming very intensive and is serious problem since very often a fertile agricultural land is lost with soil sealing. In the next period up to 2019, the areas under this category of LU are continuously increasing. Unfortunately, as previously mentioned, there is no available historical statistical data for this category of land use, due to what we are not able to perform quality check of our results gained from satellite imagery photointerpretation (Table 3-15).

Table 3-15. Settlements area, ha

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Settlements	**28,702**	**31,782**	**36,081**	**42,941**	**43,724**	**43,844**	**43,946**	**44,201**	**44,764**
Settlements Remaining Settlements	**27,997**	30,709	34,985	41,654	42,721	43,558	43,668	43,910	44,201
Land Converted to Settlements	**705**	1,074	1,096	1,287	1,003	286	278	291	563

The emission from the settlements is mainly caused by land use changes. The category of Settlements Remaining Settlements is carbon neutral and some emissions that are quite low in comparison with other sectors are due to conversion of the land use types to settlements.

The land use changes, and emission trends are calculated for the converted land for the reporting period 1990-2019. The quantity of the emitted CO_2 is quite low and vary in a very broad the ranges of 22.89 Gg CO_2-eq in 2014 up to only 6.30 in 2016 which is mainly due to the conversions of Cropland or in some cases Grassland to Settlements. During this conversions, certain quantities of CO_2 are emitted to the atmosphere, due to the cleaning of the vegetation. However, when settlements are established an urban vegetation and green areas are established as well, which should be taken into consideration. In this moment there are no reliable data for these areas' nether appropriate procedure its estimation.

Table 3-16. Emissions from settlements (CO_2-eq)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Settlements, Gg CO_2-eq,	**9**	**18**	**14**	**23**	**18**	**6**	**7**	**7**	**17**
Settlements Remaining Settlements	**0**	0	0	0	0	0	0	0	0
Land Converted to Settlements	**9**	18	14	23	18	6	7	7	17
Forest Land converted to Settlements	***0***	*3*	*0*	*4*	*6*	*5*	*5*	*3*	*9*
Cropland converted to Settlements	***4***	*11*	*10*	*17*	*6*	*1*	*1*	*2*	*6*
Grassland converted to Settlements	***6***	*4*	*5*	*2*	*6*	*0*	*2*	*2*	*2*
Wetlands converted to Settlements	***0***	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Other Land converted to Settlements	***0***	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Other land

The land that is occupied by some other land use type than Forest Land, Cropland, Wetland and Settlements is reported as Other land. Such category does not exist in the documents provided by State Statistical Office, or any other national document. However, there is class other land in CORINE LC, but it is not same other land as needed in this analysis. Therefore, the other land class was calculated as a difference between the total territory of Republic of Macedonia and sum of the land use classes Forest Land, Cropland, Wetland and Settlements.

Data for the total other land was developed as mathematical difference between territory of the Republic of Macedonia and land use classes: Forest Land, Cropland, Wetland and Settlements. Total area of Other land has declined significantly over

the period covered with this analysis, from almost 255 thousand ha. in 1990, down to bit less than 215,000 ha. in 2014, which is AN reduction of 40,000 ha. The highest intensity of decreasing is in the period 1990-2015, when significant areas of Other land were converted to Forest land and Grassland according to the findings.

Table 3-17. Other land area (ha)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Other land	**254,726**	**234,296**	**228,333**	**219,809**	**219,169**	**217,724**	**217,105**	**214,954**	**216,045**
Other land Remaining Other land	**250,286**	230,402	225,015	217,535	216,446	215,538	214,888	213,103	212,697
Land Converted to Other land	**4,440**	3,894	3,318	2,274	2,722	2,187	2,217	1,852	3,347

Emissions trend from this category of land use is significantly variable and fluctuate in a very vide ranges from only 33 Gg CO_2-eq in 2014, up to 163 Gg CO_2-eq in 2019. Out of the data presented in Table 3-18, it can be noticed that this variability of the emissions over the analysed period is mostly result to the emissions aroused with conversions of forest land to Other land. In some years like 2014, when conversions of Forest land are absent, the emissions are significantly low. Still, it should be noted, that certain categories of land use, like pastures, other land, and certain sub-categories of Forest land, during the process of photointerpretation of satellite images can be very easily mixed, so this variability of the conversion of Forest land might be result to this reason.

Table 3-18. Emissions from Other land (CO_2-eq)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Other land, Gg CO_2-eq	**121**	**96**	**74**	**33**	**68**	**127**	**71**	**118**	**163**
Other land Remaining Other land	0	0	0	0	0	0	0	0	0
Land Converted to Other land	121	96	74	33	68	127	71	118	163
Forest Land converted to Other land	*71*	*50*	*32*	*0*	*29*	*102*	*41*	*96*	*125*
Cropland converted to Other land	*47*	*41*	*37*	*30*	*33*	*19*	*24*	*19*	*19*
Grassland converted to Other land	*3*	*4*	*5*	*3*	*7*	*6*	*7*	*3*	*19*
Wetlands converted to Other land	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Other Land converted to Other land	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

3.3.3.3 Aggregate sources and non-CO_2 emissions sources on land

Non-CO_2 emission refers to the practices in the AFOLU sector, which result in an emission of so-called non-CO_2 GHG, like NOx, CO, CH_4. There are many management practices and inputs which a considered as important source of non-CO_2 emissions. The emissions considered here are from different sources, like:

a. Emission from biomass burning on Land, especially burning of Forest and Pastures, as well as burning of agricultural by-products,

b. N_2O direct and indirect emission from managed soils, including indirect N_2O emissions arousing from the inputs of N containing urea and mineral fertilizers, and liming which is a practice used for changing of soil reaction. In this case significant quantities of lime are used which provokes emission of non-CO_2 gases. Liming is not a common practice in the country. As a result of this and inexistence of data, liming is not reported.

c. NOx emission manure management is another significant source of NOx

The non-CO_2 emissions for the period 1990-2016 are slightly variable from 307.8 Gg CO_2-eq in 20000 up to 369.11 Gg CO_2-eq in year 2016. For the past 3 years from 2017-2019, the non-CO_2 emissions are significantly higher, which is due to the increasing of the values of three key sources of non-CO_2 gases: direct and indirect emissions from managed soils and indirect emission from manure management. Emissions for these three reporting years are threefold higher compared to the period 1990-2014 (see table below). This increase is most likely result to the newly adopted methodology of calculations in livestock sector (Tier-2) and the new version used for the calculation of these last three years of the inventory.

As for the other two sources of non-CO2 emissions, urea application has its highest values in the period 1990-2000, then significantly decrease. In the period 2005-2016 its values are around 1.5-1.7 Gg CO_2-eq, when the values rises again and in the past 3 years (2017-2019) are in the ranges of 2,6-2.8 Gg CO_2-eq. Emissions from rice fields are also variable and vary in a ranges of 29.17 Gg CO2-eq in 1990 to only 12.11 Gg CO_2-eq in 2015. In the period 2014-2016 are again above 20 Gg CO_2-eq, and in the past three years drops to around 15 Gg CO_2-eq. Emissions from rice fields, is directly dependent to the areas sown with this crop.

Table 3-19. GHG emissions from Aggregate sources and non-CO_2 emissions sources on land (in Gg CO_2-eq)

Categories	1990	2000	2005	2014	2015	2016	2017	2018	2019
Aggregate sources and non-CO_2 emissions sources on land	**359**	**308**	**327**	**336**	**344**	**369**	**699**	**664**	**544**
Urea application	4	4	1	2	2	2	3	3	3
Direct N2O emissions from managed soils	210	182	209	207	210	225	434	413	343
Indirect N_2O emissions from managed soils	81	68	76	75	75	81	148	140	114
Indirect N_2O emissions from manure management	35	32	29	29	35	39	98	94	68
Rice cultivations	29	23	12	24	23	23	16	15	17

3.3.4 Waste

The categories reported under the waste sector are Solid Waste Disposal, Biological Treatment of Solid Waste, Incineration and Open Burning of Waste, and Wastewater Treatment and Discharge. The data categorization format is consistent with previous years to preserve the existing time series, except in sectors where data was introduced.

According to the National Waste Management Plan 2009 – 2015, the solid waste generated in Macedonia is mostly disposed on non-compliant landfills. The landfill Drisla, serving the Skopje region, with approximately 590,000 habitants, is the only permitted landfill in Macedonia and it is relatively well managed. There are around 50 operational municipal non-compliant landfills. The need for improvement of their waste management practices has been recognized in the national, regional, and local waste management strategic documents.

In the inventory prepared in the BUR3 framework, the Solid Waste Disposal emissions are estimated in accordance with the IPCC 2006 Guidelines using the IPCC Inventory Software, which impose the First Order Decay (FOD) methodology. It produces a time-dependent emission profile that reflects the true pattern of the degradation process over time. Having in mind that solid waste disposal sites contribute the most to the sector's emissions, as well as the fact that country specific historic data on the amount of disposed waste are available, Tier 2 methodology has been used. Recent documentation reporting the amount of composted waste has made the relevant data available for the period 2011-2019. Because biological treatment of solid waste is not a widespread practice in Macedonia so country specific emission factors have not been assessed so far. Consequently, Tier 1 was applied for the estimation for the gases emitted from biological treatment of solid waste. Following the IPCC 2006 Guidelines, the Incineration and Open Burning of Waste and the Wastewater Treatment and Discharge are not found to be key sectors, thus, Tier 1 methodologies have also been applied for these sectors.

The calculations show that the Waste sector is one of the sectors with an increasing GHG emissions trend, achieving 635 Gg CO_2-eq in 2019, which is 56% more than the 1990-level or nearly 5% more than the 2016-level. Out of all the sectors, the Solid Waste Disposal category's emissions are most significant, participating with almost 80% in the total GHG emissions in 2019 (Table 3-20). The second category with a considerable amount of GHG emissions is Wastewater Treatment and Discharge, which participates with around 17% in 2019. Incineration and open burning of waste category contribute to 3.6% of the total Waste sector emissions in the last five reported years. The CH_4 and N_2O emissions from the Biological Treatment of Solid Waste category do not contribute essentially to the overall emissions due to the small amount of reported composted waste. Around 92% of the GHG emissions in the last three years of the reporting period are CH_4, while N_2O and CO_2 participate with 7% and 1%, respectively (Figure 3-13).

Table 3-20. GHG emissions from the Waste sector, by category (Gg CO_2-eq)

	1990	2000	2005	2014	2015	2016	2017	2018	2019
Waste	**407**	**413**	**435**	**574**	**595**	**607**	**611**	**622**	**635**
Solid Waste Disposal	266	299	316	441	455	470	481	491	505
Biological Treatment of Solid Waste	0	0	0	1	1	1	1	0	0
Incineration and Open Burning of Waste	9	10	14	22	23	23	23	23	23
Wastewater Treatment and Discharge	132	104	105	110	115	113	107	107	108

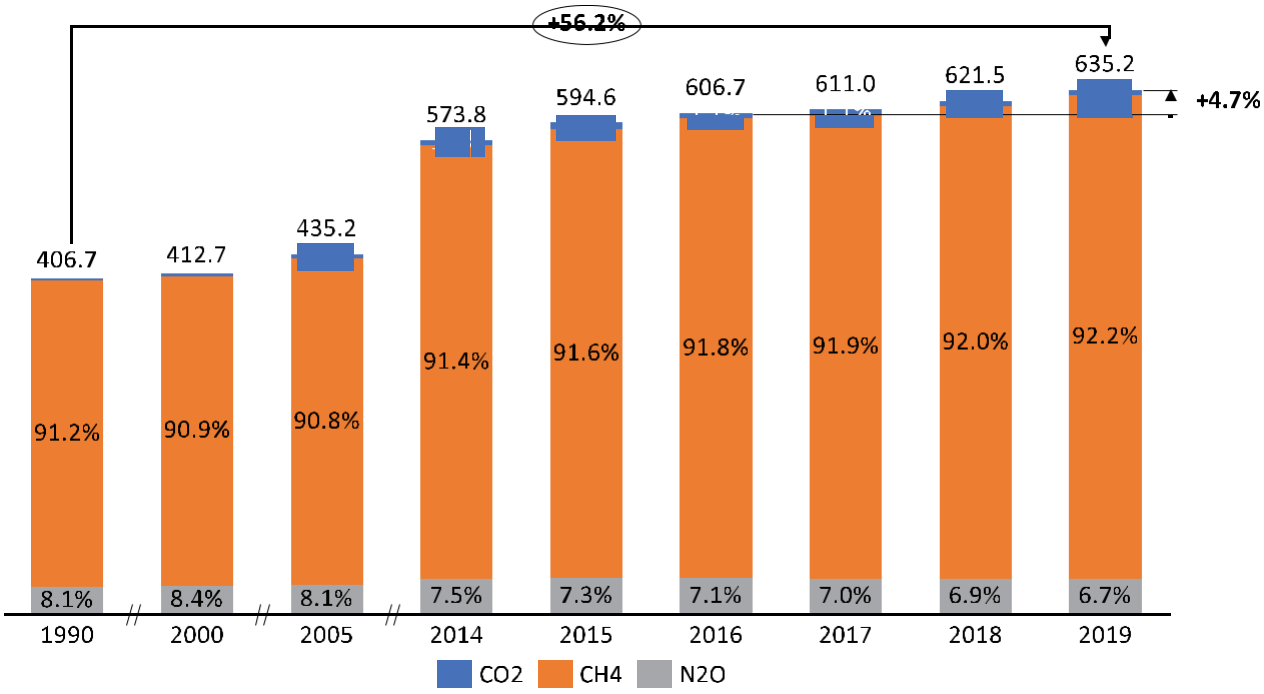


Figure 3-13. GHG emissions from the Waste sector, by gas (in Gg CO_2-eq)

3.3.4.1 Solid waste disposal

Treatment and disposal of municipal and industrial solid waste produces significant amounts CH_4. A waste by composition approach was applied in the First Order Decay (FOD) calculation. Macedonia is categorized as an Eastern European country; hence, the DOC parameter and methane generation rate constant (k) were assumed to be equal to their corresponding default values provided in the IPCC 2006 Guidelines. As it was mentioned above, based on the latest national waste management plans domestic shares for composition of municipal solid waste are created.

The results show that the amount of CO2-eq emissions from solid waste disposal have been constantly rising achieving 510 CO_2-eq in 2019 (Figure 3-14). Compared to 1990 CO_2-eq emissions in 2019 are 90% higher, while compared to 2016 around 8%.

Municipal solid waste participates with around 90% over the reporting period.

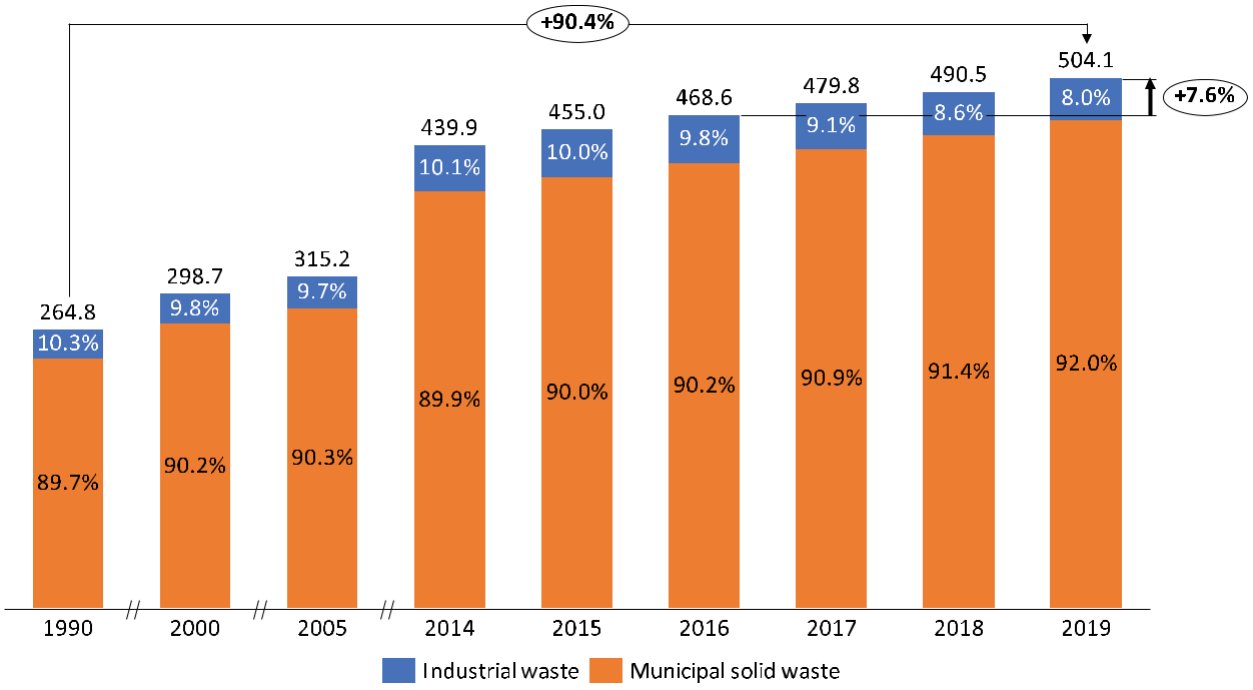


Figure 3-14. Emissions of CH4 from Solid Waste Disposal (in Gg CO_2-eq)

3.3.4.2 Biological treatment of solid waste

Biological treatment of solid waste in Macedonia is represented by the composting of waste. The existence of composting facilities has been acknowledged in the past, but it is only recently that data on the amount of composted waste has been reported. Methane is formed in anaerobic section from the compost, but it is oxidized to a large extent in aerobic sections of the compost. Composting can also produce emissions of N_2O. As no country-specific emission factors exist, default values have been used.

The emissions from composting have been estimated period, 2011 – 2019, but here only the years from 2014 to 2019 are reported. Observance shows that they are very low, i.e., around 1 Gg CO_2-eq, and decreasing in the last two years. Nevertheless, it may be concluded that the composting practice has become present to the extent that the amount of composted waste is worth reporting, which may be considered as progress. The same cannot be stated for years prior to 2011. The amount of waste composted in 2016 is equal to 2,239 t, while 1,115 t and 745 t had been composted in 2017 and 2018, respectively. The amount of composted waste for 2019, was provided by MOEPP with note that the low value is mainly due to the lack of information from all municipalities. Around 58% of the GHG emissions from Biological treatment of solid waste is CH_4, while the rest are N_2O (Figure 3-15).

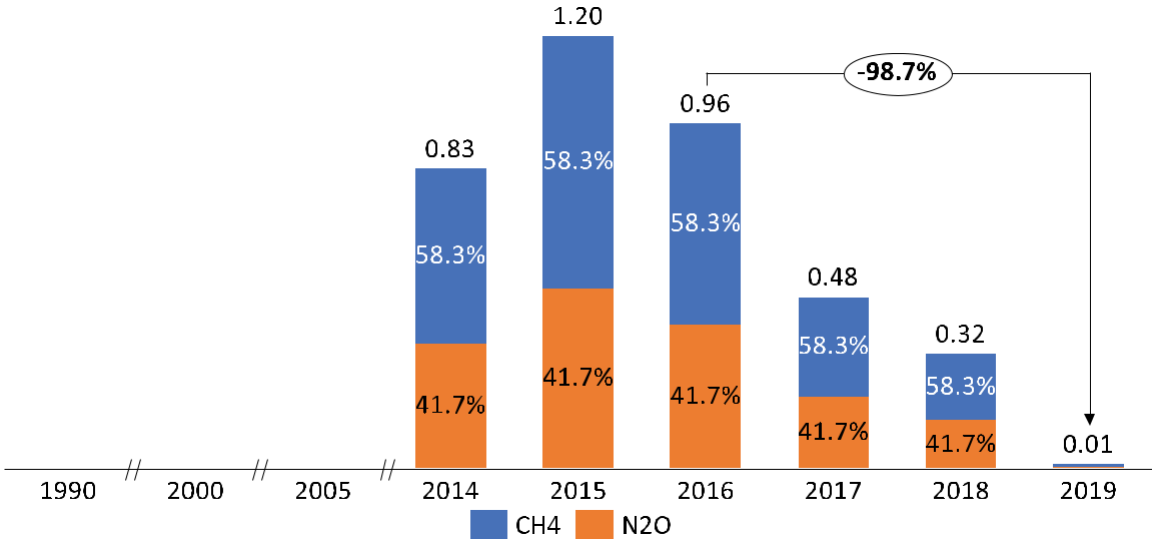


Figure 3-15. GHG emissions from Biological Treatment of Solid Waste (in Gg CO_2-eq)

3.3.4.3 Incineration and open burning of waste

Waste incineration is defined as the incineration of solid and liquid waste in controlled incineration facilities. The Drisla landfill is the only big landfill that has waste incineration facility and only medical waste is incinerated at this site. The greenhouse gas emissions from incineration of medical waste (since 2000) are considered in this report.

The emissions of carbon dioxide, methane and nitrous oxide have been estimated for this category. Methane emissions are most significant and represent most of the total emissions of the gases emitted through open burning. These emissions participated with around 56% in the last five years, while the share of CO_2 and N_2O is 29% and 15%, respectively (Figure 3-16). Most of the emissions are coming from Open Burning of Waste (98%).

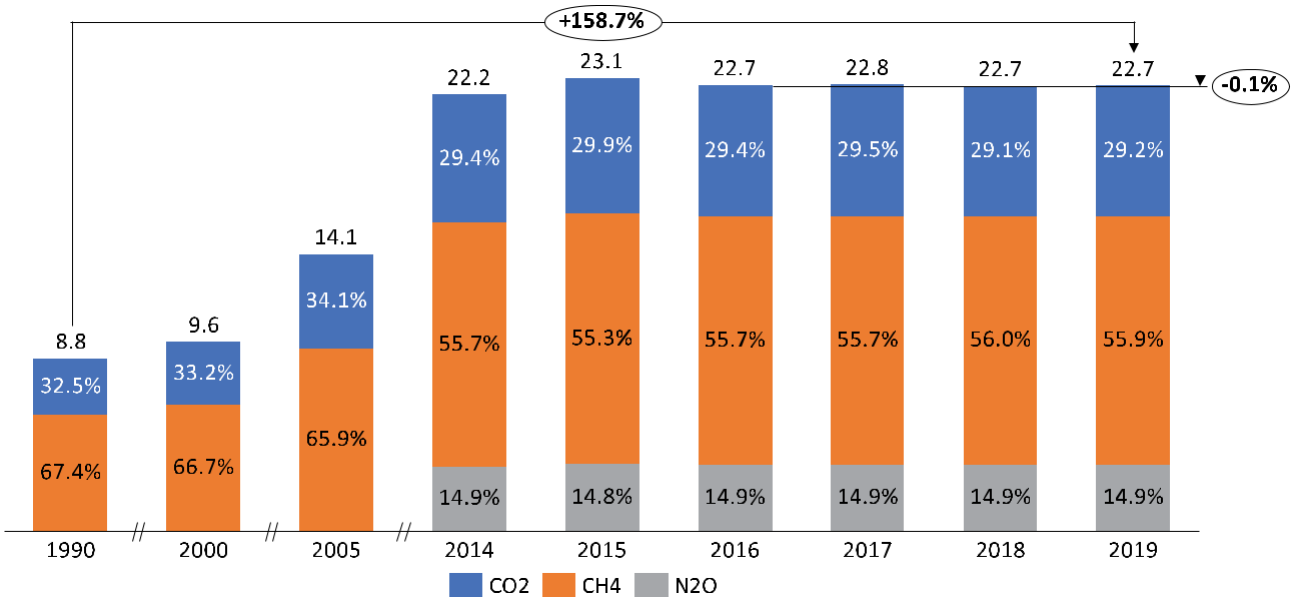


Figure 3-16. GHG emissions from Incineration and Open Burning of Waste by gasses (in Gg CO_2-eq)

3.3.4.4 Wastewater treatment and discharge

Wastewater can be a source of CH_4 when treated or disposed anaerobically. It can also be a source of N_2O emissions. CO_2 emissions from wastewater are not considered in the IPCC Guidelines because these are of biogenic origin and should not be included in national total emissions.

Wastewater originates from a variety of domestic, commercial, and industrial sources and may be treated on site (uncollected), seweged to a centralized plant (collected) or disposed untreated nearby or via an outfall. Domestic wastewater is defined as wastewater from household water use participating with around 50% in the overall emissions from the Wastewater treatment and discharge sub-category.

Domestic wastewater treatment and discharge is not a key source of GHG emissions, so the default parameters and emissions factors have been used. The GHG emissions in this category depend on the population size so the emissions gradually increase achieving around 60 CO_2-eq in 2019. Most of the of the emissions are N_2O (66%) associated with the degradation of nitrogenic components in the wastewater, such as urea, nitrate, and protein while the rest 34% are CH_4 emissions (Figure 3-17). It should be noted that the GHG emissions from this category account for 55% of the emissions in the category Wastewater Treatment and Discharge.

Methane emissions account for all the emissions which are the result of industrial wastewater treatment and discharge. The emissions in 2019 are 11% lower compared to 2016, and 40% lower compared to 1990. The share of emissions from industrial wastewater treatment and discharge out of the total emissions in the category Wastewater Treatment and Discharge are 47% in 2016, and around 44% in 2017, 2018 and 2019.

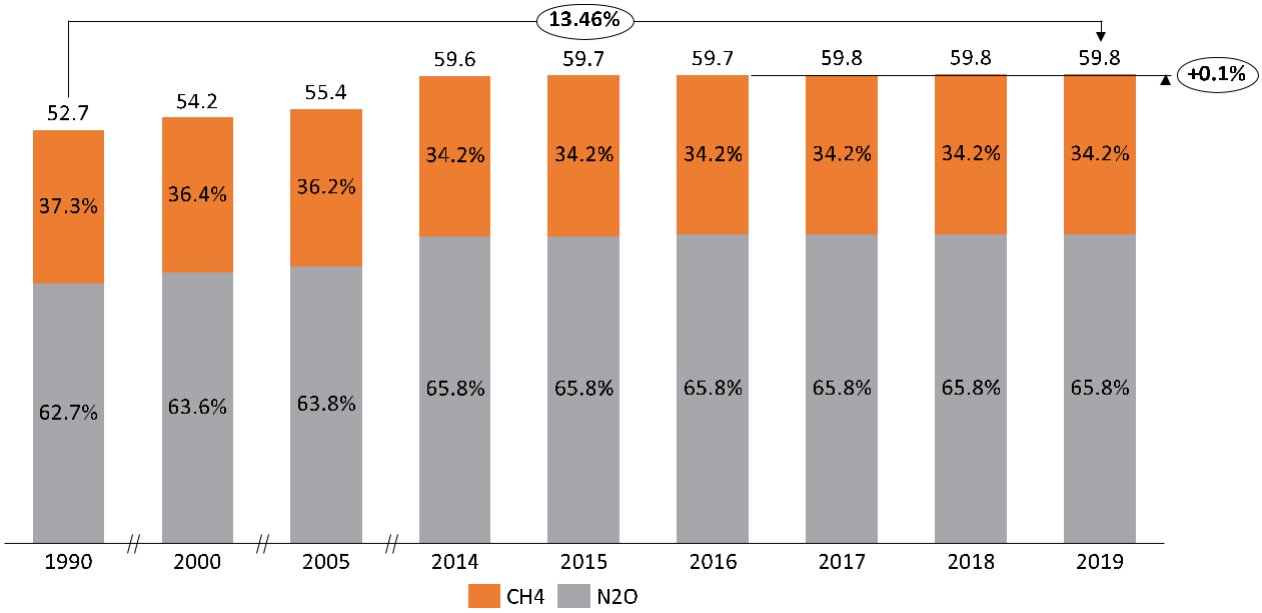


Figure 3-17. Emissions of CH_4 from Domestic Wastewater Treatment and Discharge, by gas (in Gg CO_2-eq)

3.4 Key source analysis

The analysis of key categories that contribute the most to the absolute level of national emissions and removals (level assessment) and to the trend of emissions and removals (trend assessment) is conducted using Approach 1. According to this approach, key categories are identified using a pre-determined cumulative emissions threshold. When summed together in descending order of magnitude, key categories are those that add up to 95% of the total level/trend.

The level assessment is performed for 1990 as a base year and 2019 as the latest year. The results in Gg CO_2-eq and percentages (up to 95%) for 2019 are shown in Figure 318. Consequently, the categories with the highest (absolute) values of Gg CO_2-eq (both emissions and removals) include Energy Industries – Solid Fuels (31%) (Energy sector), Road Transportation (17.5%) (Energy sector), Forest Land Remaining Forest Land (8.7%) (AFOLU sector), Enteric Fermentation (4.8%) (AFOLU sector), Solid Waste Disposal (3.9%) (Waste sector) and Manufacturing Industries and Construction – Solid Fuels (3.9%) (Energy sector). Usually, the Forest land category is relevant for sinks, but the estimates for 2019 show emissions from this category due to forest fires/wildfires.

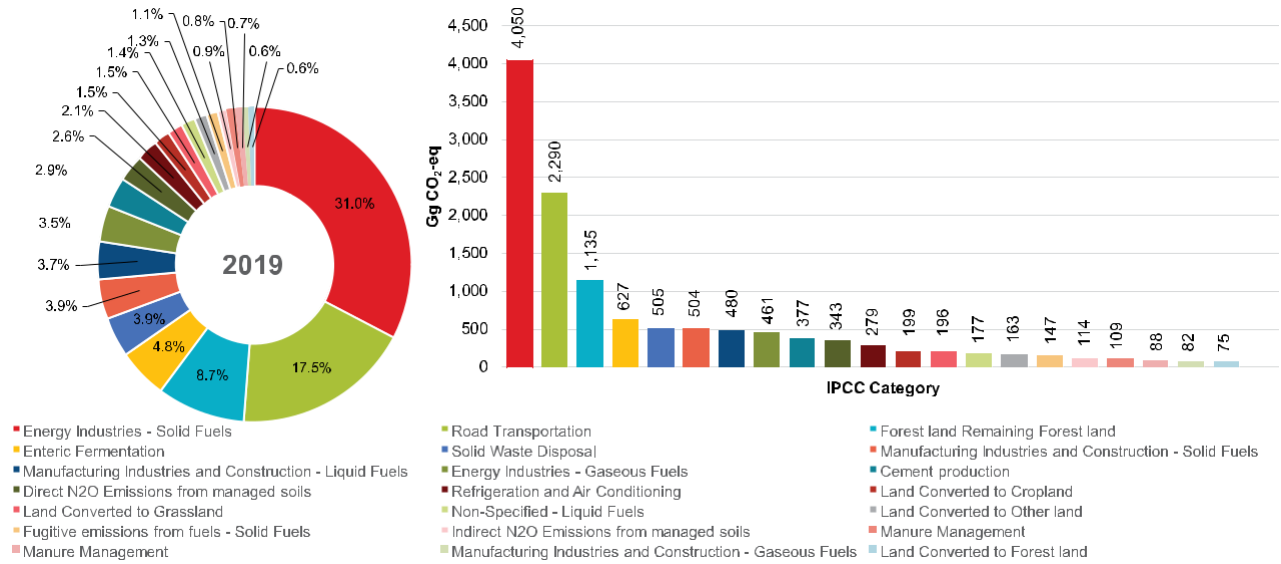


Figure 3-18. Level assessment of key categories and their contribution in 2019

The identified key categories, with both level and trend assessment, for 2019 are summarized in Table 321. For two of the four categories identified as key in the inventory only with the trend assessment (2.C.3 Aluminium production - PFCs; and 2.C.6 Zinc Production - CO_2), such processes no longer exist in the country. There has been no zinc production since 2003, and for aluminium production, there was a significant drop after 2003 when the biggest firm was closed, and no such activity occurs after 2012.

Table 3-21. Summary of key category analysis in 2019

	IPCC Category code	IPCC Category	Greenhouse gas	Identification Criteria	Comment
1	1.A.1	Energy Industries - Solid Fuels	CO_2	L1, T1	
2	1.A.3.b	Road Transportation	CO_2	L1, T1	
3	3.B.1.a	Forest land Remaining Forest land	CO_2	L1, T1	
4	3.A.1	Enteric Fermentation	CH_4	L1	
5	4.A	Solid Waste Disposal	CH_4	L1, T1	
6	1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	L1, T1	
7	1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	L1, T1	
8	1.A.1	Energy Industries - Gaseous Fuels	CO_2	L1, T1	
9	2.A.1	Cement production	CO_2	L1	
10	3.C.4	Direct N2O Emissions from managed soils	N_2O	L1, T1	
11	2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	L1, T1	
12	3.B.2.b	Land Converted to Cropland	CO_2	L1, T1	
13	3.B.3.b	Land Converted to Grassland	CO_2	L1, T1	
14	1.A.5	Non-Specified - Liquid Fuels*	CO_2	L1, T1	
15	3.B.6.b	Land Converted to Other land	CO_2	L1	
16	1.B.1	Fugitive emissions from fuels - Solid Fuels	CH_4	L1, T1	
17	3.C.5	Indirect N2O Emissions from managed soils	N_2O	L1	
18	3.A.2	Manure Management	N_2O	L1	
19	3.A.2	Manure Management	CH_4	L1	
20	1.A.2	Manufacturing Industries and Construction - Gaseous Fuels	CO_2	L1, T1	
21	3.B.1.b	Land Converted to Forest land	CO_2	L1	
22	1.A.4	Other Sectors - Liquid Fuels**	CO_2	T1	
23	1.A.1	Energy Industries - Liquid Fuels	CO_2	T1	
24	2.C.2	Ferroalloys Production	CO_2	T1	
25	2.C.6	Zinc Production	CO_2	T1	*NO since 2003*
26	2.C.3	Aluminium production	PFCs	T1	*NO since 2012*

Notation keys: L = key category according to level assessment; T = key category according to trend assessment; L1 – Level assessment, Approach 1; T1 – Trend assessment, Approach 1; NO = Not Occurring.

***Non-specified** - as a category under the Fuel combustion activities in Energy sector

****Other** sectors – as a category under the Fuel combustion activities in Energy sector, consisted of the subcategories Commercial/Institutional, Residential and Agriculture/Forestry/Fishing/Fish farms

3.5 Uncertainty estimation

There are two basic approaches for determining uncertainty of the inventories: Approach 1 (Error Propagation method) and Approach 2 (which is an implementation of the Monte Carlo method). As a well-established practice in the previous inventory reports, both methods are implemented for the purpose of this inventory, and a comparison between them is made.

The Approach 1 is based upon Error Propagation method, and it is very easy to use because it is already implemented in the IPCC Inventory Software. This uncertainty tool of the software calculates the uncertainty of the whole inventory for a given year, as well as uncertainty in trend between a year of interest and a base year. Although, the software does not determine disaggregated results at sector level, they can be calculated in spreadsheet software implementing the well-known equations for Approach 1 - Error Propagation method. For the purposes of this inventory, this method was implemented in Excel, so that uncertainty results by sector are calculated.

The second approach according to which the uncertainty can be calculated is the Monte Carlo method. According to this method, random values of the input variables are selected from within their probability density function and the corresponding output is calculated. This procedure is repeated many times or until the mean and the distribution of the output variables do not change. The input variables may include activity data, emission factors, conversion factors etc. and the output variable is the quantity of emissions.

3.5.1 Input data

To calculate the uncertainty of the emissions for each sector separately, as well as the uncertainty of the total annual emissions, it is first needed to define uncertainty values for the input data. The IPCC Inventory Software allows input of uncertainty for activity data and emission factors. Based on these data the software automatically calculates uncertainty using the Error Propagation method (Approach 1). The disadvantage of this approach is that in certain sectors where activity data and emission factor is composed of multiple inputs that have different uncertainty, those must be summarized in just two values for activity data and emission factors. Therefore, this introduces further uncertainty in the calculations. As stated previously, for the Monte Carlo method (Approach 2) a special tool has been created, which allows input of uncertainty for each input data separately.

The input data in the Energy sector, according to the Guidelines, as well as according to the confidentiality of the available resources in Macedonia is the most reliable. Accordingly, the values of the uncertainty for activity data and emission factors are set to 5% in both methods (Table 3-22). Additionally, in the IPPU sector the same input data for uncertainty are used in both methods (Table 3-22). In these two sectors, the calculations of the emissions mainly depend only on the two inserted values for activity data and emission factors, therefore it was decided to use uncertainty only for these two variables.

Table 3-22. Input data for uncertainty in the IPCC Inventory Software and Monte Carlo method for Energy and Industrial Processes and Product Use sectors (in %)

	Activity data uncertainty	Emission factors uncertainty
Energy	5	5
Industrial Processes and Product Use		
Mineral Industry		
Cement production	10	3
Glass Production	5	30
Other Process Uses of Carbonates		
Ceramics	3	5
Other Uses of Soda Ash	3	5
Other	3	5
Chemical Industry		
Soda Ash Production	5	5
Metal Industry		
Iron and Steel Production	10	5 (CO_2)
Ferroalloys Production	5	5 (CO_2 and CH_4)
Aluminium production	2	10 (CO_2) and 50 (PFC)
Product Uses as Substitutes for Ozone Depleting Substances		
Refrigeration and Air Conditioning		
Refrigeration and Stationary Air Conditioning	5	5 (HFC)

For the other two sectors - AFOLU and Waste, as activity data and emission factors are mainly calculated on the basis of multiple input data, as well as according to the directions given in the Guidelines, in the Monte Carlo method the uncertainty for each input data is entered separately (as presented in Table 3-23 and Table 3-24). When entering uncertainty in IPCC Inventory Software for these two sectors, an approximation is made to represent all these values for uncertainty by only two values by subcategory, given in Table 3-25.

To determine the input values for uncertainty in each sector, the corresponding Guidelines were followed. In most of the cases, the default IPCC values are used, however for the Livestock sub-category activity data a lower level of uncertainty is used because in the Republic of North Macedonia there are subsidies for livestock, so the number of livestock is reported by the owners which reduced the level of uncertainty.

Table 3-23. Input data for uncertainty in the Monte Carlo method for AFOLU sector (in %)

	Uncertainty
AFOLU	
Livestock	
Number of animals	5
Emission Factor	30
Land	
Forest Land	
Wood/firewood removal	20
Area	20
Fraction of biomass lost in disturbance	15
Biomass conversion and expansion factor	5
Ratio of below-ground biomass to above-ground biomass	5
Carbon fraction of dry matter	5
Cropland, Grassland, Settlement and Other Land	
Area	20
Annual biomass carbon growth	75
Annual loss of biomass carbon	75
Dead wood/litter stock, under the old land-use category	10
Stock change factor for land-use system	20
Stock change factor for management regime	15
Stock change factor for C input	20

Table 3-24. Input data for uncertainty in the Monte Carlo method for Waste sector (in %)

	Uncertainty
Waste	
Solid Waste Disposal	
Total Municipal Solid Waste	20
Fraction of MSW_T sent to SWDS	20
Degradable Organic Carbon	20
Fraction of Degradable Organic Carbon Decomposed	20
Methane Correction Factor	
=1.0	10
=0.8	20
=0.5	20
=0.4	30
=0.6	50
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	5
GDP	5
Waste Generation Rate	10

Table 3-25. Input data for uncertainty in the IPCC Inventory Software for AFOLU and Waste sectors (in %)

	Activity data uncertainty	Emission factors uncertainty
AFOLU		
Livestock	5	30
Land		
Forest land		
Forest land remaining Forest land	20	10
Land Converted to Forest land	10	10
Cropland, Grassland, Settlement and Other Land		
Land remaining Land	20	50
Land Converted to other Land	10	50
Waste	20	20

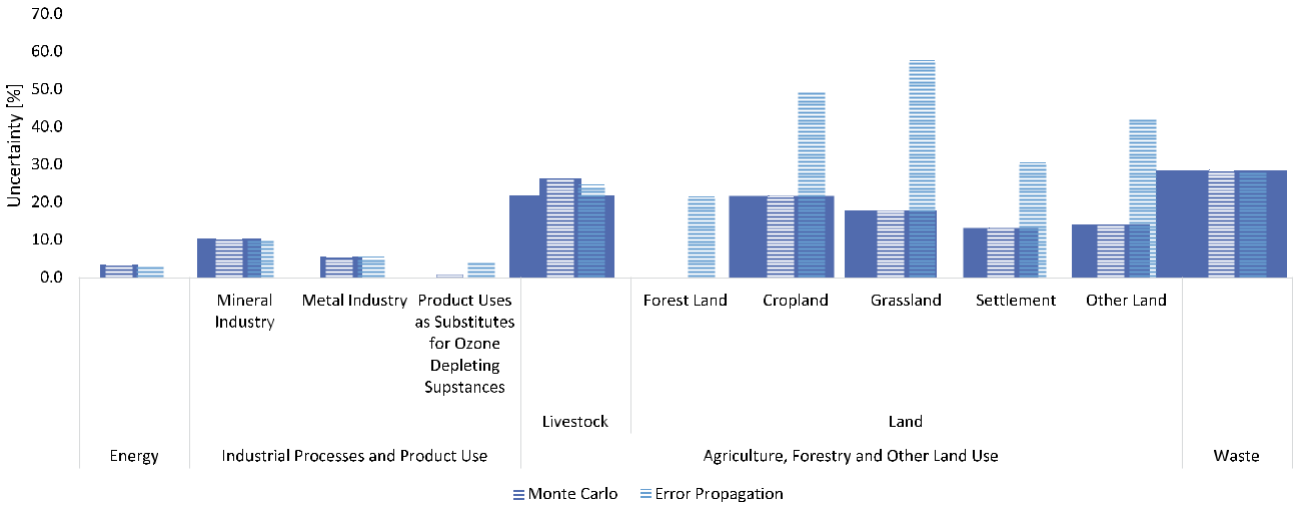
For the Monte Carlo method it is assumed that each input variable has normal distribution.

3.5.1.2 Comparison between Error Propagation method (Approach 1) and Monte Carlo method (Approach 2)

If we compare the Monte Carlo and the Error Propagation method, by subcategory (Figure 3-19), it may be noted that there are no significant differences in the obtained results for the Energy and IPPU sectors, except for the Product Uses as Substitutes for Ozone Depleting Substances subcategory. According to the Monte Carlo method, there is uncertainty of the input data (in this case only of imports), which in the final emissions for that year participate with a small percentage, while the greater part comes from the emissions from previous years.

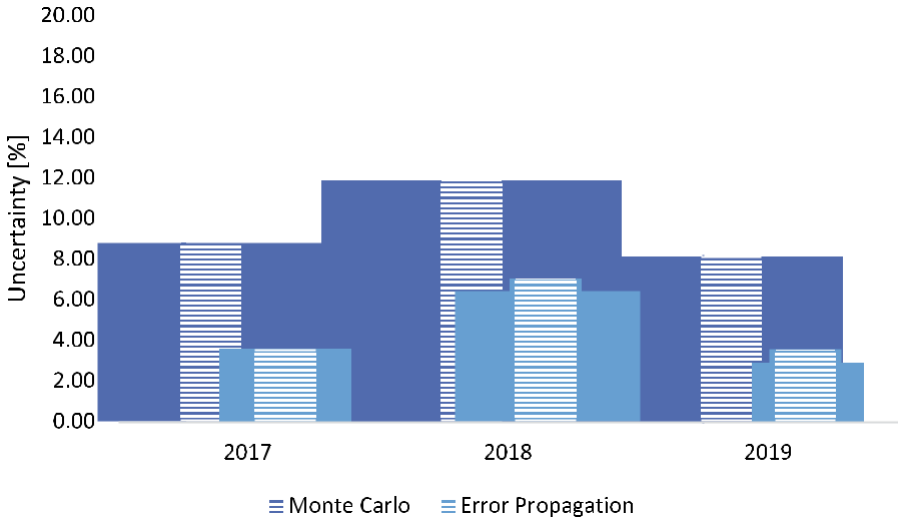
However, there are major differences in the other two sectors, due to the inability to accurately set uncertainty to all variables in the IPCC Inventory Software, i.e., the fact that all the uncertainty should be reduced to only two values (for activity data and emission factors), as previously mentioned.

Figure 3-19. Comparison of Monte Carlo and IPCC Inventory Software method by subcategory for 2018



Obviously, these differences in the emissions by subcategory when using the two approaches leads to different uncertainty in the total annual emissions (Figure 3-20). However, it can be concluded that the trend of uncertainty by year in both methods is the same, i.e., increases with the increase of the share of sectors with higher uncertainty.

Figure 3-20. **Comparison of the total yearly uncertainty between the Monte Carlo method and IPCC Inventory Software method**



From the finding that the mean emissions from all iterations in the Monte Carlo method is nearly equal to the actual estimates of the emissions and that in this method individual uncertainty for each variable may be used (which is according to the Guidelines), it can be concluded that the results obtained from Approach 2 are much more relevant.

As it is presented, the highest uncertainty is in the Waste sector. This is primarily due to the large number of variables that have uncertainty, such as the total amount of municipal waste, the fraction of that amount sent to SWDS percentage wear landfill, methane correction factor, GPD and waste generation rate.

Furthermore, there is great uncertainty in the Livestock subcategory. Following are the remaining subcategories from the AFOLU sector, where the main source of uncertainty are the areas of each type of land, as well as the areas that have been converted to other area type. However, according to the Guidelines there is also high uncertainty in the values for annual biomass carbon growth and annual loss of biomass carbon.

3.6 Good practices, improvements, and recommendations

The Summary report of the Technical analysis of the Macedonian BUR2 (TASR.2) stated that the country has reported all elements of the required information on greenhouse gases per the BUR guidelines (conclusions summarized in Table 1 of Annex I of the TASR.2) and commended North Macedonia for the level and detail of the information provided in the NIR. Therefore, this NIR was developed in the same manner, following the good practices from the previous BURs. During the preparation of this NIR, the BUR3 Technical analysis was not completed; for that reason, the Inventory team will consider the TASR3 recommendations in the next NIR.

3.6.1 Energy sector

Good practices ***(GP)***/Improvements ***(I)*** in the NC4:

- ***I:*** The GHG emissions from the Road Transportation were recalculated at a more disaggregated level, by subcategories available in the IPCC Inventory software, which include passenger cars (with and without 3- way catalysts), light-duty trucks (with and without 3-way catalysts), heavy-duty trucks and busses and motorcycles, evaporative emissions from vehicles, and emissions associated with catalytic converter use in road vehicles, i.e., urea-based catalysts. The emissions were estimated based on the fuel consumption by type of vehicle (derived from the COPERT database data from the National Road Transport Emission Inventory).

- ***GP:*** The category *Diesel and Heating Oil* used in the Energy balances until 2011 has been separated into *Road Diesel and Heating & Other fuel oil* in the updated Energy balances from 2005 onwards. Similarly, the *Biomass* category has been separated into *Biomass* and *Wood Wastes, Wood Briquettes and Pellets* and *Wood of fruit trees and other plant residues.* The advantage of the disaggregation has been reflected in this NIR and different NCVs are used in the IPCC Inventory Software for all these categories.

- ***GP/I:*** National emission factors are used for lignite, residual fuel oil and natural gas in Energy sector, Fuel combustion activities. The county-specific emission factors for natural gas were updated for 2017, 2018 and 2019.

- ***GP:*** The average CO_2 emission factor from the 2019 Refinements to the 2006 IPCC Guidelines was considered for the fugitive emissions from fuels, specifically surface mines.

Recommendations for future inventories:

- Secure and constant channels for acquiring data on composition and carbon content of fuels should be established with relevant institutions to facilitate the estimation of country specific emission factors. This can be achieved by signing some kind of agreement, for instance, a Memorandum of Understanding.

- Considering that several biogas power plants are operating in the country, their electricity production should also be included in the subsequent inventories. Since there is no reliable information on biogas production, it is suggested that the subsequent BURs further investigate the biogas production processes in the country. It would be helpful to have a separate study for each of the few biogas plants, bearing in mind that this type of technology is expected to be used more in the future.

3.6.2 IPPU

Good practices (GP)/Improvements (I) in the NC4:

- ***I*:** The HFCs emissions have been recalculated for the period 2012 – 2016, and new calculations have been made for 2017 -2019, using the updated data on import of HFCs and blends provided by the Ozone Unit of the MOEPP

Recommendations for future inventories:

- More detailed data regarding the carbon content of the feedstock in the following sectors: cement production, lime production and steel production. These data can be gathered directly from the industrial plants.

- Segregated data for the F-gas emissions from refrigeration and air-conditioning for the specific part of the equipment life cycle. These data should be collected by the Ministry of Environment and Physical Planning.

- F-gas emissions from fire protection, aerosols and solvents or reiteration that emissions from these categories are not occurring in the country.
- N2O emissions from medical appliances.
- SF6 emissions from use and disposal of electrical equipment.

3.6.3 AFOLU

3.6.3.1 Livestock

Good practices/improvements:

- Inventory of the GHG emissions in livestock for the current report was done with background data from State Statistical Office. Data for small dairy and swine farms were classified according to the survey findings in late 2019. There were results for breed used, farm management and feeding system, and manure management system in the survey. The survey enabled the use of Tier 2 for dairy cattle and swine, the highest emitters of GHG in livestock. Also, data for manure used in biogas power plants were considered. Since 2015 two power plants of 3 MW each and one plant of 1 MW have been operational. The first two plans in biogas digesters use corn silage and manure from two dairy farms. Liquid manure of 440 m3 has been collected daily (50 t daily manure and the rest is technical water). The last one (1 MW power plant) use 9 t poultry manure (layers) and 5-10 t liquid swine manure. During the emission estimation, the corresponding manure quantities from dairy cattle, swine, and layers were assigned under anaerobic digesters.

Recommendations for future inventories:

- In preparation for the next emission inventory of GHG in livestock, a new survey should be conducted for the needs of Tier 2 application, unless other sources (State Statistical Office, MAFWE, MoEPP, FVA) would provide the required data.

3.6.3.2 Land use

The inventory of the GHG emissions for the BUR3 or the sector-agriculture, was based to the available national data from the SSO and Ministry of Agriculture, Forestry and Water Economy (MAFWE) and international data sources, like LandSAT (USGS), SENTINEL 2 (ESA_Copernicus) and FAO-Stat.

Data from the SSO and satellite images were used to estimate the area under certain land use category and its dynamics, which serve as activity data according IPCC methodology. Official data published by SSO refers to the area under certain Land Use type for a given year, while data for the areas converted from one to another category of land use were calculated on the base of the available graphical data sets (LandSAT and SENTINEL 2 satellite images).

The improvement of the assessment of GHG emissions from agricultural sector is important, particularly in establishing consistent data series Land use change has been calculated for the years 1989-1990, 1999-2000, 2004-2005, 2013-2019, while for the periods 1991-1998, 2001-2003 and 2006-2012, interpolation has been made to fill the gap years Based on the data gained with satellite images processing and interpolation the whole data base has been updated for the period 1990-2019.

The classification methodology used in this study has been specially developed for North Macedonia. In addition to the satellite data (Landsat and Sentinel), build-up data, digital surface model, and slope data were used. Landsat – 5 imageries has been used for the period between 1988 – 2005, Landsat – 8 for 2014, while for the period between 2015 – 2019, yearly Sentinel – 2 imageries have been used. Before constructing the dataset, atmospheric and geometric pre-processing was performed to the satellite images. Also, two commonly used remote indices were added to the dataset, namely, Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI). The first index is used for vegetation, while the second is used for open water mapping and monitoring. Afterward, the images have been fused with the additional data. One of the most common methods to obtain land use – land cover information from satellite images is remote sensing image classification. Image classification converts the data into meaningful information. Depending on the supervision, classifications can be supervised and unsupervised, while depending on the data type, two different classification types can be distinguished: pixel and object-based classification. As object-based classification has been proven to be superior to pixel-based classification, the satellite images were classified using object-based image analysis (OBIA). The OBIA was done using ruleset developed for the study area. In the first step of the OBIA segmentation was one where the pixels have been

converted into small objects, allowing the system to detect and classify every pixel with water content. For that purpose, a threshold to the NDWI data has been set. Also, the cropland and urban area were limited using the Slope data classifying the flat areas. The urban layer has been integrated into the dataset, and as the urban layer is a binary image, the urban areas have been classified with a simple threshold. To simplify the image, a second segmentation with different parameters creating larger object has been processed. The created objects have been observed, and the threshold values have been determined. For the Forest class, both NDVI and brightness values have been used. From the sample inspection, it has been noticed that forests have significantly lower brightness than the other objects such as natural grassland, pastures, and cropland. The Natural Grassland class has been classified using NDVI and elevation threshold. As at some area, grasslands have a low slope, and an additional rule has been applied where high flat areas have been classified as Natural Grassland. Generally, using only spectral information, it is hard to distinguish pastures from some cropland areas. Thus, the main difference between these two classes is the slope. Pastures have been classified using NDVI threshold, while croplands have been classified using slope since part of the croplands does not contain any vegetation during the summer period and have low NDVI value. The accuracy assessment of the results was done using 5.031 random points and have shown accuracy of 85% which is above the acceptable rate of 75% using middle spatial resolution remote sensing data.

As planned, the following remote sensing (RS) and earth observation (EO) activities is expected to be achieved for the next inventory reports:

- Regular (annual basis) assessment of the land use based on satellite imagery from the current year.
- Maintaining data derived from this activity in geo-data base and make it available for public
- Comparing data obtained from this activity with data provided by state statistical office
- Estimating land use changes on annual basis

This improvement in LU/LUC will allow moving forward in certain cases towards Tier 2, with regards to the activity data in Land subsector of AFOLU. In addition to the LU/LUC data, other activity data sets that needs to be improved, are:

- Mineral fertilizers use – types and quantities used
- Manure –quantity, quality, and management
- Plant organic residues and by-products-quantity and management

To move to higher Tier`s in the other sectors, an in addition to the proposed measures for development and improving of the existing LU/LUC data set and other activity data, particular attention should be paid to the development of national emission factors for assessing GHG emissions/removals taking into consideration:

- Field measurement of GHG emissions under various land use types, land management practices, and inputs,
- SOC dynamics under certain land use, management practices, and inputs
- Annual biomass productivity of perennial crops measurements (orchards, vineyards, forage, etc.)

This is complicated task and there is no other choice than building national capacities on assessing of this data that is not readily available in the country. This is serious gap that should be overcome through investment in capacity building, particularly in institutions from agricultural and environmental sector.

3.6.3.3 Forestry

Good practices/improvements:

- Implemented satellite images for land use change from and to Forest land (CORINE Land Cover) for 2000, 2006, 2012 and 2018, implementation of data from satellite imagery (ESA-Copernicus product – SENTINEL 2, 1990 -2019) for forest area land use change.
- Improved data for commercial and firewood removals
- Improved and updated data for burned forest area, using data from three different sources

- Improved data for annual growth and yield of different types of forests

Recommendations for future inventories:

- Forest inventory (PE “Nacionalni sumi”, MAFWE, Faculty of Forestry)
- Installation of software for annual evidence of the Land use change
- Develop local tables for annual growth of different species
- Develop system for monitoring the natural disturbance and prompt evidence
- Collect data for other non-wood products

3.6.4 Waste

Good practices ***(GP)***/Improvements ***(I)*** in the NC4:

- ***I*****:** The emissions from incineration of clinical waste have been recalculated for period 2000 -2019, based on the updated activity data available from the SWDS where the incineration is performed (SWDS Drisla).
- ***GP:*** More industry sectors have been introduced in the subcategory Industrial wastewater treatment and discharge based on SSO data. The data have been classified in the following industrial sectors: Alcohol Refining, Beer & Malt, Coffee, Dairy Products, Meat & Poultry, Organic Chemicals, Petroleum Refineries, Plastics & Resins, Pulp & Paper (combined), Soap & Detergents, Starch Production, Sugar Refining, Vegetable Oils, Vegetables, Fruits & Juices, Wine & Vinegar. The correlation with the SSO data was made using the NACE codes. At the same time a revision of the overall time series has been made and the inconsistencies identified in the previous BUR were corrected.

Recommendations for future inventories:

- Currently, for the Solid waste disposal there are no data on waste production by industry type. It is recommended for the next inventories to disaggregate the data for waste generated from manufacturing industries by industry types, to be able to use the default values of DOC and fossil carbon contents in industrial waste for specific industry types (as per the IPCC 2006 Guidelines, Vol. 5, Ch. 2, Table 2.5). This should be done in close collaboration with the SSO.
- To include data on sludge generation from wastewater treatment plants (WWTP). Currently, some of the input data to estimate these emissions are not available for all WWTP. Therefore, it is essential to study the current situation of the WWTP in terms of their operating status, type of treatment, wastewater treatment capacity, etc.

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4 Climate Change Mitigation

4.1 Introduction

This chapter is a summary of the Climate Change Mitigation Report developed for the TBUR (available at: https://klimatskipromeni.mk/data/rest/file/download/adf7e77db88fc604670906f8c8c1b54a9514efa0e95e4a893b4981b2c8300449.pdf), the NDC Implementation Roadmap for North Macedonia 2020-2030 (available at: https://api.klimatskipromeni.mk/data/rest/file/download/c86929c13f43f00f201b38ef166822904cf3568a881e997bc608433de987eb8f.pdf), and the the latest Climate Change Mitigation Report (June 2022).

The climate change mitigation analysis presented in this chapter is built upon the analyses conducted under the Third Biennial Update Report (2020) Mitigation Report, that builds upon and continues the analyses of previous studies: Second Biennial Update Report (2018), Third National Communication on Climate Change (2014), First Biennial Update Report (2015) and the Initial Nationally Determined Contributions (2015). Meanwhile, the national climate and energy policies have been completely merged in the National Strategy for Energy Development of the Republic of North Macedonia until 2040 (2019), the draft version of the National Energy and Climate Plan –NECP (2020) and of the Long Term Strategy on Climate Change (2020) were completed, and the Climate Change Mitigation Report for the Fourth National Communication was developed (2022).

The Republic of North Macedonia (Macedonia), a **non-Annex I party** to the United Nations Framework Convention on Climate Change (UNFCCC), ratified Paris Agreement in January 2018, with the following contribution to the global efforts for GHG emissions reduction (Macedonian NDC): "To reduce the **CO_2 emissions from fossil fuels combustion for 30%**, that is, for **36% at a higher level of ambition, by 2030** compared to the business as usual (BAU) scenario."

The focus of the Macedonian NDC is put on climate change mitigation, that is, on policies and measures which lead to GHG emissions reduction, and particularly to CO_2 emissions from fossil fuels combustion which covers almost 80% of the total GHG emissions in the country. The following sectors are of dominant share: energy supply, buildings, and transport. Vulnerable sectors and climate change adaptation shall be subject to a more detailed analysis in the future NDC submissions.

The country is in the process of converting to a legislative and regulatory framework that will be informed by the 2030 Climate and Energy Framework of the European Union. It will need to adopt a Long-term Climate Action Strategy and a Law on Climate Action. This initiative is being funded by a project entitled "Law and Strategy on Climate Change," which has been programmed under the EU Instrument for Pre-Accession Assistance (IPA II) funding mechanism.

The target for climate change mitigation in Macedonia is expressed as a reduction of greenhouse gas emissions and a reduction of net greenhouse gas emissions. The difference is that the FOLU sector is included in the GHG net emissions. The **goal** for 2050 are expressed in relation to 1990, as a base year and are:

- **53% GHG emissions reduction**
- **82% net GHG emissions reduction**

The ENDC Implementation Roadmap 2020-2030, published in November 2021, provides a pathway with concrete mitigation actions and financing needs to achieve the transformational change envisioned under the ENDC, which served as a foundation to develop the sectoral projections. To assess the mitigation potential of certain measures and policies, all sectors recognized by the Intergovernmental Panel on Climate Change (IPCC) methodology: Energy, Industrial Processes and Product Use, Agriculture, Forestry and Other Land Use and Waste have been modelled.

The scenarios were supplemented with socio-economic research and with additional case study that reflect the mitigation potential of the actions induced by the private sector (industry). Modelling and analysis are based on two scenarios for the period from 2013 to 2050:

- **Baseline scenario (Scenario without Measures - WOM)**: it assumes no major changes in technology, economics, or policies so that normal circumstances can be expected to continue unchanged.
- **Mitigation scenario (Scenario with Additional Measures - WAM)**: it includes the same measures than the WEM scenario, but with different levels of penetration which leads to a higher reduction of GHG emissions.

4.2 Sectoral projections and measures

Taking into consideration all national strategic and planning documents, 65 mitigation policies and measures (PAMs) were recognized out of which:

- 32 measures in the Energy sector,
- one measure in IPPU,
- five measures in the Waste sector,
- 11 measures in AFOLU, and
- 16 additional PAMs which are enablers of mitigation actions.

Each of these measures is presented with a separate table containing all the necessary information, progress of implementation (timeframe, expected results and costs, implementing entity), as well as progress indicators. In the Energy sector, some measures are defined three different paths of implementation that correspond to a different scenario. The effect of the mitigation measures regarding energy savings, emissions reduction and costs are presented in relation to the WOM scenario.

For each sector individually (Energy, IPPU, AFOLU and Waste), and for each measure/policy that is part of this scenario, tabular representation including the following information is given: the competent entities for their realization, the necessary investments, the source of funding and indicative emissions reduction (Gg CO_2-eq). The results of the mitigation scenario are first shown separately for each sector (due to the specificity of each of the sectors), and eventually, the aggregate results are obtained.

4.2.1 Energy sector

4.2.1.1 Baseline scenario in the energy sector

As support and help in forecasting the energy demand in the period until 2050, the MARKAL (MARKet ALlocation) program package is used. MARKAL is a complex model for planning the development of the overall energy sector at local, national and/or regional level.

The energy demand projections for the Baseline scenario over the considered planning horizon (2011 – 2050) are based on the exogenous economic and demographic projections (drivers) and assumptions regarding each service demand's sensitivity to changes in the assumed driver. The model must satisfy these demands in each period, by using the existing capacity and/or by implementing new capacity for end-use technologies.

In general, most of the assumptions in the Energy sector are based on the updated version of the Strategy for Energy Development up to 2040. These include projections of:

- GDP, an average growth rate of 3.8%
- Population, decline for 0.25%
- Prices of domestic fuels for the period 2012- 2020 (Energy Regulatory Commission)
- Fuel prices – gas, coal, oil (World Energy Outlook (WEO) 2017-2021)
- CO_2 emissions price (UNDP Study on CO2 tax in North Macedonia 2021 and WEO 2017-2021)
- The import price of electricity for the period 2012- 2021 (HUPX)

To assess the impact of different climate change mitigation policies and programs on the evolution of the energy system, a Baseline Scenario was developed, considering specific characteristics of the national energy system, such as existing technology stock, all possible new technology options, resource availability and import options, and near-term policy interventions. For this purpose, all available national data sources (State Statistical Office, National energy balances, etc.)

as well as some international databases (e.g., International Energy Agency) were utilized. The key indicators for the baseline scenario are shown in Table 4-1.

Table 4-1: Key indicators for the Baseline Scenario in energy

Indicator	2011	2032	2050	Growth Rate 2011 - 2032 (%)	Growth Rate 2011 - 2050 (%)	Growth 2011 - 2032 (%)	Growth 2011 - 2050 (%)
Final Energy Consumption (ktoe)	1,863	2,758	3,754	1.89%	1.81%	48%	102%
Power Plant Capacity (MW)	1,838	2,687	2,875	1.82%	1.15%	46%	56%
Electricity Generation & Import (GWh)	8,870	11,945	14,980	1.43%	1.35%	35%	69%
Primary Energy Supply (ktoe)	3,008	4,381	5,252	1.81%	1.44%	46%	75%
CO_2 Emissions (kt)	9,481	14,118	14,166	1.91%	1.03%	49%	49%

The following results from the analysis are of note:

The increase in the useful energy demand and the lack of investment in energy efficiency leads to an increase in final energy consumption, which has a growing rate of 2.4% per year in the period analysed (Figure 4-1). Electricity and diesel will continue to play an important role in the final energy consumption participating with around 60%. If the biomass consumption is excluded, the share of the other RES (solar, geothermal) is negligible. However, the share of coal and gas is going to increase, achieving 18% in 2050.

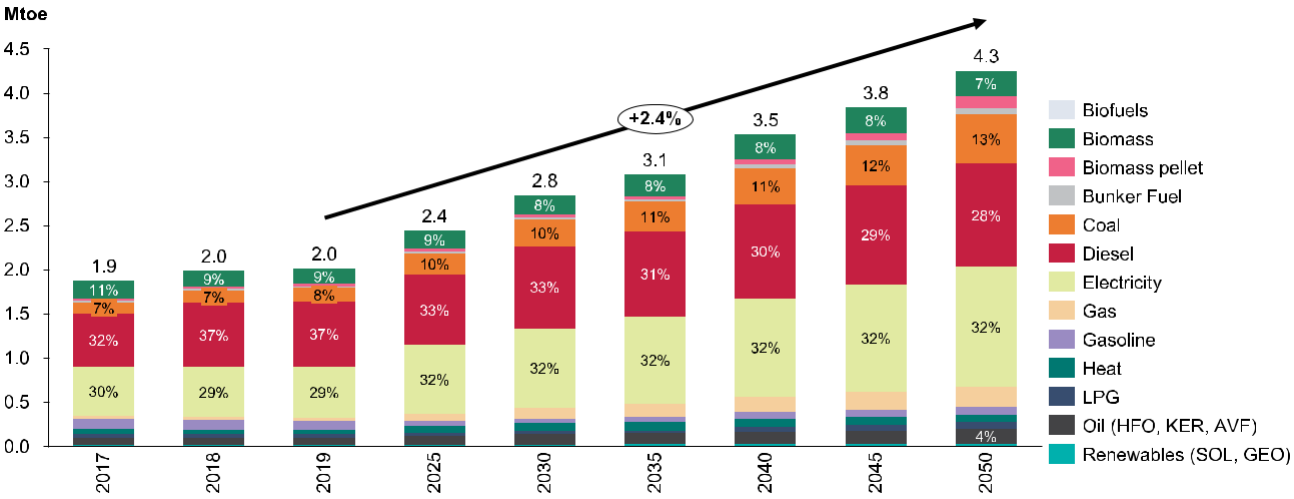


Figure 4-1: Final energy consumption by fuels

Regarding the final energy consumption by sectors, the Manufacturing Industries and Construction, Residential and the Transport sector are the most dominant ones during the whole period (Figure 4-2). The largest growth is in the Manufacturing Industries and Construction sector (more than 3 times higher in 2050 compared to 2019).

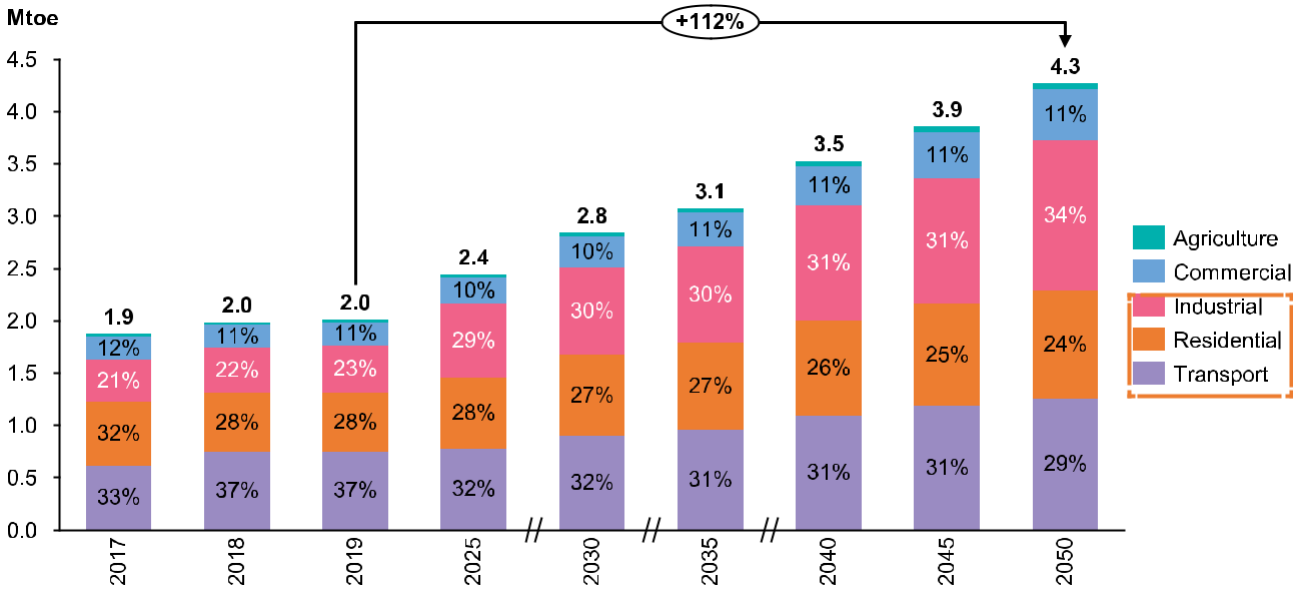


Figure 4-2. Final energy consumption by sectors

The increase of the final energy consumption, as well as not investing in RES will double the primary energy consumption in the considered period (Figure 4-3). Coal will still dominate, but to a much higher extent in the period after 2035, reaching a share of 46% in 2050. Oil products are the second largest contributors with an average share of around 30%. The fastest-growing fuel is natural gas, whose consumption is increased around 3.5 times in 2050 compared to 2019.

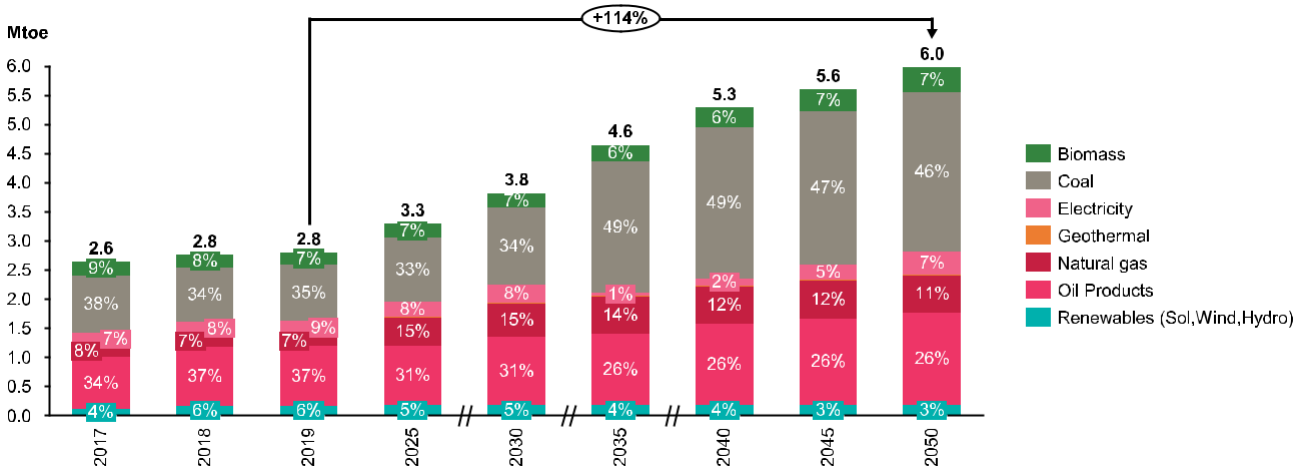


Figure 4-3. Primary energy consumption by fuels

The increase of the primary energy consumption which is based on fossil fuels will increase GHG emissions in the analysed period by 114% in 2050 relative to 2019 (Figure 4-4). Compared to the 1990 level, emissions will be increased by 122% in 2050. It is important to note that the emissions presented in Figure 4-4 for the period 2014-2050 also include the emissions from electricity import and international aviation, which are not used for reporting the national emissions in the GHG Inventory (according to the IPCC methodology). In this report, electricity import is included to properly evaluate the proposed mitigation policies and measures, and not include electricity import as a mitigation option.

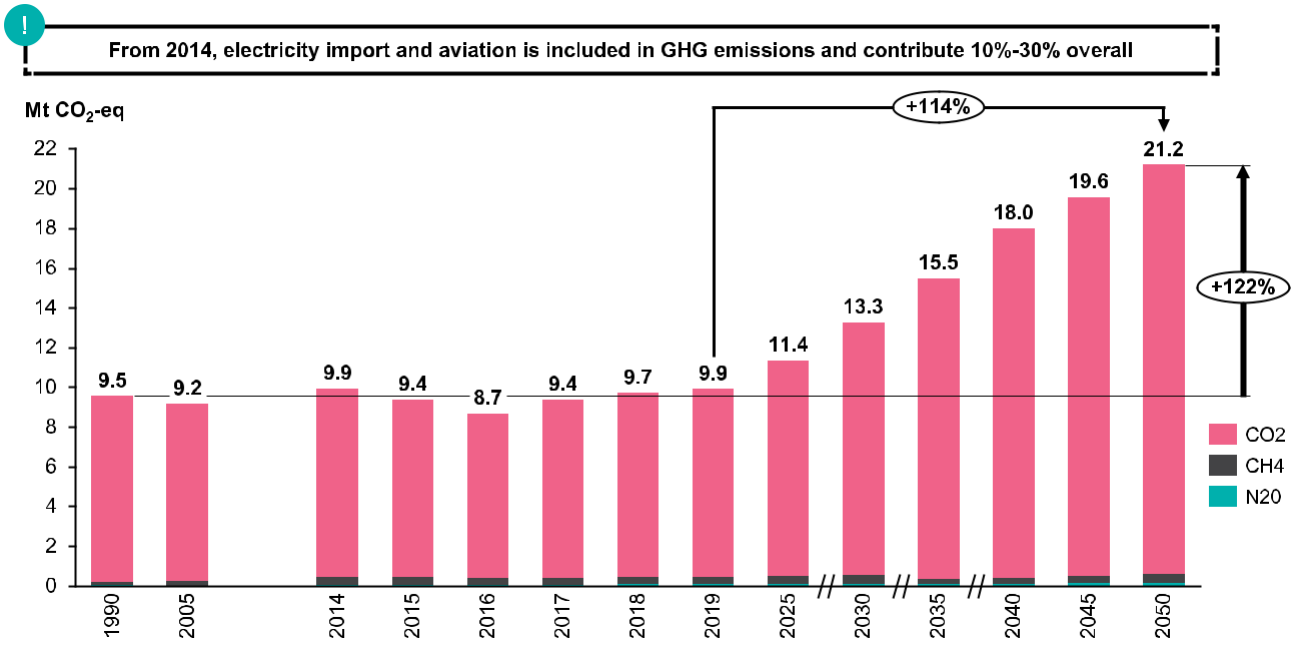


Figure 4-4. GHG emissions by gas

The consumption of coal makes the Main Activity Electricity and Heat Production sector the greatest producer of GHG emissions (a share of 49% in 2050). As can be noted, electricity import significantly affects GHG emissions with a share of around 14% during the analysed period (Figure 4-5).

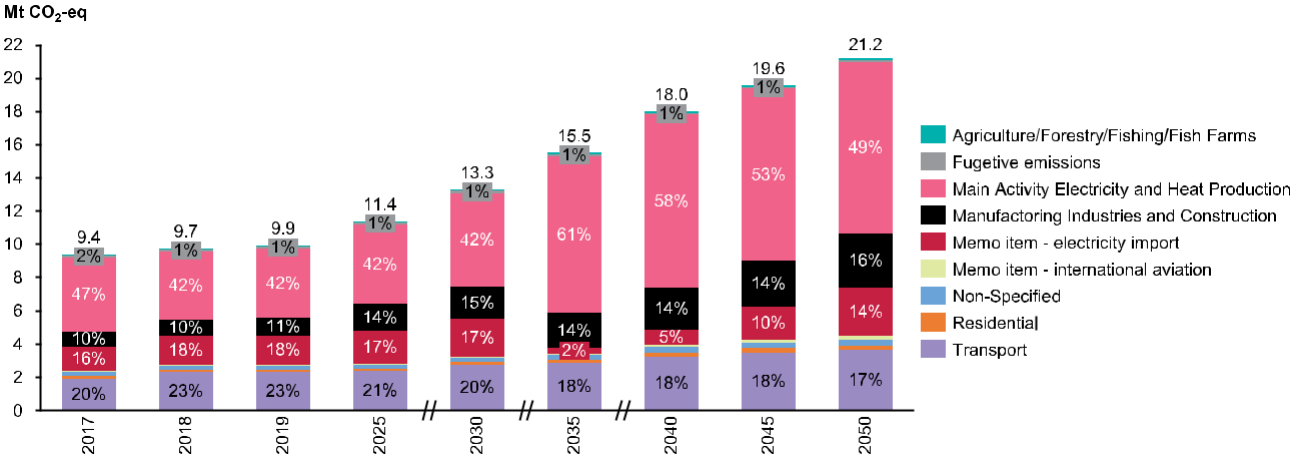


Figure 4-5. GHG emissions by sector

Based on these projections, CO_2 emissions would change from ~9.8 Mt in 2017 to ~14.4 Mt in 2050 with power generation making up the largest share. The CO_2 emissions expected in the baseline scenario from all energy sectors are given in Table 4-2.

Table 4-2. Projected CO_2 emissions by sectors under the Baseline scenario (kt)

	2014	2015	2016	2019	2020	2025	2030	2035	2040
Agriculture	466	499	522	566	600	655	700	755	80
Commercial	3922	2288	2400	2566	2711	2888	3055	3277	352
Industry	1,2465	1,2661	1,3392	1,4114	1,4977	1,5882	1,6599	1,7244	1,8811
Power Sector	7,0433	7,0699	6,5188	6,5499	7,7004	9,1411	9,3188	6,4224	6,6341
Residential	1144	1146	1533	1533	1799	2156	2360	3077	339
Transport	1,4990	1,5446	1,7554	1,9004	2,0884	2,2599	2,4755	2,6555	2,863
Total	10,3111	10,2988	10,0499	10,3383	11,7744	13,6560	14,1188	11,1702	12,2286

4.2.1.2 Mitigation measures in the energy sector

The proposed polices and measures in this section are developed based on the Strategy for energy development up to 2040 and the Climate Change Mitigation Report, prepared for this NC. The lessons learned from NECP development of the EU countries were also considered. The "Budget" information given in the tables refers to the cumulative investment cost.

The mitigation actions identified within the energy sector are split between the following sub-sectors:

- Energy supply
- Residential and non-specified
- Industry
- Transport

The overall GHG emission reduction to be achieved via the mitigation actions in the energy sector, which is expected to be **2,921 Gg CO2-eq by 2030,** and **7,292 Gg CO2-eq by 2050** compared to 1990 (Mitigation scenario).

Energy supply

The mitigation actions defined for the energy supply sub-sector aim to achieve GHG emission reductions of **1,229 Gg CO2-eq by 2030, and of 2,650 Gg CO2-eq by 2050.**

The mitigation actions identified will lead to sub-sector transformation and GHG mitigation in electricity generation and transmission, and are implementable in the short-, medium-, and long-term (2030 – 2050). These mitigation actions include:

PAM 1 Reduction of network losses

PAM 1 Reduction of network losses

Main objective: Reduction of losses in electricity and heat networks
Description: Technical measures for reducing distribution electricity losses comprise of overhead lines replacement with underground (where possible), transition to 20 kV voltage level, installation of new transformation stations to shorten the low voltage lines, as well as automation and remote network management. All these improvements will contribute to better SAIDI and SAIFI indicators. For the heating sector, technical measures include continuous replacement of existing heat pipelines with pre-insulated ones and optimization of the substation operations through automatic control.

Timeframe	Type	Sector	Gases	Oпcer
2030 – 2050	Technical	Energy supply	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development up to 2040 Development plan of MEPSO Rulebook for the manner and conditions for determining a regulated maximum revenue and regulated average tariffs for electricity transmission, organization and management of the electricity market and electricity distribution Rulebook on regulation of prices for heat energy and system services Development plan of Balkan Energy Group (BEG)
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	Technical interventions will reduce the electricity transmission and distribution losses from 12% to 8%, while the district heating system losses will be reduced from 12% to at least 10.5%.
Status of implementation	Under implementation
Steps taken	Development plan of the electricity transmission system for the period 2020 – 2029 (MEPSO AD – October 2019) Development plan of the electricity distribution system for the period 2021-2025 (Elektrodistribucija Ltd. Skopje - October 2020) A General investment plan in electricity distribution network is developed for the next 20 years. Implementing measures for operation improvement and losses reduction in the heat distribution system
Steps envisaged	Replacement of obsolete and unreliable 400 kV and 110 kV primary equipment with an average age of over 30 years (switches, circuit breakers, measuring transformers and surge arresters) and replacement of secondary equipment (relay protection, remote control systems and management, power supply, electricity metering) Replacement old electric transformer with new transformers at 20 kV voltage level Reduction of the reactive power in the power network Rehabilitation of the hot water distribution network, replacement of the existing pumps in the heating substations with new energy efficient pumps and other measures for energy efficiency improvement (modernization of the SCADA system, integration of the distribution networks). Installation of modern equipment for regulation and monitoring in the heating substations for control and reduction of the consumed heat Implementations of the Strategy for reconstruction/revitalization of the electricity transmission network developed by MEPSO. (Sopotnica-Bitola, Kicevo-Sopotnica, Oslomej-Kicevo Oslomej-Gostivar, Strumica 1-Strumica 2, Valandovo-Strumica 2, Dubrovo-Valandovo)

Indicators		Value in the last reporting year	Target value	
		2016-2018	2030	
Progress	**Network losses reduced (%)**	14.2% for electricity 12.5% heat	10.5% for electricity 10% heat	
Emissions reduction (Gg CO_2-eq)		2030	2040	2050
		104.4	168.5	168.5
Other	**Primary energy savings (ktoe)**	15.0	24.2	24.2

Finance	**Budget**	170 M€
	Source of finance	Electricity and heat distribution companies, MEPSO (16 M€)
Implementing entity		Electrcity transmission System Operator Electricity distribution system operators Heat distribution companies
Monitoring entity		Energy Regulatory Commission, Energy Agency, Ministry of Economy

PAM 2 Large hydro power plants

PAM 2 Large hydro power plants						
Main objective: Increase of the domestic generation capacity from renewable energy sources **Description:** Construction of new large hydro power plants taking into account environmental and social impacts						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Technical	Energy supply	CO_2, CH_4, N_2O	National	
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of the Macedonia up to 2040 National Water Strategy Development plan of ESM AD (JSC Macedonian Power Plants). Energy Law Water Law Law on environment Law on concession and public private partnership				
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology				
Assumptions		It is envisaged construction of large hydro power plants according to the following dynamics: Chebren – 2029 Vardar valley – 2025-2030 Tunnel Vardar – Kozjak, Veles and Gradec Globochica II – 2035 Only Chebren and small hydro on Vardar Valley are available in the WEM scenario				
Status of implementation		Under implementation				
Steps taken		Feasibility/pre-feasibility studies developed Chebren feasibility study Prequalification tender for Chebren published				
Steps envisaged		Invitation for tenders for the construction of the other hydropower plants, selection of the best bidder and commencement of the construction Analyses by MEPSO and ERC for the implementation of the Capacity Mechanism according to the Regulation 2019/943 on the internal market for electricity and according to state aid rules				
Indicators		Value in the last reporting year		Target value		
		2018		2030		
Progress	Additional installed capacity (MW)	/		808		
Emissions reduction (Gg CO_2-eq)		2030	2040	2050		
		617.7	757.8	1556.7		
Other	Primary energy savings (ktoe)	21.3	10.4	21.3		
Finance	Budget	1556 M€				
	Source of finance	Public private partnership, ESM				
Implementing entity		Government of the Republic of North Macedonia ESM AD (JSC Macedonian Power Plants). Ministry of Environment and Physical Planning Energy regulatory commission MEPSO Ministry of Economy				
Monitoring entity		Energy Agency, Ministry of Economy, Ministry of Environment and Physical Planning				

* Most critical capacities are Chebren, Veles and Gradec. Latest in 2022, concrete activities for Veles and Gradec should be undertaken. If these capacities are not built the electricity import dependence of the country increase. Another possibility is to substitute the electricity production of Veles and Gradec with production from natural gas power plants, but in this case the set GHG emissions that are coming from the electricity production will increase.

PAM 3 Incentives feed-in tariff

PAM 3 Incentives feed-in tariff					
Main objective: Incentives feed-in tariff **Description:** Construction of new small hydro power plants, wind and biogas with feed-in tariffs that will stimulate the construction					
Timeframe		Type	Sector	Gases	Scope
2030 – 2050		Technical, regulatory	Energy supply	CO_2, CH_4, N_2O	National
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of the Republic of North Macedonia until 2040 Renewable Energy Action Plan / National Plan for Energy and Climate Energy Law Decree on RES Support Measures Decision for total installed capacity for preferential producers of electricity Rulebook on preferential producers that use feed-in tariff Decision for national mandatory target for share of RE in gross energy consumption			
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology			
Assumptions		Through stimulation with feed-in tariffs, it is envisaged that by 2040 additional capacity of: 124 MW wind power plants 13 MW biogas power plants 27 MW small hydro power plants will be constructed.			
Status of implementation		Under implementation			
Steps taken		Decree on the measures for support of electricity generation from renewable energy sources adopted by the Government (5.04.2019). Decision on the total installed capacity for preferential producers of electricity adopted by the Government (5.04.2019). Rulebook on preferential producers that use feed-in tariff adopted by the Energy Regulatory Commission (06.06.2019) Temporary status of preferential producer granted to (28 December 2020) 114 MW wind power plants (ESM 13 MW Bogdanci, THOR 36 MW, Sveti Nikole/Stip, Kaltun 34 MW Demir Kapija/Gevgelija, EUROING 30 MW Bogdanci) 4 MW biogas power plants 27 MW small hydro power plants			
Steps envisaged		New feed-in tariffs to be granted based on "first come - first served" rule to the producers of electricity from eligible RE technologies until the quota determined for each technology in the Decision on the total installed capacity for preferential producers of electricity is reached Possibility of waiving the granted feed-in tariff in exchange for acquiring ownership or extended concession period of the constructed SHPP to be reviewed and possibly permitted by the relevant law Construction of power plants			
Indicators		Value in the last reporting year		Target value	
		2016-2018		2030	
Progress	Additional installed capacity (MW)	17.6		159	
Emissions reduction (Gg CO_2-eq)		2030	2040	2050	
		123.3	147.0	178.9	
Other	Primary energy savings (ktoe)	20.3	24.2	29.4	
Finance	Budget	557 M€			
	Source of finance	Private, incentives through consumer bills			
Implementing entity		Government of the Republic of North Macedonia Energy Regulatory Commission Ministry of Environment and Physical Planning Ministry of Economy, Energy Agency Private investors			
Monitoring entity		Energy Regulatory Commission			

PAM 4 Incentives feed-in premium

PAM 4 Incentives feed-in premium					
Main objective: Increase of the domestic generation capacity from renewable energy sources **Description:** Construction of solar and wind power plants with feed-in premium tariffs to stimulate the construction					
Timeframe	Type	Sector	Gases	Scope	
2030 – 2050	Technical, regulatory	Energy supply	CO_2, CH_4, N_2O	National	
Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of the Republic of North Macedonia up to 2040 Energy Law Decree on RES Support Measures Decision for total installed capacity for preferential producers of electricity Decision for national mandatory target for share of RE in gross energy consumption Annual Programme for financial support of production of electricity from RES				
Methodology	Through stimulation with feed-in premium, it is envisaged that by 2025 additional capacity will be constructed: 200 MW solar power plants				
Assumptions	Through stimulation with feed-in premium, it is envisaged that by 2040 additional capacity will be constructed: 200 MW solar power plants 64 MW wind power plants				
Status of implementation	Under implementation				
Steps taken	Decree on the measures for support of electricity generation from renewable energy sources as well as decision on the total installed capacity for preferential producers of electricity adopted (5.04.2019). Tender on awarding an agreement for right to use premium for electricity produced from photovoltaic power plants constructed on land owned by the Republic of North Macedonia (21.07.2019) Tender on awarding the right to use a premium for electricity produced from photovoltaic power plants built on land not owned by the Republic of North Macedonia or on land owned by the Republic of North Macedonia on which right to use has been established (2.10.2019) Based on the conducted tenders, the right to use feed-in premiums was granted for PV power plants with total of 60 MW installed capacity				
Steps envisaged	Construction of photovoltaic power plants for which the right to use premium has been awarded Conducting new tenders for awarding agreement for right to use premium for electricity produced from photovoltaic power plant constructed on land owned by the Republic of North Macedonia, on average once per year Conducting new tenders for awarding the right to use a premium for electricity produced from photovoltaic power plants built on land not owned by the Republic of North Macedonia or on land owned by the Republic of North Macedonia on which right to use has been established, on average once per year				
Indicators		Value in the last reporting year	Indicative trajectory	Target value	
		2018		2025	
Progress	Installed capacity (MW)	/		200	
Emissions reduction (Gg CO_2-eq)		2030	2040	2050	
		108	108	108	
Other	Primary energy savings (ktoe)	21.5	21.5	21.5	
Finance	Budget	160 M€			
	Source of finance	Private, incentives from the central government budget			
Implementing entity	Government of the Republic of North Macedonia Ministry of Economy Private investors				
Monitoring entity	Ministry of Economy				

PAM 5 Biomass power plants (CHP optional)

PAM 5 Biomass power plants (CHP optional)

Main objective: Increase of the domestic generation capacity from renewable energy sources
Description: This measure considers construction of distributed small sized biomass power plants (CHP optional) with stimulation through feed-in tariffs. Beside increasing the RES share with this CHPs, they should also contribute in increasing the flexibility of the electricity system and ensuring the security of supply. It is envisioned that industrial and municipal solid waste biomass will be used, taking into account the sustainability of the biomass at national level.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, regulatory	Energy supply	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of the Republic of North Macedonia up to 2040 Energy Law Decree on RES Support Measures Decision for total installed capacity for preferential producers of electricity Rulebook on preferential producers that use feed-in tariff Decision for national mandatory target for share of RE in gross energy consumption
Methodology	Through stimulation with feed-in tariffs, it is envisaged that by 2025 biomass power plants with capacity of 5 MW will be constructed
Assumptions	Through stimulation with feed-in tariffs, it is envisaged that by 2040 biomass power plants with capacity of 15 MW will be constructed
Status of implementation	Under implementation
Steps taken	Decree on the measures for support of electricity generation from renewable energy sources adopted by the Government (5.04.2019). Decision on the total installed capacity for preferential producers of electricity adopted by the Government (5.04.2019). Rulebook on preferential producers that use feed-in tariff adopted by the Energy Regulatory Commission (06.06.2019) Temporary status of preferential producer granted to 3.15 MW (28 December 2020)
Steps envisaged	Amend the Decree on the measures for support of electricity generation from renewable energy sources to provide different treatment (tariff amount, period, etc.) for CHP plants that use industrial and municipal solid waste Implement the plan for development / construction of regional landfills Attract the investors trough by meetings through economic chambers of commerce Construction of power plants

Indicators		Value in the last reporting year	Target value
		2018	2030
Progress	Installed capacity (MW)	/	10

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	21	21	21
Other – Primary energy savings (ktoe)	3	3	3

Finance	Budget	24.3 M€
	Source of finance	Private, incentives from the central government budget
Implementing entity		Government of the Republic of North Macedonia Energy Regulatory Commission Ministry of Environment and Physical Planning Ministry of Economy, Energy Agency Private investors
Monitoring entity		Ministry of Economy, Energy Agency

PAM 6 Solar rooftop power plants

PAM 6 Solar rooftop power plants

Main objective: Increase of the domestic generation capacity from renewable energy sources
Description: Construction of solar rooftop power plants, on private as well as public buildings, either prosumers or systems from which the overall produced electricity will be used for own purposes or will be stored. One of the possibilities for increasing the installed capacity of solar roof-top systems is through renewable energy communities.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, regulatory	Household, commercial and industry sector	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of Macedonia up to 2040 Law on Energy Bylaws on renewable energy Solar strategy 2022 (European commission)
Methodology [for estimating the emissions]	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	800 MW solar capacities are envisioned to be constructed by 2050
Status of implementation [idea, planning phase, under implementation]	Under implementation
Steps taken	Rulebook on renewable energy sources adopted. Distribution grid code adopted Program for promotion of renewable energy sources and improvement of energy efficiency in household for 2021, adopted (subsidies are planned) Through the project „Design and implementation of photovoltaic systems in rural municipalities“ rooftop PV systems were installed on 108 public buildings Several companies have installed rooftop PV systems (such as Vitaminka, Makprogres, Maks, AgroGama, Maktois, Frotirka, Palteks, Alpinkom, Evropa 92, ABMG, Fikoplast, Birosef) Few hospitals in Skopje have installed rooftop PV systems (such as Polyclinic Bukurest, hospitals Bit Pazar and Cair)
Steps envisaged	Amend the Energy Law, VAT Law and Rulebook on RES to improve the net-billing legal framework and make it in line with EnC guidelines on prosumers Information campaigns

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2016-2018	2020	2025	2030
Progress	Installed capacity (MW)	3.3			256
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		84.6	214.6		234.9
Other	Primary energy savings (ktoe)	15.4	39.2		42.9

Finance	Budget	699 M€
	Source of finance	Private, donors, subsidies from national and local budget, EE fund
Implementing entity		Government of the Republic of North Macedonia Energy Regulatory Commission Ministry of Economy, Energy Agency Ministry of Finance Elektrodistribucija Skopje Suppliers of electricity End-users of electricity
Monitoring entity		Ministry of Economy, Energy Agency

PAM 7 RES without incentives

PAM 7 RES without incentives					
Main objective: Increase of the domestic generation capacity from renewable energy sources **Description:** Construction of wind, solar and biogas power plants on different location in Macedonia carefully selected in order to avoid the impact on environment compared to benefits of generated electricity					
Timeframe		Type	Sector	Gases	Scope
2030 – 2050		Technical, regulatory	Energy supply	CO_2, CH_4, N_2O	National
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of the Republic of Macedonia up to 2040 Electricity Transmission and Distribution networks Development plans Energy Law Law on Urban Planning, Law on Construction, Law on Environment, Water Law, and Law on Construction land. Law on Strategic Investment Bylaws for renewable energy Electricity Transmission and distribution Grid codes			
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology			
Assumptions		The following capacities by scenario without incentives are envisioned to be constructed by 2040: Wind – 950 MW Solar – 1600 MW Biogas – 10 MW			
Status of implementation		Under implementation			
Steps taken		Decree on the measures for support of electricity generation from renewable energy sources adopted (5.04.2019). Decision on the total installed capacity for preferential producers of electricity adopted (5.04.2019). Electricity grid code adopted Construction of 100MW Oslomej PV started			
Steps envisaged		Development of methodology for selection of best for location construction of solar and wind PP Planning the battery storage capacity and establishing regulatory framework			
Indicators		Value in the last reporting year			Target value
		2016-2018			2050
Progress	Installed capacity (MW)	2.7			950,1600,10
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		74.0	219.8		286.6
Other	Primary energy savings (ktoe)	10.6	31.4		41.0
Finance	Budget	2193 M€			
	Source of finance	Private, ESM			
Implementing entity		Government of the Republic of North Macedonia Ministry of Economy Ministry of Transport and Communications, Electricity TSO Electricity Market Operator JSC Macedonian Power Plants (ESM AD) Private investors			
Monitoring entity		Ministry of Economy, Energy Agency			

PAM 8 Development of the biofuels market

PAM 8 Development of the biofuels market					
Main objective: the RES share in the transport sector is almost zero and it is the main reason for not achieving the country 2020 target. In order to fulfil the 2030 RES target in the transport sector, but also the overall RES target it is necessary to have a functional biofuels market. **Description:** Increase the share of biofuels in line with the requirement of the recast on the RES Directive (2018/2001).					
Timeframe		Type	Sector	Gases	Scope
2030 – 2050		Regulatory, policy	Energy	CO_2, CH_4, N_2O	National
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of the Republic of Macedonia up to 2040 Biennial report on the progress of increased utilization of renewable energy sources			
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology			
Assumptions		aw on biofuels as well as action plan will be adopted in line with the requirements of the RES Directive (2018/2001). The share of biofuels in 2030 will be 10%			
Status of implementation		Under implementation			
Steps taken		Draft version of the Law on Biofuels developed Development of study on RES target in transport in 2030 in EnC countries Development of study on biofuels in Macedonia			
Steps envisaged		Adoption of the Law on Biofuels Completion of legal framework on biofuels by adopting the set of bylaws stemming from the Law on Biofuels Developing and adopting the Action plan on biofuels in which, among other things support measures for domestic producers of biofuels and obligations for oil traders to meet the national target for share of biofuels will be specified Allocating annual funds in the state budget for supporting the production of biofuels			
Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2018	2020	2025	2030
Progress	% of biofuels	0	0	5	10
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		96	96		96
Other	Primary energy savings (ktoe)				
Finance	Budget	n/a			
	Source of finance	Central government budget, consumers			
Implementing entity		Government of the Republic of North Macedonia Ministry of economy Ministry of Finance Ministry of Environment and Physical Planning Energy Regulatory Commission Oil traders			
Monitoring entity		Ministry of economy			

Residential and Non-specified

The mitigation actions defined for the residential and non-specified sub-sector aim to achieve GHG emission reductions of **774.8 Gg CO2-eq by 2030,** and of **2,265.3 Gg CO2-eq by 2050.**

The mitigation actions identified include a wide range of energy efficiency technologies focusing on improved lightening and buildings. These mitigation actions include:

PAM 9 Energy efficiency obligation schemes

PAM 9 Energy efficiency obligation schemes

Main objective: Fulfilment of the obligation under Article 7 of the EE Directive
Description: To set up the scheme the average annual final consumption for the period 2014 – 2016 is used. The measure implements the possibilities from the Article 7 of the EE Directive, i.e. Article 14 of the national Energy Efficiency Law, to exclude the transport sector consumption (paragraph 1) from the sum of the average annual consumption and reduce the consumption in the industry sector (paragraph 2).

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, regulatory	All sectors (excl. transport and part of the industry according to Annex I of the Directive 2003/87/EC)	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Law on energy efficiency Directive for EE
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	1.Final energy savings targets of: 0.35% in 2021 – 2030 0.2% in 2031 – 2050 of the average annual energy sales to final customers in the period 2014 – 2016 excluding the customers in the transport sector as well as industries of Annex I of the Directive 2003/87/EC 2. Up to 30% of the costs will be covered through subsidies by the distribution companies or suppliers.
Status of implementation	Under implementation
Steps taken	Law on Energy Efficiency adopted
Steps envisaged	The Decree for obligation scheme, in which the obligation schemes will be elaborated in details (obligated parties, methodology for calculation of annual energy savings, targets for annual energy savings, measures for achieving the targets, etc.) should be drafted, adopted and implemented by the end of 2021. One of the recommendations given in Appendix III as a part of the guideline for the development of Building renovation strategy is to Develop an ambitious Energy Efficiency Obligation scheme which focuses on delivering holistic and deep renovation of buildings.

Indicators		Value in the last reporting year		Target value
		2018		2030
Progress indicators	Primary energy savings (ktoe)	2030	2040	2050
		10.3	24.4	58.4
	Final energy savings (ktoe)	10.3	24.4	58.4
Emissions reduction ($Gg\ CO_2\ eq$)		15.2	35.9	86,0
Finance	Budget	124 M€		
	Source of finance	Consumers through their bills		
Implementing entity		Government of the Republic of North Macedonia Ministry of economy Energy Agency Energy Regulatory Commission Distribution system operators Suppliersof electricity and gas		
Monitoring entity		Ministry of Economy		

PAM 10 Solar thermal collectors

PAM 10 Solar thermal collectors								
Main objective: Reduction of the energy costs and improvement of the efficiency **Description:** Hot water electric heaters are one of the biggest energy consumers with a major impact on bills. On the other hand, the reduced investment cost for purchasing and installation of solar thermal collectors is of great importance because it can drop consumer bills for hot water. Also, these systems serve for energy savings and can satisfy at least 50% at annual level, depending on the hot water needs. Furthermore, solar thermal collectors can be used in combination with electricity and district heating systems.								
Timeframe		Type		Sector		Gases		Scope
2030 – 2050		Technical		Households and commercial sector		CO_2, CH_4, N_2O		National
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of North Macedonia up to 2040 Law on Energy Law on Energy Efficiency Bylaws for renewable energy Program for the promotion of renewable energy						
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology						
Assumptions		Share of solar thermal collectors in hot water useful demand by 2050 to be 55% in household sector and 40% in commercial sector						
Status of implementation		Under implementation						
Steps taken		Program for promotion of renewable energy sources and improvement of energy efficiency in household for 2021, adopted (subsidies are planned)						
Steps envisaged		Continuation of adoption and implementation of annual programmes with incentive measures for solar thermal collectors installation						
Indicators		Value in the last reporting year					Target value	
		2016-2018					2030	
Progress	Number of new installed solar collectors	7195*						
	Average area per collector (m^2)	3						
Emissions reduction (Gg CO_2-eq)		2030		2040		2050		
		14.8		19.9		23.3		
Other	Final energy savings (ktoe)	5.2		7.0		8.1		
	Primary energy savings (ktoe)	7.4		9.9		11.6		
Finance	Budget	60 M€						
	Source of finance	Private, EE fund, incentives from the central government budget, donors						
Implementing entity		Government Ministry of economy, Energy Agency End-users Municipalities and city of Skopje						
Monitoring entity		Ministry of Economy, Energy Agency						

* Just those that applied for subsidies from the Ministry of Economy

PAM 11 Labeling of electric appliances and equipment

PAM 11 Labeling of electric appliances and equipment

Main objective: Increased energy savings in the households, public and commercial buildings
Description: Placing on the market of energy related products that are properly designed and labelled is necessary to ensure that the products sold in Macedonia comply with the EU regulations, as well as to contribute towards greater energy savings by their users (households, public and commercial entities). Proper labelling of energy related products must be observed, so that relevant information on the energy consumption of these products is provided to their buyers and end-users.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory	Households and commercial sector	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of North Macedonia up to 2040 Law on Energy Efficiency Third Energy Efficiency Action Plan Rulebook on labelling consumption of energy and other resources on devices using energy. Regulation on eco-design of energy-related products
Methodology [for estimating the emissions]	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	As a result of this measure, it is expected that by 2025 the share of energy efficient technologies (A+++, A++, A+, A or A, B, C according to the new Rulebook for labelling of appliances) will be 10% in the overall stock.
Status of implementation [idea, planning phase, under implementation]	Under implementation
Steps taken	Rulebook on labelling consumption of energy and other resources on devices using energy adopted in September 2016 by the Ministry of Economy Regulation on eco-design of energy-related products adopted by the Government in 2012 Market inspectors trained on the basic eco-labelling and eco-design rules and requirements stemming from the Energy Efficiency Law
Steps envisaged	Adoption of the new Rulebook on labelling consumption of energy and other resources on devices using energy that will incorporate the latest EU technical regulations for certain products Adoption of the new Decree on eco-design of energy-related products that will incorporate the latest EU technical regulations for certain products Information campaigns that will target the producers of these products, but more importantly traders and consumers Continuous education of market and environment inspectors on this subject matter

Indicators		Value in the last reporting year		Target value
		2016-2018		2030
Progress	Number of devices sold (A+++, A++, A+, A)	7789		
Emissions reduction (Gg CO_2-eq)		2030	2040	2050
		42.4	10.,5	240,9
Other	Final energy savings (ktoe)	1.6	3.8	9.0
	Primary energy savings (ktoe)	2.3	5.4	12.8
Finance	Budget	48 M€		
	Source of finance	Private, EE fund		

Implementing entity	Ministry of economy, Energy Agency State Market Inspectorate, State Environment Inspectorate Producers and suppliers of electrical equipment and household appliances End-users
Monitoring entity	Ministry of Economy, Energy Agency

PAM 12 Increased use of heat pumps

PAM 12 Increased use of heat pumps

Main objective: More efficient use of electricity

Description: Phasing out heating devices with resistive heaters, as well as inefficient biomass stoves and their replacement with heat pumps in compliance with EU Climate and Energy Policy.

Cooling is the fastest-growing end use in buildings worldwide. As it is stated in the Assessment of the potential of climate friendly cooling solutions[6], in a typical building in North Macedonia that cools even for part of the year, colling can amount to well over 20% of primary energy demand. The thermal properties and positioning / solar radiance of a building influence both heating and cooling demand and the heating and cooling systems can be combined to become much more efficient in the case of the use of heat pumps. This is especially important since a large share of the population uses electricity for both heating and cooling. Cooling is also increasingly recognised at the EU level as needing to be dealt with and assessing cooling demand is now required as a part of aligning to the Energy Performance in Buildings Directive (EPBD)[7].

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory, policy	Households and commercial sector	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency Third Energy Efficiency Action Plan Municipal Energy Efficiency Program EU Climate and Energy Policy
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	It is assumed that heating devices with resistive heaters will be gradually replaced with heat pumps.
Status of implementation	Planning phase
Steps taken	Energy Efficiency Law adopted Program for promotion of renewable energy sources and improvement of energy efficiency in household for 2021, adopted (subsidies are planned) Starting from 2019 the City of Skopje and other municipalities (Aerodrom, Kocani, Kavadarci, Bitola) are subsidizing heat pumps. In total 2103 households are subsidized for heat pumps in 2019. The state-owned power generation company Elektrani na Severna Makedonija (ESM) has allocated funds of € 10 million for subsidizing the households who replace their inefficient stoves and boilers based on firewood, coal, and oil with high-efficiency heat pumps (inverter air conditioners). Hence, each household which replaced their inefficient stoves and boilers with high-efficiency heat pumps will be reimbursed for up to € 1,000. This subsidy is available for households only in the cities with the highest air pollution in the country, including Bitola, Kicevo, Tetovo, and Skopje. Subsidies for purchasing of high-efficiency heat pumps are provided to 5,200 households in Skopje, 2,500 households in Bitola, 1,500 households in Tetovo, and 800 households in Kičevo, during 2020. Project of UNDP for improvement of the air quality with the replacement of the wood stove and introduction of EE measures in at least 100 household from the Aerodrom municipality
Steps envisaged	Adopting a Decision to ban the sale of heating devices with resistive heaters. Adopting a Rulebook for RES Equipment installers Implementation of the requirements related to Heat Pumps according to the Directive 2018/2001 on the promotion of the use of energy from renewable sources (recast) Continuation of the program for subsidies (in 2019, about 2100 inverter air conditioners were subsidized, out of a total of about 10000 purchased or 20% of the air conditioners. It is assumed that in the following years again 20% will be subsidized, with a maximum of 50% of the investment from the municipalities and the city of Skopje. Donors participate with about 1% according to the 2020 example from UNDP.) Campaign for awareness raising for citizens implemented in cooperation with CSOs Adopting a ban of using coal for household heating

[6] Assessment of the potential of climate friendly cooling solutions (2021) https://api.klimatskipromeni.mk/data/rest/file/download/b5811cf8f22110c19459 cbe3d243dca38f7d93ff3f9285ff55037ac4881bbe86.pdf

[7] See various links at https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_ en#energy-performance-of-buildings-standards

Indicators			Value in the last reporting year	Indicative trajectory		Target value
			2016-2018	2020	2025	2030
Progress		Number of heat pump sold	37226			
Emissions reduction (Gg CO_2-eq)			2030	2040		2050
			281,7	430.3		555.9
Other		Final energy savings (ktoe)	106.1	162.1		209.4
		Primary energy savings (ktoe)	142.0	216.9		280.2
Finance		Budget	240 M€			
		Source of finance	Private, EE fund, incentives from the central and local government budget, donors			
Implementing entity			Ministry of Economy, Energy Agency End-users CSOs			
Monitoring entity			Ministry of Economy, Energy Agency			

PAM 13 Public awareness campaigns and network of energy efficiency (EE) info centers

PAM 13 Public awareness campaigns and network of energy efficiency (EE) info centers

Main objective: Implement information campaigns that will raise public awareness about the importance, effects and benefits energy efficiency
Description: Although a large number of campaigns for the promotion of energy efficiency by different stakeholders are provided, still there is a lack of knowledge about the benefits of the EE. Article 12 of the EE Directive stipulates that the country should takes appropriate measures to promote and facilitate an efficient use of energy by small energy customers, including domestic customer. This can be done using different mechanisms. One of them is the establishment of EE info centers in the local self-governments. Following the examples from the EU, besides this measure, several others should be implemented such as:

- Education, starting from the kindergarten,
- Training of the employees in the public institutions at the central and local level,
- Creation of calculation tool that will show the financial and environmental effects from the implementation of a certain measure.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Information	Households and commercial sector	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	Investment in public awareness rising campaigns that will increase the share of more efficient appliances (with higher class of efficiency), in the overall stock, by 2050 to 80%
Status of implementation	Under implementation
Steps taken	Platform for energy efficiency, for education of the population and journalists and experience sharing of the private sector for successfully implemented EE measures implemented. Info Center for Energy of the City of Skopje opened. Free advices to the customers for reasonable consumption of electricity enabled by EVN's Customer Service Centre
Steps envisaged	Broadcasting of TV spots, announcements, campaigns and documentary films Extension of the Platform for energy efficiency Continuous work of the existing and opening new information centers.

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2016-2018*	2020	2025	2030
Progress	Number of devices sold (A+++, A++, A+, A)	31155			

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	117.9	279.1	669.0
Other – Final energy savings (ktoe)	39.8	94.2	225.8
Other – Primary energy savings (ktoe)	58.6	138.8	332.7

Finance – Budget	16 M€ + 482 M€ (investment in advanced technologies)
Finance – Source of finance	Private sector, donors, central and local governments
Implementing entity	Ministry of Economy, Energy Agency Energy suppliers End-users
Monitoring entity	Ministry of Economy, Energy Agency

* In the 4th NEEAP this measure is reported as Public awareness campaigns and network of EE info centers and Increased use of more efficient biomass stoves

PAM 14 Retrofitting of existing residential buildings

PAM 14 Retrofitting of existing residential buildings

Main objective: To meet the requirements under the Energy Efficiency Law
Description: The measure considers reconstructions of residential buildings including windows replacement, initiated by the owners and/or supported by commercial banks and funds. This measure will provide issuing of certificates for energy performance of buildings, as a prerequisite for putting the reconstructions into operation.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, regulatory	Households	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency Rulebook on Energy Performance of Buildings Rulebook on Energy Audits
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	The existing residential buildings, while meet the standard for at least C class. The annual renovation rate considered is 2%.
Status of implementation	Under implementation
Steps taken	31 buildings for collective housing were renovated (EE measures implemented) under the USAID/Habitat Project for residential energy efficiency. Financial support for rehabilitation of buildings for collective housing with implementation of EE measures provided by some municipalities. Call for applications for reimbursement of 50% of the costs for windows replacement and installation of PVC and aluminum windows, but not more than 500 €, provided by the Ministry of Economy. Law on Energy Efficiency adopted. Program for promotion of renewable energy sources and improvement of energy efficiency in household for 2021, adopted (subsidies for windows replacement are planned) Project of UNDP for improvement of the air quality with the replacement of the wood stove and introduction of EE measures in at least 100 household from the Aerodrom municipality The Regional Energy Efficiency Programme (REEP) for the Western Balkans was established in June 2017 by the EBRD with the support of the European Union (EU) and in partnership with the Energy Community Secretariat with the aim of addressing financing, legislative, technical, and other barriers to sustainable energy investments in the region. As part of the extension of the REEP programme, the EBRD established the Western Balkans Green Economy Financing Facility (WB GEFF – Residential) with the form of credit lines for a total of up to EUR 85 million extended to Participating Financial Intermediaries in the six countries (North Macedonia, Albania, Bosnia and Herzegovina, Kosovo, Montenegro, and Serbia), for on-lending to eligible Sub-borrowers to finance residential energy efficiency investments. These energy efficiency improvements and/or renewable energy installations undertaken by private individuals in individual apartments or family houses or measures implemented on a building level by housing collectives – groups of individuals, housing associations, housing management companies. The credit lines are supported with a grant funded Investment Incentives up to 20% of the investment cost or the sub-loan amount provided to sub-borrowers to incentivize the uptake of energy efficiency and renewable energy investments. The disbursement of the sub-loans is made through four commercial banks in the country (Ohridska Bank, Sparkasse Bank, Procredit Bank, and NLB Bank). North Macedonia is a leader in the Western Balkan countries for disbursement of sub-loans and verification of completed sub-projects under WB GEFF. By the end of 2020 there were about 1,670 verified sub-projects from all partner commercial banks in North Macedonia in excess of around EUR 12 million. The average sub-loan amount was about EUR 7,200.
Steps envisaged	Development of building topology National Building Renovation Strategy to be developed and adopted by the end of 2021 or early 2022 and revised three years later Bylaws on energy performances of buildings and energy audits to be adopted System for verification of certificates for energy performance of buildings and Registry of issued certificates to be established and updated by the Energy Agency. Establishment of an Energy Efficiency Fund. Continuous Government financial support for reimbursement of costs for windows replacement

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2016-2018*	2020	2025	2030
Progress	Area retrofitted (m^2)	1481469			
	Energy consumption per heated/cooled area (kWh/m^2)	158			
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		20.5	56.6		90.3
Other	Final energy savings (ktoe)	40.1	110.7		176.4
	Primary energy savings (ktoe)	47.8	131.8		210.0
Finance	Budget	3187 M€			
	Source of finance	Private, donors through commercial EE loans, EE fund			
Implementing entity		Ministry of Economy, Energy Agency Donors and financial institutions Households			
Monitoring entity		Ministry of Economy, Energy Agency			

* The savings are reported together with Retrofitting of existing commercial buildings and Construction of new buildings (in the 4th NEEAP reported as Replacement of windows, Retrofitting of existing buildings (res+com), Construction of new residential buildings and Construction of new commercial buildings)

PAM 15 Retrofitting of existing central government buildings

PAM 15 Retrofitting of existing central government buildings

Main objective: Retrofitting of existing public buildings with aim to meet the objectives of the EE Directive and the Energy Efficiency Law
Description: Having in mind the situation with the energy performance of the public buildings at central level and the role that they should play, it is essential to boost their renovation. Article 10 of the EE Law is of great importance because it can be a starting point for the retrofit expansion. In absence of recent information about the public building stock, in the calculations the heated area of building stock from the National Program for EE in public buildings (Draft version) is considered (including health care sector, universities, student dormitories, science institutions, social care institutions, centers for social affairs, as well as state administrative sector – Ministry of Economy, Ministry of Education and Science, Ministry of Environment and Physical Planning and Ministry of Transport and Communications). In addition, the specific consumption given in the same document is used (average 214 kWh/m2).
This measure considers reconstruction including windows replacement of existing public buildings under jurisdiction of the central government. The measure will provide issuing of certificates for energy performance of buildings, as a prerequisite for putting the reconstructions into operation.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, regulatory	Central government buildings	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions		Annual renovation rate of 3% of the existing central government buildings
Status of implementation		Under implementation
Steps taken		Draft National Program for energy efficiency in public buildings in the Republic of Macedonia (Phase I) was developed under the GEF Sustainable Energy Project "Resilient Skopje" – Climate Change Strategy for the City of Skopje developed.
Steps envisaged		National Building Renovation Strategy to be developed and adopted. Bylaws on energy performances of buildings and energy audits to be adopted List of public sector buildings with at least 250m2 total usable floor area each that do not meet the minimum energy performance criteria be developed and published in 2021 3-years Plan for retrofitting of existing central government buildings to be developed and adopted Establishment of an Energy Efficiency Fund.

Indicators		Value in the last reporting year		Target value
		2016-2018*		2030
Progress	Area retrofitted (m^2)	151030		
	Energy consumption per heated/cooled area (kWh/m^2)	214		
Emissions reduction (Gg CO_2-eq)		2030	2040	2050
		20.9	38.6	58.9
Other	Final energy savings (ktoe)	5.3	9.8	14.9
	Primary energy savings (ktoe)	7.3	13.4	20.5
Finance	Budget	290 M€		
	Source of finance	Central government budget, donors		
Implementing entity		Ministry of Economy, Energy Agency Ministry of Finance Local self-government Municipal public enterprises Donors and financial institutions		
Monitoring entity		Ministry of Economy, Energy Agency		

* The savings are reported together with the measure Retrofitting of existing local self-government buildings (in the NEEAP reported as Retrofitting of existing central and local self-government buildings and Construction of new central and local self-government buildings)

PAM 16 Retrofitting of existing local self-government buildings

PAM 16 Retrofitting of existing local self-government buildings

Main objective: Retrofitting of existing public buildings with aim to meet the objectives of the EE Directive and the Energy Efficiency Law
Description: Local self-government should be encouraged by the central government renovation strategy, so they can put special attention on buildings under their competence.
For the calculations, the heated area of building stock from the National Program for EE in public buildings (Draft version) is considered (including primary and secondary schools, kindergartens, pupils' dormitories, municipalities and the City of Skopje buildings). In addition, the specific consumption given in the same document is used (average 214 kWh/m2).
This measure considers reconstruction including windows replacement of existing public buildings under jurisdiction of the local self-government. The measure will provide issuing of certificates for energy performance of buildings, as a prerequisite for putting the reconstructions into operation

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, regulatory	Local self-government buildings	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency			
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology			
Assumptions	Annual renovation rate of 1.5% of the existing local self-government buildings.			
Status of implementation	Under implementation			
Steps taken	Draft National Program for energy efficiency in public buildings in the Republic of Macedonia (Phase I) was developed under the GEF Sustainable Energy Project "Resilient Skopje" – Climate Change Strategy for the City of Skopje developed. Law on Energy Efficiency adopted.			
Steps envisaged	National Building Renovation Strategy to be developed and adopted. Bylawfstrs on energy performances of buildings, energy audits and municipalities' energy efficiency programmes and plans to be adopted Regular adoption of energy efficiency programmes and plans by the municipalities and reports on their implementation Fully-fledged information system on monitoring and management of energy consumption and MVP tool Establishment of an Energy Efficiency Fund.			
Indicators	Value in the last reporting year	Indicative trajectory		Target value
	2016-2018	2020	2025	2030
Progress – Area retrofitted (m^2)	See PAM 15			
Progress – Energy consumption per heated/cooled area (kWh/m^2)	See PAM 15			
Emissions reduction (Gg CO_2-eq)	2030		2040	2050
	20.9		38.6	58.9
Other – Final energy savings (ktoe)	5.3		9.8	14.9
Other – Primary energy savings (ktoe)	7.3		13.4	20.5
Finance – Budget	280 M€			
Finance – Source of finance	Local self-government budget, donors			
Implementing entity	Ministry of Economy, Energy Agency Ministry of Finance Local self-government Municipal public enterprises Donors and financial institutions			
Monitoring entity	Ministry of Economy, Energy Agency			

PAM 17 Retrofitting of existing commercial buildings

PAM 17 Retrofitting of existing commercial buildings								
Main objective: Retrofitting of existing commercial buildings with aim to meet the objectives of the EE Directive and the Energy Efficiency Law **Description:** There is lack of data for the commercial building stock, but according to third NEEAP the commercial building area is estimated to nearly 8 million m2. This measure considers reconstructions of existing commercial buildings including windows replacement initiated by the owners and/or supported by commercial banks and funds. The measure will provide issuing of certificates for energy performance of buildings, as a prerequisite for putting the reconstructions into operation.								
Timeframe		Type		Sector		Gases		Scope
2030 – 2050		Technical, regulatory		Commercial sector		CO_2, CH_4, N_2O		National
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency						
Methodology [for estimating the emissions]		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology						
Assumptions		Annual renovation rate of 1.5% of the existing commercial buildings.						
Status of implementation [idea, planning phase, under implementation]		Under implementation						
Steps taken		Law on Energy Efficiency adopted.						
Steps envisaged		Bylaws on energy performances of buildings and energy audits to be adopted Establishment of an Energy Efficiency Fund One of the recommendations given in Appendix III as a part of the guideline for the development od Building renovation strategy is to undertake a building stock analysis, covering the non-residential stock similar to the survey provided by the SSO for the households						
Indicators		Value in the last reporting year		Indicative trajectory				Target value
		2016-2018		2020		2025		2030
Progress	Area retrofitted (m^2)	SEE PAM 14						
Emissions reduction (Gg CO_2-eq)		2030		2040				2050
		48.6		86.7				150.7
Other	Final energy savings (ktoe)	12.3		21.9				38.1
	Primary energy savings (ktoe)	16.9		30.1				52.3
Finance	Budget	880 M€						
	Source of finance	Private, donors through commercial EE loans, EE fund						
Implementing entity		Ministry of Economy, Energy Agency Ministry of Finance Commercial building owners						
Monitoring entity		Ministry of Economy, Energy Agency						

PAM 18 Construction of new buildings

PAM 18 Construction of new buildings

Main objective: Construction of new buildings that will meet the minimum criteria set in the Rulebook of energy performance in buildings

Description: An energy efficient building reduces maintenance and utility costs, but, in many cases, improves durability, lessens noise, increases comfort and creates a healthy and safe indoor environment. A further goal of energy efficient construction is to limit damage to the ecosystem and reduce the use of natural resources like energy, land, water, and raw materials. This measure will provide issuing of certificates for energy performance of buildings, as a prerequisite for putting the building into operation.

Timeframe	Type	Sector	Gases	Scope
2020 – 2040	Technical, regulatory	Households	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency
Methodology [for estimating the emissions]	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	Construction of new residential buildings, while meeting the minimum energy performance requirements as the first criteria (in accordance with national legislation and cost-optimal calculations)
Status of implementation [idea, planning phase, under implementation]	Under implementation
Steps taken	Financial support for construction of new buildings at municipality level Law on Energy Efficiency adopted.
Steps envisaged	Bylaws on energy performances of buildings and energy audits to be adopted Establishment of an Energy Efficiency Fund

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2016-2018	2020	2025	2030
Progress	Area retrofitted (m^2)	See PAM 14			
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		21.3	32.6		46.3
Other	Final energy savings (ktoe)	12.9	19.8		28.0
	Primary energy savings (ktoe)	15.1	23.1		32.7

Finance	Budget	370 M€
	Source of finance	Private, donors through commercial EE loans, EE fund
Implementing entity		Ministry of Economy, Energy Agency Donors and financial institutions Investors (households)
Monitoring entity		Ministry of Economy, Energy Agency

PAM 19 Construction of passive buildings

PAM 19 Construction of passive buildings						
Main objective: After 31.12.2020 all new building should be nearly zero-energy buildings **Description:** The measure considers construction of new passive residential buildings in compliance with the EU Directive 2010/31/EU. This measure will provide issuing of certificates for energy performance of buildings, as a prerequisite for putting the building into operation.						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Technical, regulatory	Households	CO_2, CH_4, N_2O	National	
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of North Macedonia up to 2040 Law on energy efficiency				
Methodology [for estimating the emissions]		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology				
Assumptions		Construction of new passive buildings, while meeting the standard for at least A+ class (15 kWh/m2) starting from 2020 and continuously increasing their number so that in 2040, more than 90% of new buildings are assumed to be passive.				
Status of implementation [idea, planning phase, under implementation]		Under implementation				
Steps taken		Law on Energy Efficiency adopted.				
Steps envisaged		National Building Renovation Strategy to be developed and adopted. Bylaws on energy performances of buildings, energy audits and municipalities' energy efficiency programmes and plans to be adopted Plan for increasing the number of passive buildings with approximately zero energy consumption to be developed and adopted in 2022 Establishment of an Energy Efficiency Fund				
Indicators		Value in the last reporting year	Indicative trajectory		Target value	
		2016-2018*	2020	2025	2030	
Progress	Area retrofitted (m^2)					
Emissions reduction (Gg CO_2-eq)		2030		2040	2050	
		16.6		58.2	94.0	
Other	Final energy savings (ktoe)	8.3		29.1	47.0	
	Primary energy savings (ktoe)	10.3		36.0	58.1	
Finance	Budget	1520 M€				
	Source of finance	Private, donors through commercial EE loans, EE fund, financial support at municipality level				
Implementing entity		Ministry of Economy, Energy Agency Ministry of Transport and Communication Donors and financial institutions Investors (households)				
Monitoring entity		Ministry of Economy, Energy Agency				

* In the 4th NEEAP reported as Construction of passive buildings and EE certificates for buildings

PAM 20 Phasing out of incandescent lights

PAM 20 Phasing out of incandescent lights

Main objective: Improve the efficiency of lighting following the EU policies

Description: Governments around the world have passed measures to phase out incandescent light bulbs for general lighting in favour of more energy-efficient lighting alternatives. The goal is to improve energy efficiency, rather than forbid the use of incandescent technology. This measure includes replacing conventional incandescent light bulbs with halogen ones (at the beginning) and later with compact fluorescent (CFL) and LED.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory, policy	Households and commercial sector	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of North Macedonia up to 2040 Law on Energy Efficiency Commision Regulation(EC) No 244/2009 implementing Directive 2005/32/EC of the European Parlament and of the Council with regard to ecodesign requirements for non-directional household lamps
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	As incandescent lights are prohibited in EU since 2012 (and also following countries from EnC, such as Montenegro), it is assumed that the new Decree on eco-design of energy-related products will include prohibit of sales of incandescent light bulbs (with a transitional period of 2-3 years)
Status of implementation	Under implementation
Steps taken	The price of LED lights is decreasing and is approaching the price of incandescent lights.
Steps envisaged	Adoption of new Decree on eco-design of energy-related products in which the most recent EU implementing measures (technical regulations) related to non-directional, fluorescent and high intensity discharge lamps (lights) will be transposed and possibly prohibit sales of incandescent light bulbs in a certain transition period. Information campaign targeting lamps suppliers and consumers

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2016-2018	2020	2025	2030
Progress	Number of light bulbs sold (LED, CFL)				
	Installed capacity (MW)				
	Electricity consumption (MWh)				

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	114.0	131.9	139.5

Other		2030	2040	2050
	Final energy savings (ktoe)	36.3	42.0	44.4
	Primary energy savings (ktoe)	49.2	56.9	60.2

Finance	Budget	1027 M€
	Source of finance	Central government budget, private
Implementing entity		Government of the Republic of North Macedonia Ministry of Economy, Energy Agency State Market Inspectorate Lamps suppliers End-users
Monitoring entity		Ministry of Economy, Energy Agency

PAM 21 Improvement of the street lighting in the municipalities

PAM 21 Improvement of the street lighting in the municipalities

Main objective: Reduce the costs and increase the quality of street lighting

Description: The cost of street lighting, including electricity and maintenance, can have a huge impact on the budget of the municipalities. In addition, having in mind that a lot of manufactories work on daily bases on the improvement of the light bulbs, new opportunities are being opened for the municipalities. The inefficient light bulbs should be replaced, purchasing new ones that comply with the criteria of belonging to the highest EE class possible (CFL and LED lamps).

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical	Local self-government	CO_2, CH_4, N_2O	Local

Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of North Macedonia up to 2040 Law on Energy Efficiency
Methodology		Replacement of the mercury lamps with sodium and LED lamps. Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions		Improvement rate of 100% of street lighting by 2040.
Status of implementation		Under implementation
Steps taken		Street lighting in some municipalities replaced Tenders completed and/or replacement of street lights ongoing in more than 10 municipalities Promotional activities for the implementation of public-private partnership (PPP) taken
Steps envisaged		Adoption of Decree on energy performance contracts Energy Agency to develop and publish Instruction for energy performance contracts and tenders for their award Energy Agency to start keeping list of ESCO and publishing it, as well as other energy performance contract related information on its web site Continuing the promotional activities for the implementation of public-private partnership

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2016-2018	2020	2025	2030
Progress	Number of light bulbs replaced (LED, CFL)				
	Installed capacity (MW)				
	Electricity consumption (MWh)				

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	37.9	37.9	37.9

Other				
	Final energy savings (ktoe)	7.8	7.8	7.8
	Primary energy savings (ktoe)	14.2	14.2	14.2

Finance	Budget	40 M€
	Source of finance	Central and local government budget, ESCO
Implementing entity		Government of the Republic of North Macedonia Energy Regulatory Commission Ministry of Environment and Physical Planning Ministry of Economy, Energy Agency Local self-government
Monitoring entity		Ministry of Economy, Energy Agency

PAM 22 "Green procurements"

PAM 22 "Green procurements"						
Main objective: Application of energy efficiency criteria ("greening") in public procurement procedures **Description:** According to Article 6 from the EE Directive, central governments can purchase only products, services and buildings with high energy-efficiency performance. Intensified activities should take place to ensure legal and technical knowledge and skills of public sector entities for inclusion and evaluation of requirements for energy efficiency in public procurement procedures by applying the criteria of most economically advantageous tender.						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Regulatory	Public bodies	CO_2, CH_4, N_2O	National	
Relevant planning documents, legal and regulatory acts		trategy for Energy Development of North Macedonia up to 2040 Law on Energy Efficiency				
Methodology		Implementation of energy efficiency criteria. Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology				
Assumptions		Increased rate of advanced energy efficiency technology due to public procurement by 7%				
Status of implementation		Under implementation				
Steps taken		Law on Energy Efficiency adopted Law on Public procurements				
Steps envisaged		Drafting and adopting the following bylaws from the Law on Energy efficiency: Decree on eco-design of energy related products, Rulebook on Eco-labelling of energy related products, Rulebook on energy performance of buildings and Rulebook on green procurements that will include methodology for determining the energy efficiency level of other products as foreseen in the article 13 of the EE Law Organizing specialized trainings for contracting authorities on this subject matter Developing model technical specifications for purchase of certain energy related products of general use that will include green and energy efficiency criteria, thus facilitating the procurement process				
Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value	
		2016-2018	2020	2025	2030	
Progress	Number of devices purchase (A++, A+, A					
Emissions reduction (Gg CO_2-eq)		2030	2040		2050	
		2.9	6.9		16.5	
Other	Final energy savings (ktoe)	1.4	3.2		7.7	
	Primary energy savings (ktoe)	2.0	4.7		11.3	
Finance	Budget	34 M€				
	Source of finance	Central and local government budget				
Implementing entity		Ministry of Economy, Energy Agency Public Procurement Bureau Local self-government				
Monitoring entity		Ministry of Economy, Energy Agency				

PAM 23 Increased use of central heating systems

PAM 23 Increased use of central heating systems						
Main objective: Reduction of local air pollution, as household heating is one of the main sources for local pollution **Description:** Increased use of the existing central heating systems through the implementation of information campaigns for connecting new consumers, including those who have been disconnected from the system in the past.						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Technical, information	Households and commercial	CO_2, CH_4, N_2O	National	
Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of North Macedonia up to 2040 Law on Energy Efficiency Energy Law, Law on urban planning, Law on Construction Study for determining the techno-economic optimal and environmentally sustainable structure of heating and implementation of the central supply of sanitary hot water in the City of Skopje Energy development program of the Municipality				
Methodology		Implementation of information campaigns. Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology				
Assumptions		Information campaigns will contribute to maximize the utilization of the existing network as well as to enable construction of new network, which will increase the heat consumption for at least 40%.				
Status of implementation		Under implementation				
Steps taken		Studies for analysis of the central heating system and implementation of central supply of sanitary hot water developed for the city of Skopje Information campaigns for re-connection of the previously disconnected consumers and attraction of new consumers implemented Reduced the VAT from 18% to 5%				
Steps envisaged		Continuing the implementation of the information campaigns Enlargement of Heat Distribution network in Skopje Development of the District Heating in Municipality of Bitola Development of a study for introduction of small cogeneration highly efficient plants in other cities (primarily Tetovo, Kumanovo and Gostivar according to the guidelines from the Annex)				
Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value	
		2016-2018	2020	2025	2030	
Progress	Number of new consumers					
Emissions reduction (Gg CO_2-eq)		2030	2040		2050	
		4.14	16.76		24.81	
Other	Final energy savings (ktoe)	3.3	13.5		20.0	
	Primary energy savings (ktoe)	4.8	19.3		28.5	
Finance	Budget	20 M€				
	Source of finance	Private, EE fund, incentives from the central and local government budget				
Implementing entity		Ministry of Economy, Energy Agency Balkan energy Dooel Skopje JSC Skopje Sever "Energetika" –Skopje, subsidiary to JSC Macedonian Power Plants (ESM AD) Private investors				
Monitoring entity		Energy Regulatory Commission Ministry of Economy, Energy Agency				

Some of the energy efficiency measures are urgent and require implementation in a short-term as they are expected to bring benefits within a short timeframe. Among these measures are the phasing out of incandescent lights and the improvement of street lightening municipalities

Industry

The mitigation actions defined for the industry sub-sector aim to achieve GHG emission reductions of **298.6 Gg CO2-eq by 2030,** and of **1,458 Gg CO2-eq by 2050.**
According to the IPCC methodology, it is important to mention that the Energy sector includes all sub-sectors that have energy consumption, i.e., in the Energy sector the emissions from fuel consumption are reported. It often happens that the Industry subsector (Manufacturing, Industry and Construction) is equated with the IPPU sector. The IPPU sector includes emissions which are result from certain industrial processes, while the Industry sub-sector in the Energy sector includes emissions from fuel consumption in the Industry.
The mitigation actions identified include a wide range of energy efficiency technologies focusing on improving industrial processes. These mitigation actions include:

PAM 24 Energy management in manufacturing industries

PAM 24 Energy management in manufacturing industries

Main objective: Efficient management of manufacturing processes in industry aiming to increase production using the same energy consumption.

Description: This measure considers implementation of obligatory energy audits of large companies and implementation of ISO 50001 standard, as well as advanced measurement and introduction of new IT technologies. This will enable prevention of defects, better process control and quicker response times in manufacturing using advanced data analysis and predictive technologies.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory, technical	Industry	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on energy efficiency
Methodology	Implementation of information campaigns . Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	Improvement of the systems efficiency in manufacturing industries at annual rate of 0.15%.
Status of implementation	Under implementation
Steps taken	Promotion of ISO 50001 standards completed Training on implementation of energy management in industry organized Certificates for energy auditors issued USAID project for energy management in industry realized in 17 companies UNIDO/GEF Project in which one of the activities is Program for energy management in industrial companies according to ISO 50001 standard and the UNIDO Methodology. Initial results achieved in 12 companies and additionally Program for replications of the energy management systems realized in 5 companies
Steps envisaged	Continuation of the implementation of ISO 50001 standard in more industrial companies (manufacturing industries). Drafting and adopting the Rulebook on energy audits in large companies based on and with the content prescribed in article 16 of the EE Law Implementation of obligatory energy audits.

Indicators		Indicator value in the last reporting year		Indicator target valu
		2016-2018		2030
Progress				
Emissions reduction (Gg CO_2-eq)		2030	2040	2050
		28.4	35.6	50,8
Other	Final energy savings (ktoe)	7.3	9.2	13.1
	Primary energy savings (ktoe)	9.6	12.0	17.2
Finance	Budget	Negligible (the implementation of ISO 500001 is 0.15 mill. EUR/big company*)		
	Source of finance	Private, donors through commercial EE loans		
Implementing entity		Ministry of Economy, Energy Agency Private companies		
Monitoring entity		Energy Regulatory Commission Ministry of Economy, Energy Agency		

* Study of the Industry Sector - Analysis of Mitigation Policies and Measures (SUTIND), 2020, MANU

PAM 25 Introduction of efficient electric motors

PAM 25 Introduction of efficient electric motors

Main objective: Increase the competitiveness of the industrial products through improvement of the efficiency in the production process and reducing the resources.

Description: Electric motors are responsible for a high share of the total electricity consumption in industries. This measure considers replacement of the obsolete machines currently in use, with new more efficient motors

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical	Industry	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on energy efficiency				
Methodology	Implementation of information campaigns . Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology				
Assumptions	It is envisaged that the share of efficient electric motors by 2040 will be 60%				
Status of implementation	Under implementation				
Steps taken	New efficient electric motors installed in a number of companies				
Steps envisaged	Replacement of the existing electric motors from the production processes in the industry facilities in Macedonia with more efficient ones				
Indicators	Indicator value in the last reporting year	Indicative trajectory			Indicator target value
	2016-2018	2020	2025		2030
Progress					
Emissions reduction (Gg CO_2-eq)	2030	2040			2050
	32.98	50.86			102.67
Other – Final energy savings (ktoe)	8.8	13.6			27.5
Other – Primary energy savings (ktoe)	12.6	19.4			39.2
Finance – Budget	172.0 M€				
Finance – Source of finance	Private, donors through commercial EE loans				
Implementing entity	Ministry of Economy, Energy Agency Private companies				
Monitoring entity	nergy Regulatory Commission Ministry of Economy, Energy Agency				

PAM 26 Introduction of more advanced technologies

PAM 26 Introduction of more advanced technologies

Main objective: Introduction of more advanced technologies in the industrial processes that will also enable use of more environmental friendly fuels.

Description: Advanced industrial technologies present major opportunities for further reduction of the energy consumption and potentially lower costs as well as environmental benefits. In addition, they can help various industries to progress at a much faster rate

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical	Industry	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on energy efficiency
Methodology		Implementation of information campaigns . Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions		The share of more advanced technologies by 2040 is 60% from all technologies.
Status of implementation		Under implementation
Steps taken		Construction of gas network in Macedonia Klechovce-Valve station 5 (Stip), finished in 2016 Valve station 5(Stip)-Negotino, finished in 2019
Steps envisaged		Finishing the construction of gas network in Macedonia Negotino (Kavadarci)-Bitola, 76.36% realized November 2019 Skopje-Tetovo-Gostivar, 53.1% realized November 2019 Gostivar-Kicevo, in a process of obtaining building permit (by 2022) Kicevo-Ohrid (to be finished by 2025) Valve station 5 (Stip)-Radovis-Strumica Inventory on the companies where coal or natural gas fuel can be replaced Development of strategy for introduction of hydrogen

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2016-2018	2020	2025	2030
Progress	Gas energy consumption				
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		237.22	747.88		1304.50
Other	Final energy savings (ktoe)	72.1	227.4		396,6
	Primary energy savings (ktoe)	75,9	239.3		417.4

Finance	Budget	1414 M€
	Source of finance	Private, donors through commercial EE loans, EE fund
Implementing entity		Government of the Republic of North Macedonia Ministry of Environment and Physical Planning Ministry of Economy, Energy Agency Private investors
Monitoring entity		Ministry of Economy, Energy Agency

Transport

The mitigation actions defined for the transport sub-sector aim to achieve GHG emission reductions of **619.3 Gg CO2-eq by 2030,** and of **918.7 Gg CO2-eq by 2050.**
The mitigation actions identified will lead to sub-sector transformation and GHG mitigation in the transport sub-sector. The proposed measures have a different timeline between short-, medium-, and long-term (2030 - 2050). These mitigation actions include:

PAM 27 Increased use of the railway

PAM 27 Increased use of the railway

Main objective: Improve the energy efficiency in the transport sector using cheap and efficient railway transport.

Description: Although the rail transport is cheap, official statistical data show that in the last three years there is a downward trend. Using this mode of transport as one of the most efficient can also improve the competitiveness of the companies. Therefore, at least several listed measures should be implemented, aiming to return the utilization level of this transport as of three years ago, and further increase it. The measure includes:

- ☒ implement raising awareness campaigns
- ☒ invest in stations and improve the "access to the stations"
- ☒ increase the network security and expand the network coverage

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, information	Transport	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	National Transport Strategy Strategy for Energy Development of the Republic of Macedonia up to 2040
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	By 2040, 5% of the passenger kilometers of cars, 1% of passenger kilometers of busses and 10% of tonnes kilometers of heavy duty vehicles will be realized by railway transport.
Status of implementation	Under implementation
Steps taken	50 freight cars and six compositions consisting of a locomotive and passenger cars ordered by the Government as part of a project with the European Bank for Reconstruction and Development (EBRD). Some of these have already been received and put into use. Campaigns for cheaper/free driving of certain categories of passengers (young people, pensioners, etc.) carried out
Steps envisaged	Implement promotional campaigns for raising public awareness Continuing the campaigns for cheaper/free driving Enabling additional conditions for companies Liberalize the railway passenger transport Develop and implement projects for railway network reconstruction and expansion, as well as for renewal of train (cars and locomotives) fleet

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2016-2018	2020	2025	2030
Progress	Increase of tonnes km in railway transport (tkm)				
	Increase of passenger km in railway transport (pkm)				

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	91.7	98.0	102.9
Other: Final energy savings (ktoe)	37.2	39.7	41.7
Other: Primary energy savings (ktoe)	29.8	31.8	33.4

Finance: Budget	434 M€
Finance: Source of finance	Central government budget
Implementing entity	Government of the Republic of North Macedonia Ministry of Transport and Communications Ministry of Economy, Energy Agency JSC Macedonian Railway Transport End-users Private companies
Monitoring entity	Ministry of Economy, Energy Agency

PAM 28 Renewing of the national car fleet

PAM 28 Renewing of the national car fleet

Main objective: Use of more advanced technologies in order to slow down the growing energy consumption in the transport sector, which is complex and with limited capabilities of energy use reduction.

Description: The measures recommended in the Study on the transport sector analysis of policies and measures should be implemented: Reduction of VAT from 18% to 5% for hybrid and electric vehicles; Direct subsidizing of hybrid vehicles, Excise duties of diesel fuel and petrol need to be gradually equaled.

Obligations of public institutions to purchase vehicles with low CO_2 emissions (up to 90 gCO2/km by 2020 and 50 gCO_2/km by 2025).

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory, policy, information	Transport	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	National Transport Strategy Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on vehicles Law on vehicle tax
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	It is assumed that only new vehicles and vehicles not older than eight years will be sold, i.e. vehicles that meet EU standards such as CO2 emissions in 2020 of 95 g CO2/km, and 70 g CO2/km by 2025. In addition, advanced technologies such as diesel and gasoline HEV will be used with a share of 35% in the total passenger km from cars by 2040.
Status of implementation	Under implementation
Steps taken	Law on vehicles adopted (August 2019) Law on vehicle tax adopted Bylaws stemming from the Law on vehicle tax adopted
Steps envisaged	Implementation of the program for subsidizing for purchasing vehicles stipulated in the Law on vehicles, Revision of the Law on excise duty to be prepared (excise duties of diesel fuel and petrol need to be gradually equalized). Amend the VAT Law in order to reduce the VAT rate from 18% to 5% for hybrid and electric vehicles Starting from 2022, obligations of public institutions to purchase vehicles with low CO2, which in the first phase could be done by the Government obligating the public institutions under its jurisdiction to foresee in their annual procurement plans purchase of certain percentage of such vehicles, while in the second phase the obligation could be put in the EE Law and / or the Law on Biofuels, thus making it mandatory for all public institutions Increase the EURO standard for import of cars

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2016-2018	2020	2025	2030
Progress	Number of vehicles per type				
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		28.3	30.3		33.5
Other	Final energy savings (ktoe)	23.0	24.7		27.3
	Primary energy savings (ktoe)	23.0	24.7		27.3
Finance	Budget	1172 M€			
	Source of finance	Private, EE fund, incentives from the central government budget			

Implementing entity	Government of the Republic of North Macedonia Ministry of Transport and Communications Ministry of Finance Ministry of Economy, Energy Agency End-users
Monitoring entity	Ministry of Economy, Energy Agency Ministry of interior

PAM 29 Renewing of other national road fleet

PAM 29 Renewing of other national road fleet

Main objective: Reduction of the local air pollution.

Description: This measure anticipates introduction of a regulation that will enable renewal of the vehicle fleet of light duty and heavy goods vehicles and buses.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory, policy	Transport	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	National Transport Strategy Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on vehicles Law on vehicle tax
Methodology [for estimating the emissions]	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	It is assumed that only new advanced vehicles such as HEVs that meet EU standards for exhaust fumes will be sold.
Status of implementation [idea, planning phase, under implementation]	Under implementation
Steps taken	Law on vehicles adopted (August 2019) Bylaws stemming from the Law on vehicle tax adopted
Steps envisaged	Successive implementation of EURO standards (EU new standard is a EURO 6, while in Macedonia is EURO 4) for import of new EE vehicles Raise the minimum standard for the passenger transport vehicles from eco category 3 to eco category 2 Implementation of Bus Rapid Transport (BRT) system for Skopje.

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2016-2018	2020	2025	2030
Progress	Number of vehicles per type				

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	351.4	400.8	447.3

Other		2030	2040	2050
	Final energy savings (ktoe)	110.8	126.3	141.0
	Primary energy savings (ktoe)	110.8	126.3	141.0

Finance	Budget	5381 M€
	Source of finance	Private
Implementing entity		Government of the Republic of North Macedonia Ministry of Transport and Communications Ministry of Economy, Energy Agency Association of road transport carriers Private companies
Monitoring entity		Ministry of Transport and Communications Ministry of Economy, Energy Agency

PAM 30 Advanced mobility

PAM 30 Advanced mobility

Main objective: Reduction of the local air pollution.

Description: The measure includes conducting campaigns/providing subsidies and systems for use of new or rented bicycles, electric scooters, promoting walking, and introduction of parking policies that would reduce the use of cars in the city area. People, especially in smaller towns where a lot of them use cars for short distances, would increase the use of bicycles/electric scooters or walking.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory, technical, information	Transport	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	National Transport Strategy Strategy for Energy Development of the Republic of Macedonia up to 2040 Decisions made by municipalities to subsidize buying of new bicycles
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	By 2050, 5% of short distance passenger kilometres will be replaced by walking, using bicycles or electric scooters
Status of implementation	Under implementation
Steps taken	Subsidies and campaigns for buying new bicycles/electric scooters implemented Systems for bicycles renting implemented Bicycles tracks constructed Zonal parking implemented New multi-level car parks constructed In the period 2016-2019 around 17,500 bicycles and around 300 electric scooters were subsidized. The subsides at the yearly level are around 230000 €.
Steps envisaged	Continue the implementation of the campaigns and subsidies for buying new bicycles and renting bicycles Continue the construction of new bicycles tracks

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2016-2018	2020	2025	2030
Progress	Number of bicycles/ electric scooters	12660*			

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	3.0	6.4	12.5

Other		2030	2040	2050
	Final energy savings (ktoe)	1	2.5	4.8
	Primary energy savings (ktoe)	1	2.5	4.8

Finance	Budget	12
	Source of finance	Private, EE fund, incentives from the central and local government budget, donors
Implementing entity		Ministry of Economy, Energy Agency Local self-government End-users
Monitoring entity		Ministry of Economy, Energy Agency Local self-government

* Only those that applied for subsidies

PAM 31 Construction of the railway to Republic of Bulgaria

PAM 31 Construction of the railway to Republic of Bulgaria

Main objective: Connecting the Republic of Macedonia with the Republic of Bulgaria and extending the export to external markets, not just in the neighboring countries but in the Southeast Europe and Turkey region, using the railway transport.

Description: Construction of the railway to Republic of Bulgaria.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical, policy	Transport	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts		Work Program of the Government of the Republic of North Macedonia National Transport Strategy
Methodology [for estimating the emissions]		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions		By 2040 up to 5% of the tonne kilometers (to the Republic of Bulgaria) of the heavy goods vehicles will be replaced by the railroad transport.
Status of implementation [idea, planning phase, under implementation]		Under implementation
Steps taken		In 2017, EU awarded 70 mil. EUR grant to the Government for construction of this railway line First phase (Kumanovo - Beljakovce) is under construction, 67% constructed by the end of 2019 Since the construction of the first phase was cancelled, new tender was published for both the first and the second phase in February 2021 (North Macedonia: Rail Corridor VIII, First And Second Section Re-Tender Eastern Part Of Railway Corridor VIII, First Section Kumanovo-Baljakovce And Second Section, Beljakovce – Kriva Palanka).
Steps envisaged		Finish the construction of the first and the second phase by the end of 2024 Tender for the third phase (Kriva Palanka – Deve Bair) to be announced.

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2016-2018	2020	2025	2030
Progress	Increase of the tonnes km in the railway transport (tkm)				

Emissions reduction (Gg CO2-eq)	2030	2040	2050
	24.6	37,5	50.3

Other		2030	2040	2050
	Final energy savings (ktoe)	10.2	15.3	20.5
	Primary energy savings (ktoe)	8.2	12.2	16.2

Finance	Budget	720 M€ (infrastructure+trains)
	Source of finance	Central government budget
Implementing entity		Government of the Republic of North Macedonia Ministry of Transport and Communications
Monitoring entity		Ministry of Transport and Communications

PAM 32 Electrification of the transport

PAM 32 Electrification of the transport							
Main objective: Transition from society based on fossil fuels to low carbon society, where the renewable energy and electrification of the transport will play the most important role. **Description:** At least the following measures recommended in the "Study on the transport sector, analysis of policies and measures" should be implemented: Direct subsidizing of electric vehicles, 5000 EUR Obligation to place fast chargers at all gas stations on motorways (at every 100 km by 2020)							
Timeframe		Type		Sector	Gases	Scope	
2030 – 2050		Regulatory, policy, information		Transport	CO_2, CH_4, N_2O	National	
Relevant planning documents, lega and regulatory acts		National Transport Strategy Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on vehicles Law on vehicle tax					
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology					
Assumptions		It is envisaged that by 2050 the share of electric vehicles and "plug-in" hybrid electric vehicles in the total passenger km from cars will be 55%.					
Status of implementation		Under implementation					
Steps taken		Chargers installed at specific locations in the City of Skopje, as well as other cities Law on vehicles substantially amended in August 2019 Law on vehicle tax and bylaws adopted in 2019 Exemption from paying excise duty for electric vehicles Reservation of Greenparking in all public parking lots Base the methodology for calculation of vehicle tax on import on CO_2					
Steps envisaged		Amend the VAT Law in order to reduce the VAT rate from 18% to 5% for hybrid and electric vehicles Development of studies for determining the best locations for installation of electric vehicles chargers from the aspect of the power grid. Funds in the budget should be allocated for the realization of the Program for subsidizing new vehicles Development of strategy for electrification of the transport sector Development of strategy for introduction of hydrogen					
Indicators		Indicator value in the last reporting year	Indicative trajectory			Indicator target value	
		2018	2020	2025		2030	
Progress	Increase of the tonnes km in the railway transport (tkm)						
Emissions reduction (Gg CO_2-eq)		2030	2040	2050			
		120.3	259.7	272.2			
Other	Final energy savings (ktoe)	60.7	125.6	131.7			
	Primary energy savings (ktoe)	40.8	83.8	87.8			
Finance	Budget	7579 M€					
	Source of finance	Private, EE fund, incentives from the central government budget					
Implementing entity		Government of the Republic of North Macedonia Ministry of Transport and Communications Ministry of Economy, Energy Agency					
Monitoring entity		Ministry of Economy, Energy Agency Ministry of interior					

* Although these vehicles are more efficient than fossil fuel vehicles, the emissions from this measure may increase, considering that the electricity in the power system is mainly produced from fossil fuels, therefore this measure should be implemented in parallel with the measures for electricity generation from RES.

These mitigation measures have a long-term character and require a strategic approach to ensure awareness raising, to incentivise behavioural change and establish enabling conditions such as legislation and infrastructure such as charging networks.

4.2.1.3 Measures overview and investment needs

Compared to the Baseline Scenario, the Mitigation scenario includes 32 measures/policies in the energy sector, as presented in Table 4-3.

Table 4-3. Review of the measures/policies included in the Mitigation scenario of the energy sector

	Policy/measure	Competent entity for realization	Budget (mil. €)	Source of finance	Indicative emissions reduction ($Gg\ CO_2$-eq)		
					2030	2040	2050
1	Reduction of network losses	• Electricity distribution companies • Heat distribution companies • Energy Agency, Ministry of Economy	170	Distribution and transmission companies	104.4	168.5	168.5
2	Large hydropower plants	• JSC ESM • Ministry of Environment and Physical Planning • Ministry of Economy, Energy Agency	1556	JSC ESM, Public Private Partnership, Independent power producers	617.7	757.8	1556.7
3	Incentives Feed-in tariff	• Government of the Republic of North Macedonia • Energy Regulatory Commission • Ministry of Environment and Physical Planning • Ministry of Economy, Energy Agency • Private investors	557	Independent power producers Consumers of electricity through bills	123.3	147.0	178.9
4	Incentives feed-in premium	• Government of the Republic of North Macedonia • Energy Regulatory Commission • Ministry of Economy • Private investors	160	Independent power producers, incentives from the central government budget	108.0	108.0	108.0
5	Biomass power plants (CHP optional)	• Government of the Republic of North Macedonia • Energy Regulatory Commission • Ministry of Environment and Physical Planning • Ministry of Economy, Energy Agency • Private investors	24.3	Independent power producers Consumers of electricity through bills	21.0	21.0	21.0
6	Solar rooftop power plants	• Government of the Republic of North Macedonia • Energy Regulatory Commission • Ministry of Economy, Energy Agency • Elektrodustribucija Skopje • Suppliers of electricity • End-users of electricity	699	Independent power producers, donors, subsidies from national and local budget, EE fund	84.6	214.6	234.9
7	RES without incentives	• Government of the Republic of North Macedonia • Energy Regulatory Commission • Ministry of Economy, Energy Agency • JSC Macedonian Power Plants (ESM AD) • Private investors	2194	Public private partnership, Independent power producers, ESM	74.0	219.8	286.6
8	Development of the biofuels market	• Government of the Republic of North Macedonia • Ministry of economy • Companies that sell oil products	n/a	Central government budget, consumers	96.0	96.0	96.0
9	Energy efficiency obligation schemes	• Ministry of economy • Distribution system operators • Suppliers and traders of electricity and gas	124	Consumers through their bills	10.3	24.4	58.4

	Policy/measure	Competent entity for realization	Budget (mil. €)	Source of finance	Indicative emissions reduction (Gg CO_2-eq)		
					2030	2040	2050
10	Solar thermal collectors	• Ministry of Economy, Energy Agency • End-users	60	Private, EE fund, incentives from the central government budget, donors	14.8	19.9	23.3
11	Labeling of electric appliances and equipment	• Ministry of Economy, Energy Agency • Producers and suppliers of electrical equipment and household appliances • End-users	48	Private, EE fund	42.4	100.5	240.9
12	Increased use of heat pumps	• Ministry of Economy, Energy Agency • End-users	240	Private, EE fund, incentives from the central and local government budget, donors	281.7	430.3	555.9
13	Public awareness campaigns and network of EE info centers	• Ministry of Economy, Energy Agency • Energy suppliers • End-users	598	Private sector, donors, central and local governments	117.9	279.1	669.0
14	Retrofitting of existing residential buildings	• Ministry of Economy, Energy Agency • Donors and financial institutions • Households	3187	Private, donors through commercial EE loans, EE fund	20.5	56.6	90.3
15	Retrofitting of existing central government buildings	• Ministry of Economy, Energy Agency • Ministry of Finance • Local self-government • Municipal public enterprises • Donors and financial institutions	290	Central government budget, donors	20.9	38.6	58.9
16	Retrofitting of existing local self-government buildings	• Ministry of Economy, Energy Agency • Ministry of Finance • Local self-government • Municipal public enterprises • Donors and financial institutions	280	Local self-government budget, donors	20.9	38.6	58.9
17	Retrofitting of existing commercial buildings	• Ministry of Economy, Energy Agency • Ministry of Finance • Commercial buildings owners	880	Private, donors through commercial EE loans, EE fund	48.6	86.7	150.7
18	Construction of new buildings	• Ministry of Economy, Energy Agency • Donors and financial institutions • Investors (households)	370	Private, donors through commercial EE loans, EE fund	21.3	32.6	46.3
19	Construction of passive buildings	• Ministry of Economy, Energy Agency • Donors and financial institutions • Investors (households)	1520	Private, donors through commercial EE loans, EE fund	16.6	58.2	94.0
20	Phasing out of incandescent lights	• Government of the Republic of North Macedonia • Ministry of Economy, Energy Agency • End-users	1027	Central government budget, private	114.0	131.9	139.5
21	Improvement of the street lighting in the municipalities	• Government of the Republic of North Macedonia • Energy Regulatory Commission • Ministry of Environment and Physical Planning • Ministry of Economy, Energy Agency	40	Central and local government budget, ESCO	37.9	37.9	37.9
22	Green procurements	• Local self-government • Ministry of Economy, Energy Agency • Public Procurement Bureau • Local self-government	34	Central and local government budget	2.9	6.9	16.5

	Policy/measure	Competent entity for realization	Budget (mil. €)	Source of finance	Indicative emissions reduction ($Gg\ CO_2$-eq)		
					2030	2040	2050
23	Increased use of central heating systems	• Ministry of Economy, Energy Agency • Balkan energy Dooel Skopje • JSC Skopje Sever • "Energetika" –Skopje, subsidiary to JSC Macedonian Power Plants (ESM AD) • Private investors	20	Private, EE fund, incentives from the central and local government budget	4.1	16.8	24.8
24	Energy management in manufacturing industries	• Ministry of Economy, Energy Agency • Private companies	n/a	Private, donors through commercial EE loans	28.4	35.6	50.8
25	Introduction of efficient electric motors	• Private companies • Ministry of Economy, Energy Agency	172	Private, donors through commercial EE loans	33.0	50.9	102.7
26	Introduction of more advanced technologies	• Government of the Republic of North Macedonia • Ministry of Environment and Physical Planning • Ministry of Economy, Energy Agency • Private investors	1414	Private, donors through commercial EE loans, EE fund	237.2	747.9	1304.5
27	Increased use of the railway	• Government of the RM • Ministry of Transport and Communication • Ministry of Economy, Energy Agency • JSC Makedonski zeleznici • End-users • Private companies	434	Central government budget	91.7	98.0	102.9
28	Renewing of the national car fleet	• Government of the RM • Ministry of Transport and Communication • Ministry of Economy, Energy Agency • End-users	1172	Private, EE fund, incentives from the central government budget	28.3	30.3	33.5
29	Renewing of other national road fleet	• Government of the Republic of North Macedonia • Ministry of Transport and Communications • Ministry of Interior Affairs • Ministry of Economy, Energy Agency • Private companies	5381	Private sector	351.4	400.8	447.3
30	Advanced mobility	• Ministry of Economy, Energy Agency • Local self-government • End-users	12	Private, EE fund, incentives from the central and local government budget, donors	3.0	6.4	12.5
31	*Construction of the railway to the Republic of Bulgaria*	• *Government of the Republic of North Macedonia* • *Ministry of Transport and Communications* • *Ministry of Economy, Energy Agency*	*720*	*Central government budget*	*24.6*	*37.5*	*50.3*
32	Electrification of the transport	• Government of the Republic of North Macedonia • Ministry of Transport and Communications • Ministry of economy	7579	Private, EE fund, incentives from the central government budget	120.3	259.7	272.2
Total			30,962		2,921	4,758	7,292

For the implementation of the Mitigation measures in the Energy sector, investments of 30,962 mil. € are needed, for the period from 2020 to 2050.

It is important to emphasize that the investments in the WAM scenario contribute to reducing the total system costs (€ 35,958 million discounted in 2012) compared to the reference scenario costs (€ 39,786 million), which is a reduction of 9.6%. If all of the measures are implemented in parallel and the "Energy efficiency first" principal is applied, then the total investment can be reduced by about 25%. Measures with the most significant potential for greenhouse gas emissions reduction are the RES without incentives, Large hydro power plants and Phasing out of incandescent lights.

4.2.2 IPPU sector

4.2.2.1 Baseline

In the IPPU sector there are emissions from the following categories: Mineral Industry, Metal Industry and Product Uses as Substitutes for ODS.

The fundamental assumption used to plan the GHG emissions in this sector is that they are mainly dependent on the increase of the production index growth in the specific industry. Based on this assumption, an analysis of the correlation between the emissions and the added value in each industry category is made. However, this assumption does not apply to the category Product Uses as Substitutes for ODS, where the main source of emissions is from imported appliances (such as refrigerators and air conditioners). For this category it is assumed that the import of appliances depends on GDP, in the WOM scenario.

It is projected that GHG emissions from the Mineral industry, in the period up to 2050 will continue to be mainly constant, with a slight reduction in 2050 when compared to the average value in the period 2006-2019 (Figure 4-6).

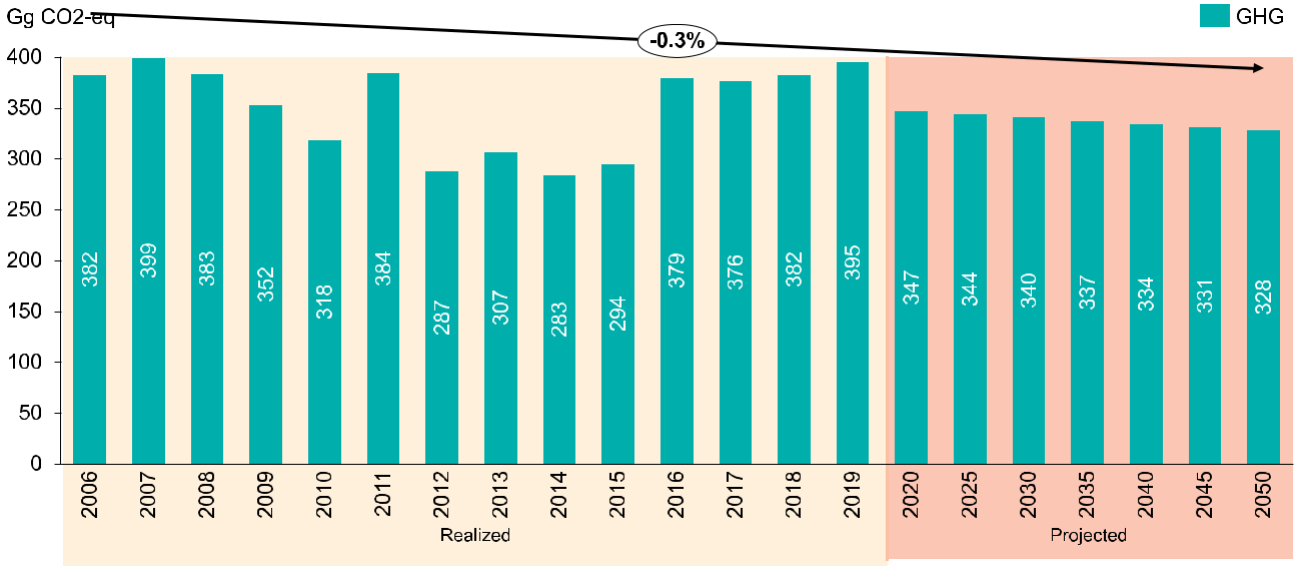


Figure 4-6: Historic and projected GHG emissions and value added in the Mineral industry (in Gg CO_2-eq)

The emissions in the Metal industry are positively correlated to the production index growth in this category, so the emissions increase with annual rate of 2.9% up to 2050 (which corresponds to the increase in the production index growth), reaching around 900 Gg CO2-eq in 2050 (Figure 4-7).

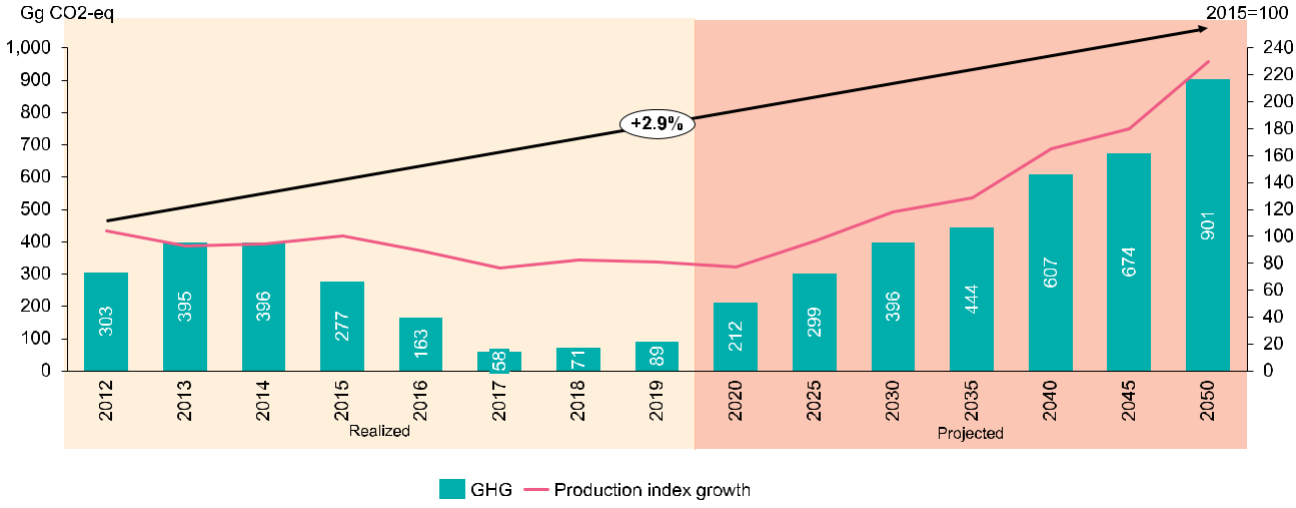


Figure 4-7: Historic and projected GHG emissions and value added in the Metal industry (in Gg CO_2-eq)

The emissions in the category Product Uses as Substitutes for ODS follow the growth of the GDP in Macedonia, and in 2050 they will achieve around 900 Gg CO_2-eq or around 3 times more compared to 2019 (Figure 4-8).

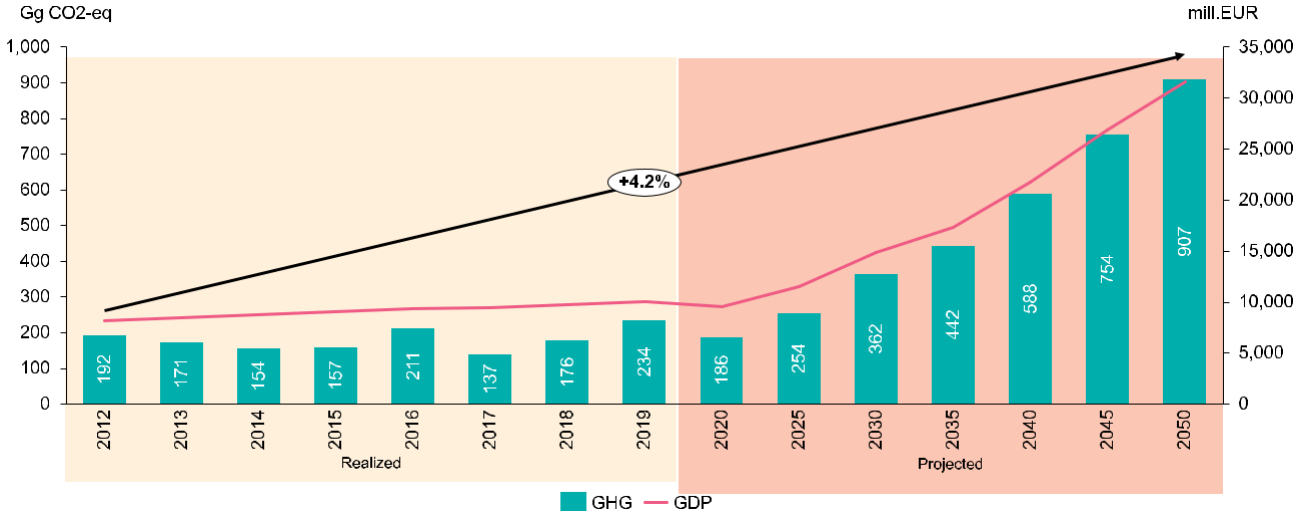


Figure 4-8: Realized and projected GHG emissions in the category Product Uses as Substitutes for Ozone Depleting Substances and GDP (in Gg CO_2-eq)

Summing up the projections of the emissions in the IPPU sector shows that there is an increase of about 2 times in 2050, compared to 2019 (Figure 4-9). The emissions will reach 2,136 Gg CO_2-eq in 2050. Product Uses as Substitutes for ODS will be the most dominant category with an emission share of 42.5% in 2050 (32.6% in 2019). The share of the Metal Industry is also increasing, reaching 42.2% in 2050. Since the emissions in the Mineral industry are almost constant, their share is reduced to 15.3% in 2050.

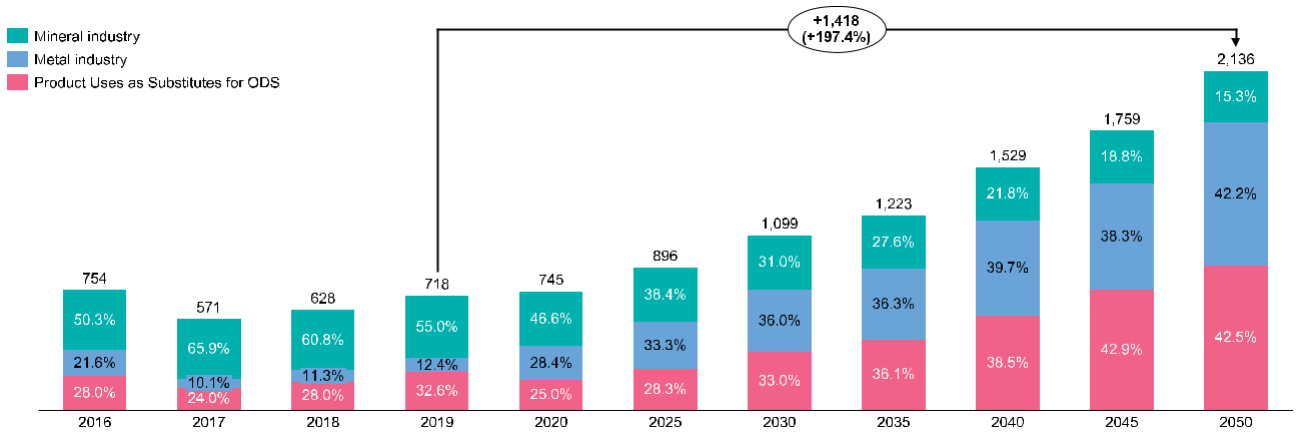


Figure 4-9: Total GHG emissions in Industrial processes and product use sector by categories (in Gg CO_2-eq)

4.2.2.2 Mitigation measures in the IPPU sector

The proposed polices and measures in this section are developed based on the Climate Change Mitigation Report, prepared for this NC.

The overall GHG emission reduction to be achieved via the mitigation actions in the IPPU sector, which is expected to be **225.6 Gg CO_2-eq by 2030,** and **861.6 Gg CO_2-eq by 2050** compared to 1990 (Mitigation scenario). The mitigation actions include:

PAM 33 Implementation of Kigali amendment on HFC phase-down

PAM 33 Implementation of Kigali amendment on HFC phase-down					
Main objective: Phase-down of greenhouse gases hydrofluorocarbons (HFCs) **Description:** The Kigali Amendment is an amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer. The Amendment adds powerful greenhouse gases hydrofluorocarbons (HFCs) to the list of substances controlled under the Protocol and which are to be phased down. The Republic of North Macedonia has become the 94th country to ratify the Kigali Amendment to phase down HFC refrigerants. North Macedonia is following the schedule of the Kigali Amendment to the Montreal Protocol, for Annex 5 countries, starting with a freeze in 2024 of the HFCs and ending with a permanent 80% reduction in 2045.					
Timeframe		Type	Sector	Gases	Scope
2030 – 2050		Technical, regulatory	IPPU	HFC	National
Relevant planning documents, legal and regulatory acts		Order for banning the import and export of products containing chlorofluorocarbons (HCFCs) („Official Gazette of the Republic of Macedonia“ No. 92/10) Order to limit the import of substances that deplete the ozone layer („Official Gazette of the Republic of Macedonia“ no. 92/10, 150/12): Order for banning the sale of 1,1-dichloro-1-fluoroethane (HCFC 141b) and mixtures containing 1,1-dichloro-1-fluoroethane (HCFC 141b) („Official Gazette of the Republic of North Macedonia“ no. 111/21) RATIFICATION ACT OF THE AMENDMENT TO THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER			
Methodology		IPPU model developed in Excel			
Assumptions		Phase-down schedule for N. Macedonia of HFC according to Kigali Amendment: Baseline formula – average consumption for 2020-2022 + 65% of hydrochlorofluorocarbon (HCFC) baseline 2024 - freeze 2029 - -10% 2035 - -30% 2040 - -50% 2045 - -80% Since the data for the consumption in 2020-2022 of HFC is still not reported, in this measure the average consumption in the period 2017-2019 is assumed for the baseline. The addition of 65% of HCFC in the baseline is optional, and is not advisable to be considered if the consumption of HCFC is reduced to zero. Having the legal acts which are in place in North Macedonia, the consumption (i.e. import) of HCFH is minimal, and equal to 0 in 2017, and therefore this addition is not considered in this measure.			
Status of implementation		Under implementation			
Steps taken		Ratification of the Amendment to the Montreal protocol on substances that deplete the ozone layer Ongoing UNIDO project for implementation of the Kigali Amendment to the Montreal Protocol, considering the situation in the country with regard to the current HFC consumption. Legal documents, stakeholder engagement, and awareness raising events are in progress, which led to the ratification of the Kigali Amendment in February 2020 (https://open.unido.org/projects/MK/projects/200289)			
Steps envisaged		Implementation of the schedule for HFC phase-down, with the help of projects supported by Montreal Protocol fund			
Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2019	2030	2040	2050
Progress	HFC [tonnes]	120	139	80	0
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		225.6	471.6		861.6
Finance	Budget	N/A			
	Source of finance	Montreal Protocol fund, private sector			
Implementing entity		Minister of Environment and Physical Planning			
Monitoring entity		Minister of Environment and Physical Planning			

4.2.2.3 Measures overview and investment needs

In the Mitigation scenario, there is one measure that is envisioned in the IPPU sector, i.e. the Product Uses as Substitutes for ODS category, as shown in Table 4-4.

Table 4-4. Review of the measures/policies included in the Mitigation scenario of the IPPU sector

#	Policy/ measure	Competent entity for realization	Budget (mil. €)	Source of finance	Indicative emissions reduction ($Gg\ CO_2$-eq)		
					2030	2040	2050
1	Implementation of Kigali amendment on HFC phase-down	Ministry of Environment and Physical Planning	N/A	Private sector	225.6	471.6	861.6
Total			N/A		225.6	471.6	861.6

4.2.3 AFOLU sector

4.2.3.1 Baseline scenario in the AFOLU sector

The major drivers of GHG emissions in the AFOLU sector explained by IPCC (increased livestock numbers, increased area under agriculture, increased use of fertilizer, increased area under irrigation, increased human, and animal populations etc.) are not noticed in the country, quite the opposite, the official data show that the livestock number decreased, as well as utilized agricultural area and irrigated area. In addition, there is no evidence on increasing in fertilizer use. Moreover, the population in the country has been almost stable in the last 30 years. The scenario used in predicting the GHG emission from the AFOLU sector was based on the present situation of decreasing trends. Nevertheless, such a situation can quickly change and become outdated as a result of significant investments in the sector.

In defining the WOM scenario for the AFOLU sector, the hypothesis that the rate of conversion of the land for the period 2000-2019 will keep the same trend by 2050. The assessment of the values for the period 2013-2050 was prepared employing a simple extrapolation method. Still, it is very difficult to make forecasts for the land use trends and change in land use for such a long period. However, CO_2 emissions are calculated according to the basic dynamics of the past changes in land use. Besides, in this scenario, it was assumed that no mitigation measures will be applied, i.e., the usual practice in land use will be continued. In the Livestock sector the size of the population is expected to be reduced.

The following results from the analysis are of note:

In the period 2014 to 2050 the AFOLU sector emissions in the WOM scenario will increase by 7% (Figure 4-10). The main reason is decreasing of the forest carbon sink for almost 10%. At the same time, the emissions from the other land use are increased by around 30%. Dairy cows and other cattle are the main emitters of GHG emissions in livestock production, while other species (sheep, goats, horses, pigs, and poultry) participate considerably less. Enteric fermentation will remain the main source of methane emissions. However, it is projected that emissions from the Livestock sub-sector will reduce mainly due to the reduction in the number of animals. The GHG emissions from the sub-sector Aggregate sources and non-CO_2 emissions sources on land in 2050 will remain at almost the same level as in 2017, while the sinks from the sub-sector Other are increased although the share of this sector in total sinks is negligible.

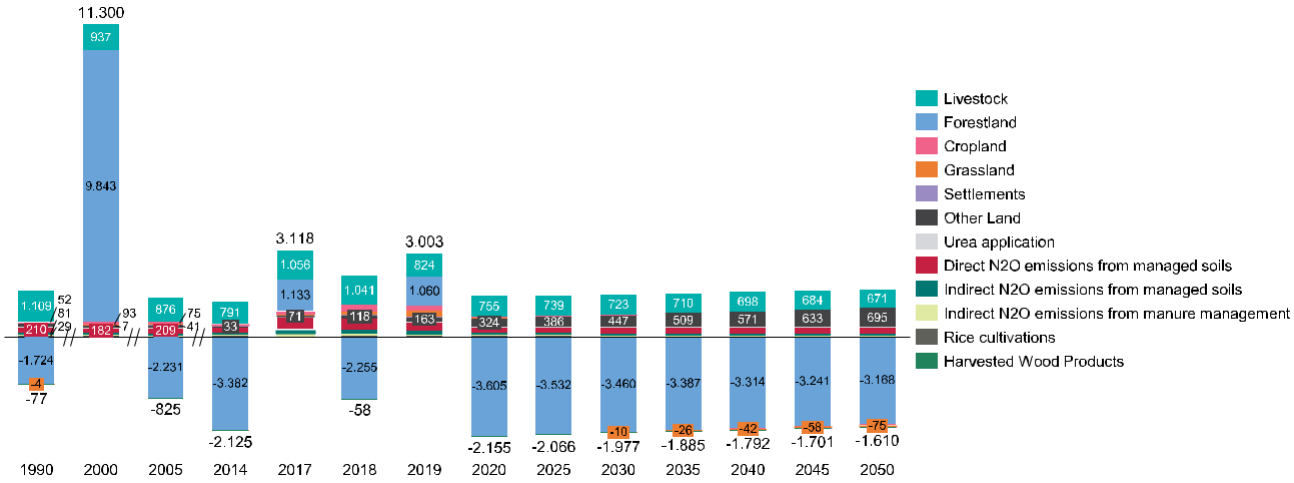


Figure 41-0. Total GHG emissions in AFOLU sector by subcategories (in Gg CO_2-eq)

4.3.3.2 Mitigation measures in the AFOLU sector

The mitigation actions identified within the Agriculture, Forestry, and other Land Use (AFOLU) sector are split between the following sub-sectors:

- Livestock
- Forestry
- Land use change

The overall GHG emission reduction to be achieved via the mitigation actions in the AFOLU sector, which is expected to be **939.6 Gg CO_2-eq by 2030,** and **1,301.4 Gg CO_2-eq by 2040,** compared to 1990. The measures from the Forestry category contribute the most to the reduction of greenhouse gas emissions, i.e. they account for 50.5% of the total emission reduction from the Agriculture, Forestry and Other Land use sector in 2030.

Livestock

The mitigation actions defined for the livestock sub-sector aim to achieve GHG emission reductions of **38.2 Gg CO_2-eq by 2030,** and of **69.4 Gg CO_2-eq by 2040.**

The mitigation actions identified will lead to sub-sector transformation contributing to GHG mitigation in livestock, and can be implemented in the short-, medium-, and long-term (2030 - 2040). These mitigation actions include:

PAM 34 Reduction of CH4 emissions from enteric fermentation in dairy cows by 3%

PAM 34 Reduction of CH4 emissions from enteric fermentation in dairy cows by 3%

Main objective: Decrease level of CH4 emission from enteric fermentation in highly productive dairy cows

Description: By modification of the feed composition and nutrition practice in dairy cows, the emission of CH4 due to enteric fermentation can be reduced by 20%. It is foreseen that the number of dairy cows under intensive farming system will be increased form present 1% to 30% in 2040. Because of highly productive cows involved the CH4 emission will also increase. But, with modification of feed content (adding carbohydrates, high quality forages and tannins) into TMR, the CH4 emission will be decreased by 20%. The mitigation measure can be easily applied on dairy farms, by nutrition management. It is also cost effective; do not require additional subsidies or incentives. Practical training and demonstration for farmers will be sufficient.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Education, Technical	AFLOU-Livestock	CH_4	National

Relevant planning documents, legal and regulatory acts	Strategy for Agriculture Development IPARD program
Methodology	Regression model, IPCC methodology
Assumptions	Increased number of highly productive dairy cows under intensive farming, Introduced modified TMR and nutrition management. Expected to be on organized in farms with more than 50 heads
Status of implementation	Under implementation
Steps taken	TMR with partly modified feed composition in already used on two intensive farms that account about 1% of the dairy cow population
Steps envisaged	Development advisory package for TMR modified feed and nutrition management for the intensive dairy farms with more than 50 cows, Incentives for dissemination of the advisory package to target farmers, Monitoring of the effect of TMR modified feed and nutrition management, and further improvements.

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030
Progress: Number of farms (dairy cows as a percentage of the total population) used TMR modified feed and nutrition management on biannual base	1%			
Emissions reduction (Gg CO_2-eq)	2030	2040		2050
	35	63.6		

Finance: Budget	0.2 mil. EUR
Finance: Source of finance	Private sector, IPARD programme
Implementing entity	Ministry of Agriculture Forestry and Water Economy
Monitoring entity	Ministry of Agriculture Forestry and Water Economy

PAM 35 Reduction of N2O emissions from manure management in dairy cows by 20%

PAM 35 Reduction of N2O emissions from manure management in dairy cows by 20%						
Main objective: Decrease level of N2O emission from manure management in highly productive dairy cows **Description:** By modification of the manure management in dairy cows, the emission of N2O can be reduced up to 20%. It is foreseen that the number of dairy cows under intensive farming system with more than 50 heads will be increased form present 1% to 30% in 2040. All those farms will need to apply improved manure management in order to reduce N loss, and NxO emissions. Therefore, on farm manure management system needs to modify. The mitigation measure considers on farm adaption on existing farms and moderate investments on newly established farms. It will require subsidies for adapting and incentives in farm design and construction.						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Education, Technical	AFLOU-Livestock	N_2O	National	
Relevant planning documents, legal and regulatory acts		Law for Nature Protection IPARD program, Agro-ecology measures in national program				
Methodology		Regression model, IPCC methodology				
Assumptions		Target group are the farms with more than 50 heads. The manure management practice is expected to be change from solid fraction (N loss factor 40), to below animal (N loss factor 28). It can be applied to 10% of the population and shift toward practice is expected to be done in 15% of the farms by 2025. The proportion of the high productive dairy cows is expected to reach 25% in 2040. In such action the reduction of the N2O emissions in manure management on dairy cows will be up to 25% by 2040. Increased number of highly productive dairy cows under intensive farming, On farm modified manure management.				
Status of implementation		Planning phase				
Steps taken		None				
Steps envisaged		Adaption in manure management on intensive dairy farms with more than 50 cows, Design and construction of intensive dairy farms with more than 50 cows, Monitoring of the effect modified manure management in the intensive dairy farms with more than 50 cows.				
Indicators		Indicator value in the last reporting year	Indicative trajectory			Indicator target value
		2018	2020	2025		2030
Progress	Number of farms (dairy cows as a percentage of the total population) used modified manure management on 2-5 years base.	0%				
Emissions reduction (Gg CO_2-eq)		2030	2040	2050		
		2.1	3.9			
Finance	Budget	1 mil. EUR				
	Source of finance	Private sector, IPARD programme				
Implementing entity		Ministry of Agriculture Forestry and Water Economy				
Monitoring entity		Ministry of Agriculture Forestry and Water Economy				

PAM 36 Reduction of N2O emissions from manure management in swine farms by 13%

PAM 36 Reduction of N2O emissions from manure management in swine farms by 13%

Main objective: Decrease level of NO2 emission from manure management in highly productive swine farms

Description: By modification of the manure management in swine farms, the emission of N2O can be reduced up to 50%. It is foreseen that number of fatteners and number of fatteners per sow will increase, while the total number of sows will remain stable over period. Number of swine farms with more than 1000 fatteners and/or 350 sows will also increase, and they need to adapt improved manure management system, in order to reduce N loss. In 2040 is expected that 90% of fatteners will be produced on those farms, accounting for 75% of sow in the country. The mitigation measure consider on farm adaption on existing farms and moderate investments on newly established farms. It will require subsidies for adapting and incentives in farm design and construction.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Education, Technical	AFLOU-Livestock	N_2O	National

Relevant planning documents, legal and regulatory acts	Law for Nature Protection IPARD program, Agro-ecology measures in national program
Methodology	Regression model, IPCC methodology
Assumptions	Swine production system is expected to shift towards intensification that will bring modification of the swine farms. The management practice is supposed to shift form solid manure towards below animal (practice that already exists on large swine farms). Then the fraction of N loss will be reduced by 50%. The implementation of shift will be slightly over years in category sows and finishing pigs (e.g. sows from 55% in 2020 to 75% in 2040; finishing pigs from 70% in 2020 to 92% in 2040 Increased number of highly productive swine farms with more than 1000 fatteners and/or 350 sows, On farm modified manure management.
Status of implementation	Under implementation
Steps taken	Existing swine farms with more than 1000 fatteners and/or 350 sows are working on modification in manure management system
Steps envisaged	Adaption in manure management on intensive swine farms with more than 1000 fatteners and/or 350 sows, Design and construction of intensive swine farms with more than 1000 fatteners and/or 350 sows, Monitoring of the effect modified manure management in the intensive swine farms with more than 1000 fatteners and/or 350 sows

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030
Progress: Number of farms (fatteners and sows as a percentage of the total population) used modified manure management on 2-5 years base.	0%			

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	0.4	0.7	

Finance	Budget	1 mil. EUR
	Source of finance	Private sector, IPARD programme
Implementing entity		Ministry of Agriculture Forestry and Water Economy
Monitoring entity		Ministry of Agriculture Forestry and Water Economy

PAM 37 Reduction of N2O emissions from manure in dairy cows by 20% for farms below 50 Livestock Units

PAM 37 Reduction of N2O emissions from manure in dairy cows by 20% for farms below 50 Livestock Units

Main objective: Decrease level of N2O emission from manure management in dairy cows on farm farms below 50 Livestock Units

Description: By modification of the manure management in dairy cows, the emission of N2O can be reduced up to 30%. In discussion with farmers, the most common system is dry manure management, where manure together with bedding (mostly wheat or barley straw) are taken out of the barn daily or within week. The manure than is composting on pile near the farm. Farmers do not use any cover of manure nor tanks for collecting liquid drainage of the pile. Fermentation is usually mixed where in bottom parts is anaerobic, but on the surface, due to aeration it is aerobic. Manure is used as fertilizer mostly within 2-3 months (depending on storage capacity on the farm and field availability). Depending on manure fermentation the loss of N can be up to 60%. The N loss and reduction of the N2O emissions can be reached by prolonging fermentation period up to 6 months and covering the pile. Hence the measure is to support farmers with less than 50 cows to provide proper manure storage places for longer period.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Education, Technical	AFLOU-Livestock	N_2O	National

Relevant planning documents, legal and regulatory acts	IPARD program, Agro-ecology measures in national program
Methodology	Regression model, IPCC methodology
Assumptions	Replaced low productive with high productive dairy cows, On farm modified manure management for farms with 10 to 50 cows. Dairy cow produce manure about 7% of the life weight per day. Milking cows are weighted between 500 and 650 kg, depending on breed and conditions. Heifers 1-2 year, calves 3-12 months and young calves 0-3 months are transformed into adult cow by coefficient 2, 4 and 10, respectively. For simplicity, animal units (AU) should be used as a base (1 AU = 500 kg). Based on usual feed consumption, bedding material (annual average use of 8% wheat/barley straw) it can be expected about 0.04 m3 manure per AU/day. The manure has about 40% moisture and during the storage reduce volume for 40%. For the period of 6 months total volume of 5 m3 per AU should be expected. For pile composting, a trench with clay or concreate floor with inclination of 4% is required. The pile needs to be protected from rainfall (either by roof or covered by plastic foil. Aeration is occurring when fresh manure is adding, taking care that old and already fermented one should be always on top. By prolonging manure storage and covering period the reduction of N2O emission will be for 30% is expected.
Status of implementation	Planning phase
Steps taken	None
Steps envisaged	Provide incentives to build on farm manure storage place, Train farmers for BAT in manure management, Monitoring of the effect modified manure management

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030
Progress: Number of farms (dairy cows as a percentage of the total population) used modified manure management in 7 years.	0%			

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	0.7	1.2	

Finance: Budget	1 mil. EUR
Source of finance	Private sector, IPARD programme
Implementing entity	Ministry of Agriculture Forestry and Water Economy
Monitoring entity	Ministry of Agriculture Forestry and Water Economy

These mitigation measures are of long-term character and will contribute as well to reaching EU targets. The implementation of these measures does not require substantial financing and at the same time will results social and environmental benefits.

1.

Forestry

The mitigation actions defined for the forestry sub-sector aim to achieve GHG emission reductions of **657.5 Gg CO_2-eq by 2030** and keeping same impact by 2050.
The mitigation actions identified will lead to sub-sector transformation contributing to GHG mitigation in livestock, and can be implemented in the short-, medium-, and long-term (2030 - 2040). These mitigation actions include:

PAM 38 Establishing integrated management of forest fires

PAM 38 Establishing integrated management of forest fires					
Main objective: Reducing the average annual burned area for 6000 ha **Description:** Forest fires are already detected as a very significant problem of forest loss and source of GHG emissions. In the period from 1999 to 2019 year the average annual number of forest fires is 229 fires, average annual burned area is 10,985 ha and average annual damage is estimated on 6,9 million Euro. The total burned forest area in the same period is around 219,163 ha with the total damage of around 138 million. This measure includes the protection of the forest area by preventing the forest fires and the damages resulting from forest fires.					
Timeframe		Type	Sector	Gases	Scope
2030 – 2050		Technical	AFLOU-Forestry	CO_2, CH_4, N_2O	National
Relevant planning documents, legal and regulatory acts		Law on forest, Special rule book for forest fire protection, Strategy for development of the forest fire protection, diseases and insects with action plan for realization of the projects and procurements for the needs of PE „Makedonski sumi“			
Methodology		Regression model, IPCC methodology			
Assumptions		Up to 3000 ha will be burned annually on average			
Status of implementation		Under implementation			
Steps taken		The location for building and establishment of a forest fire training center in the frame of the PE „National forests“ is already chosen, the plan prepared and 8 vehicles are purchased.			
Steps envisaged		Phase I - Procurement of vehicles for initial attack, had tools and personal protective equipment (PPE) Duration: one year Vehicles procurement: 25 specialized vehicles for initial attack 25 vehicles x 40,000 € = 1,000,000 € 50 sets of hand tools and PPE for 50 crews of five fire fighters (two per vehicle) 1 set of hand tools and PPE = 4,000 € 50 sets x 5,000 € = 250,000 € Phase II - Specialized training for fire fighters (six days) 50 craws x 5 persons = 250 fire fighters 250 fire fighters x 800 € = 200,000 €			
Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target valueиндикаторот
		2018	2020	2025	2030
Progress	Forest area (ha)				
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		345	345		
Finance	Budget	1.45 mil. EUR			
	Source of finance	PE “National forests”, other forest enterprises			
Implementing entity		Ministry of Agriculture Forestry and Water Economy, through PE „National forests“			
Monitoring entity		Ministry of Agriculture Forestry and Water Economy, through PE „National forests“			

PAM 39 Afforestation

PAM 39 Afforestation						
Main objective: Afforestation of 5000 ha of barren land with Oak (Quercus spp.) **Description:** Afforestation and reforestation may change landscapes and may have an impact on the provision of landscape-related goods and services. The supply with goods and services benefiting people and societies and the conservation of traditional cultural landscapes, as well as landscape ecology, need to be taken into account. According to the many strategic documents there are about 1,500,000 ha barren land aimed for afforestation or reforestation.						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Technical	AFLOU-Forestry	CO_2	National	
Relevant planning documents, legal and regulatory acts		Law on forest				
Methodology		Regression model, IPCC methodology				
Assumptions		The oak is species resistant on high air temperature and small amount of precipitations-dry conditions (conditions that are expected in agreement with the official national scenarios on climate change for Macedonia) and lees sensitive to forest fires, as well. Besides, the economic and technical value of the timber mass is high. The afforestation could be done on one location (all 5,000 ha) or distributed but not to more than five location. Minimum 80 % of the seedlings have to be alive after third year of the afforestation and with good health and morphological condition should be maintained				
Status of implementation		Under implementation				
Steps taken		There are already existed nurseries for production of more than 8.000.000 seedlings annually				
Steps envisaged		Area for afforestation should be chosen, around 7.5 million Oak seedlings should be produced, afforestation to be done with proper care in the next 5 years Phase I – seedling production Duration: 3 years Number of seedlings: 2,500 seedlings/ha x 5,000 ha = 12,500,000 seedlings Costs for seedling production: 12,500,000 seedlings x 20 den. = 250,000,000=4,100,000 € Phase II – soil preparation and afforestation Sub phase - soil preparation Duration: four months Costs: 5,000 ha x 15,000 den = 75,000,000 den = 1,250.000 € Sub phase - afforestation Duration: six months Costs: 5,000 ha x 20,000 den = 100,000,000 den = 1,650,000 € Phase III – maintenance and protection Duration: five years Costs: 5.000 ha x 10.000 den = 50.000.000 den = 800.000 €				
Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value	
		2018	2020	2025	2030	
Progress	Forest area (ha)					
	Forest planted/ covered with new seedlings (ha)					
Emissions reduction (Gg CO_2-eq)		2030	2040		2050	
		312.5	312.5			
Finance	Budget	7.8 mil. EUR				
	Source of finance	PE “National forests”, other forest enterprises				
Implementing entity		Ministry of Agriculture Forestry and Water Economy				
Monitoring entity		Ministry of Agriculture Forestry and Water Economy				

These mitigation measures are of long-term character and will contribute as well to reaching EU targets. The implementation of these measures does not require substantial financing and at the same time will results in considerable GHG emission reductions and additional social and environmental benefits (815 new jobs).

Land use change

The mitigation actions defined for the land use change sub-sector aim to achieve GHG emission reductions of **243.9 Gg CO_2-eq by 2030**, and of **574.5 Gg CO_2-eq by 2050**.

The mitigation actions identified in the land-use sub-sector will enhance the carbon sinks via the following measures:

PAM 40 Conversion of land use of field crops above 15% inclination

PAM 40 Conversion of land use of field crops above 15% inclination					
Main objective: To reduce the intensity of soil erosion and loss of soil organic matter **Description:** Cultivation of land on inclined terrain causes intensive processes of soil erosion and mineralization of sol organic matter. These processes lead to intensive decomposition of soil organic matter and emission of soil carbon into atmosphere. Conversion of such areas into perennial grassland (pastures, meadows) will significantly decrease intensity of soil organic matter depletion and emission of soil carbon, and will lead to carbon sink. Areas above 15% inclination by law should not be cultivated and are not considered as agricultural land. This conversion supposes land use change and change of the production system, which might influence the net annual income of primary producers. Due to this, its implementation should be supported with incentives, especially in the first years of conversion, in order to bridge possible loss of incomes in farm holds.					
Timeframe		Type	Sector	Gases	Scope
2030 – 2050		Education, Technical	AFLOU-Land	CO_2,	National
Relevant planning documents, legal and regulatory acts		Law on agricultural land Rulebook on GAP Rulebook on cross compliance for minimum requirements of GAP and environmental protection			
Methodology		Regression model, IPCC methodology			
Assumptions		The total area of almost 3000ha is intensively cultivated which leads to decreasing of SOM as a result of its intensive decomposition and intensive soil erosion processes. If conversion to grass land is implemented, the estimated SOM increase is for more than 2% which for the total converted area of 2975 ha. The conversion of land use, should: Stop the intensive process of erosion of the top soil layer which leads to loss of soil organic matter and its intensive ex-city mineralization, Stop on site mineralization of soil organic matter due to intensive processes of cultivation, Intensify carbon sink through accumulation of soil organic matter			
Status of implementation		Under implementation			
Steps taken		The effects of conversion of crop land to grass land has been monitored on two experimental fields in the past four years, Land Parcel Identification System has been established and will serve as a tool for control of the process of conversion			
Steps envisaged		Establishment of system for systematic control of land use and land use change on national level, Institutional support to primary producers with subsiding the process of conversion of crop fields into grassland			
Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2018	2020	2025	2030
Progress	Area converted on yearly base (ha/year)				
Emissions reduction (Gg CO_2-eq)		2030	2040		2050
		3.7	5.3		
Finance	Budget	1.5 mil. EUR			
	Source of finance	Private sector, IPARD programme			
Implementing entity		Ministry of Agriculture Forestry and Water Economy			
Monitoring entity		Ministry of Agriculture Forestry and Water Economy			

PAM 41 Contour cultivation on areas under field crops on inclined terrains (5-15%)

PAM 41 Contour cultivation on areas under field crops on inclined terrains (5-15%)

Main objective: To reduce erosion of top soil and conservation of soil organic mater

Description: Regular cultivation in crop production means a massive disturbance of top soil layer, which cause intensive mineralization of soil organic matter (SOM) and CO2 emissions. Downslope cultivation of cropland usually causes intensive processes of soil erosion. Field experiments showed that the quantity of eroded sediment is multiply higher if compared to contour cultivation. This eroded sediment is reach with SOM which in such circumstances is rapidly mineralized, due to what significant quantity of soil carbon is released into atmosphere.

Contour cultivation means that all agro-technical operations should be across the slope. This measure is easy to be implemented, since it does not require a special technical capacities and know-how. In practice, farmers usually are not aware of its importance and influence of the overall soil fertility. With a systematic campaign for increasing the awareness of the farmers this measure can be widely adopted.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Education, Technical	AFLOU-Land	CO_2	National

Relevant planning documents, legal and regulatory acts	Law on agricultural land Law on water Rulebook on Good Agricultural Practices Rulebook on cross compliance for minimum requirements of GAP and environmental protection
Methodology [for estimating the emissions]	Regression model, IPCC methodology
Assumptions	14,000 ha (30%) of the total 47,090 ha of no-irrigated land on inclined terrines (above 5%) are planned for this measure Decreasing of soil erosion processes of the top soil layer and SOM loss with contour ploughing of inclined cropland, Increasing of soil carbon with preservation of SOM in the top soil layer
Status of implementation [idea, planning phase, under implementation]	Under implementation
Steps taken	Contour cultivation tested in practice of two experimental sites, Contour cultivation promoted among farmers within several national and international Projects
Steps envisaged	Incorporation of contour cultivation as an agro-ecological measure into strategic documents, Promotion of contour cultivation among farmers, Institutional support to primary producers with subsiding the process of adoption of the system of contour cultivation

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030
Progress: Area in ha with contour cultivation				

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	28	39.7	

Finance: Budget	1.0 mil. EUR
Finance: Source of finance	Private sector, IPARD programme
Implementing entity	Ministry of Agriculture Forestry and Water Economy
Monitoring entity	Ministry of Agriculture Forestry and Water Economy

PAM 42 Perennial grass in orchard and vineyards on inclined terrains (>5%)

PAM 42 Perennial grass in orchard and vineyards on inclined terrains (>5%)						
Main objective: Reducing of soil erosion and increasing of SOM in vineyards and orchards on inclined terrains (5-15% slope) **Description:** In vineyards and orchard on locations where rows are oriented downslope, as a result of intensive classical system of cultivation, an intensive processes of soil erosion and depletion of SOM occurs, which lead to intensive emissions of soil carbon. Simple change of cultivation system with establishment of perennial grass can significantly mitigate the process of SOM loss and emissions of soil carbon. The measure is easy to be implemented with low initial cost.						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Education, Technical	AFLOU-Land	CO_2	National	
Relevant planning documents, legal and regulatory acts		Law on agricultural land Law on water Rulebook on GAP Rulebook on cross compliance for minimum requirements of GAP and environmental protection				
Methodology [for estimating the emissions]		Regression model, IPCC methodology				
Assumptions		Decreasing of soil erosion processes of the top soil layer and SOM loss when classical type of cultivation system with deep plowing is replaced with perennial grass and no-tillage system Increasing of soil carbon with accumulation of SOM in the top soil layer due to mulching of moved biomass and accumulation of biomaterial in the root zone of the perennial grass.				
Status of implementation [idea, planning phase, under implementation]		Under implementation				
Steps taken		Perennial grass in vineyards and orchards as a cover crop tested in practice in two regions, Perennial grass in vineyards and orchards as an agro-ecological measure promoted among farmers within several national and international Projects				
Steps envisaged		To foresee cover crops in perennial plantations (vineyards and orchards) as an agro-ecological measure into strategic documents, To promote the effects of cover crops among vine and fruit growers, Institutional support to primary producers with subsiding the process of implementing the measure				
Indicators		Indicator value in the last reporting year	Indicative trajectory			Indicator target value
		2018	2020	2025		2030
Progress	Area of vineyards and orchards under perennial grass (ha)					
Emissions reduction (Gg CO_2-eq)		2030	2040	2050		
		8.9	12.6			
Finance	Budget	1 mil. EUR				
	Source of finance	Private sector, IPARD programme				
Implementing entity		Ministry of Agriculture Forestry and Water Economy				
Monitoring entity		Ministry of Agriculture Forestry and Water Economy				

PAM 43 Use of biochar for carbon sink on agricultural land

PAM 43 Use of biochar for carbon sink on agricultural land

Main objective: Carbon sink by negative emission technology

Description: The agricultural soils in the country are characterized as soils with relatively low carbon content and with average to low fertility. The application of biochar can improve soil water holding capacity, nutrients storage into the soil, and increase yield. Biochar can capture even 3 times more CO2 compared to its weight, because of its high carbon concentration. Biochar was included for the first time as a promising negative emission technology in the new IPCC special report "An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty" published in 2018. The process of application of biochar should go through several steps: i) research, ii) development the suitable technology for various soil/crop combination iii) experimental/demonstrative sites iv) development the measure for support from national programs for support of agriculture v) promotion of measure. This is new measure, need some research, therefore, in period 2017 – 2040 we predict only 15 years of active use of the measure.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Research, Education, Technical	AFLOU-Land/ Agriculture	CO_2	National

Relevant planning documents, legal and regulatory acts	Biochar is not present in any strategic document in the country
Methodology	Regression model, IPCC methodology
Assumptions	Sinking the amount of 330.3 Gg-eq CO2-eq and removing that amount from the atmosphere Increasing of soil carbon content with adding of biochar as persistent carbon source. Most of the biochar will remain in the in the top soil layer due to available application technology incorporation biochar by plow on the plowing depth. The positive effects on the soil fertility and soil health Local production of the biochar by using residual biomass that is usually burnt in open fires.
Status of implementation	Idea
Steps taken	None
Steps envisaged	To conduct experimental research and to determine optimal biochar application rates for different soil/crop combinations To foresee application of biochar on arable land as an agro-ecological measure into strategic documents, To promote the effects of biochar on soil health, yield and environment, Institutional support to primary producers with subsiding the process of implementing the measure

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	Area of vineyards and orchards under perennial grass (ha)			
Emissions reduction (Gg CO_2-eq)	2030	2040	2050	
	110	330.3		
Finance	Budget	30 mil. EUR		
	Source of finance	Private sector, IPARD programme		
Implementing entity		Ministry of Agriculture Forestry and Water Economy		
Monitoring entity		Ministry of Agriculture Forestry and Water Economy		

PAM 44 Photovoltaic Irrigation

PAM 44 Photovoltaic Irrigation								
Main objective: Mitigation by replacing the non-renewable energy sources for water pumping with renewable, thus reducing the CO2 emission **Description:** Installation of photovoltaic system for irrigation purposes with 2.4 kW installed capacity, capable to run 1.1 kW 3 phase pump. The two cases are considered as mitigation practice, replacing the petrol pump with consumption of 0,3l petrol per hour (one of the most popular pumps in the country) with 3 phase AC pump and adding photovoltaic and replacing 1.1 kW electricity pump with 3 phase AC pump and adding the photovoltaic. The measure is suitable for already established on farm irrigation systems, but also for new establishing of the irrigation systems with on-farm water source. The measure is compatible with IPARD 2 measure "Production of energy from renewable resources for self-consumption, through processing of plant and animal products from primary and secondary biomass (except biomass from fishery products) for production of biogas and/or biofuels, use of solar energy, windmills, geo-thermal energy etc".							
Timeframe		Type		Sector		Gases		Scope
2030 – 2050		Research, Education, Technical		AFLOU-Land/ Agriculture		CO_2		National
Relevant planning documents, legal and regulatory acts		Law on Agriculture and Rural Development National strategy on Agriculture and Rural Development IPARD2						
Methodology [for estimating the emissions]		Regression model, IPCC methodology						
Assumptions		About 1000 installations annually in the period of 20 years, reaching about than 20 000 hectares irrigated by photovoltaic as energy source.						
Status of implementation [idea, planning phase, under implementation]		Planning phase						
Steps taken		There is possibility for getting support from IPARD2 funds. The measure provides up to 65% of co-financing and promoting of photovoltaic irrigation if the frame of this measure is feasible						
Steps envisaged		To promote the photovoltaic irrigation as mitigation measure To include the measure in agri-environmental scheme To investigate possibilities for diversification of farm incomes trough distributing the excess of electricity produced into the network.						
Indicators		Indicator value in the last reporting year	Indicative trajectory					Indicator target value
		2018	2020		2025			2030
Progress	Increase in installed capacity (MW)							
Emissions reduction (Gg CO_2-eq)		2030	2040		2050			
		93.3	186.6					
Finance	Budget	47 mil. EUR						
	Source of finance	Private sector, IPARD programme						
Implementing entity		Ministry of Agriculture Forestry and Water Economy						
Monitoring entity		Ministry of Economy, Energy Agency						

These mitigation measures are of short-to mid-term character and will contribute as well to reaching EU targets. The measures for the conversion of land can be implemented with no costs and thus should be a priority. Contour cultivation means that all agro-technical operations should be across slope and exclude areas above 15% inclination. With a systematic campaign for increasing the awareness of the farmers this measure can be widely adopted. Using government land, it may be possible to offer smaller plots of better land in exchange for the inclined terrains. The implementation of these measures does not require substantial financing and at the same time will results in multiple additional social and environmental benefits.

4.2.3.3 Measures overview and investment needs

In the Mitigation scenario, 11 measures/policies are included from the Agriculture, Forestry and Other land use sector, from which four are from Livestock, two from Forestry, and five form Agriculture and Other land use (Table 4-5).

Table 4-5. Review of the measures/policies included in the Mitigation scenario of the Agriculture, Forestry and Other land use sector

	Policy/ measure	*Competent entity for realization*	*Budget (mil. €)*	*Source of finance*	*Indicative emissions reduction (Gg CO_2-eq)*		
					2020	2030	2040
1	Reduction of CH4 emissions from enteric fermentation in dairy cows by 3%	Ministry of Agriculture, Forestry and Water Economy	0.2	Private sector	3.2	35.0	63.6
2	Reduction of N2O emissions from manure management in dairy cows by 20%	Ministry of Agriculture, Forestry and Water Economy	1	Private sector	0.2	2.1	3.9
3	Reduction of NO2 emissions from manure management in swine farms by 13%	Ministry of Agriculture, Forestry and Water Economy	1	Private sector	0	0.4	0.7
4	Reduction of N2O emissions from manure in dairy cows by 20% for farms below 50 Livestock Units	Ministry of Agriculture, Forestry and Water Economy	1	Private sector	0.1	0.7	1.2
5	Establishing integrated management of forest fires	PE "National forests" Ministry of Agriculture, Forestry and Water Economy	1.5	PE "National forests", other forest enterprices	345	345	345
6	Afforestation	PE "National forests" Ministry of Agriculture, Forestry and Water Economy	7.8	PE "National forests", other forest enterprices	0	312.5	312.5
7	Conversion of land use of field crops above 15% inclination	Ministry of Agriculture, Forestry and Water Economy	1.5	Private sector	1.0	3.7	5.3
8	Contour cultivation on areas under field crops on inclined terrains (5-15%)	Ministry of Agriculture, Forestry and Water Economy	1	Private sector	5.0	28.0	39.7
9	Perennial grass in orchard and vineyards on inclined terrains (>5%)	Ministry of Agriculture, Forestry and Water Economy	1	Private sector	1.6	8.9	12.6
10	Use of biochar for carbon sink on agricultural land	Ministry of Agriculture, Forestry and Water Economy	30	Private sector	0	110.0	330.3
11	Photovoltaic irrigation	Ministry of Agriculture, Forestry and Water Economy	47	Private sector	0	93.3	186.6
Total			**93**		**356.1**	**939.6**	**1,301.4**

Using the proposed measures in the Agriculture, Forestry and Other land use sector in 2040, a greenhouse gas emissions reduction of 1,301Gg CO_2-eq can be achieved. The measures from the Forestry category contribute the most to the reduction of greenhouse gas emissions, i.e. they account for 50.5% of the total emission reduction from the Agriculture, Forestry and Other Land use sector in 2040. In order to obtain this reduction, it is necessary to invest 93 € mil. for the period from 2020-2040. 90% of the investments are from the private sector. Measures with the most significant potential for greenhouse gas emissions reduction are the Use of biochar for carbon sink on agricultural land and Afforestation.

4.2.4 Waste sector

4.2.4.1 Baseline scenario in the waste sector

The approach established as a part of the SBUR and TBUR is also used in the 4th National Communication. In the Waste and Energy sectors, the same key drivers are used, i.e., GDP and population. To calculate the GHG emissions from Municipal Solid Waste Disposal, one of the key parameters, besides population, is the amount of waste per capita. For that purpose, the comparison of the amount of waste per capita in Macedonia with the countries in the nearby region as well as with the European Union 28 (EU28) was made. It is interesting to note that for example in Austria the quantity of waste during the period 2008-2017 is stable. The same situation is with Greece and Croatia, while in Bulgaria the amount of waste per capita is reduced by about 30%. At the EU 28 level there is a downward trend, while in Macedonia, if 2017 is excluded, there is a trend of growth. At the EU 28 level there is a downward trend, presented with the black dotted line, while in Macedonia, there is a trend of growth, presented with the red dotted line in Figure 4-11. It is assumed that these trends will continue up to around 2030, after which there is a decreasing trend in North Macedonia, which corresponds to the EU 28 trend.

In the reference scenario it is also assumed that the composition of waste going to solid waste disposal will remain the same during the whole period as they are for 2018, i.e., food – 36.7%, garden – 10.7%, paper – 10.8%, wood – 0.4%, textile – 3.7%, nappies – 5.0% and plastic, other inert – 32.6%. Additionally, the distribution of waste-by-waste management treatment will be equal to the distribution in 2018, for the whole period. For calculating the industrial waste, the data for the value added for the industry from the MARKAL model are used.

A completely new Excel model able to calculate the GHG emissions from the Waste sector was developed in the SBUR, and used in the TBUR, as well as in this National Communication. This model is based on the methodology implemented in the IPCC software and thus covering all subcategories of the Waste sector. With the help of this software and the assumptions made, the emissions for the period until 2050 are calculated.

In the reference scenario mechanical and biological treatment with composting is included (Figure 4-1064-6). Based on the historical data for the period 2011-2019, an equation for the trendline of the emissions from composting is obtained. Based on this equation, the emissions for the period from 2020 to 2050 are calculated.

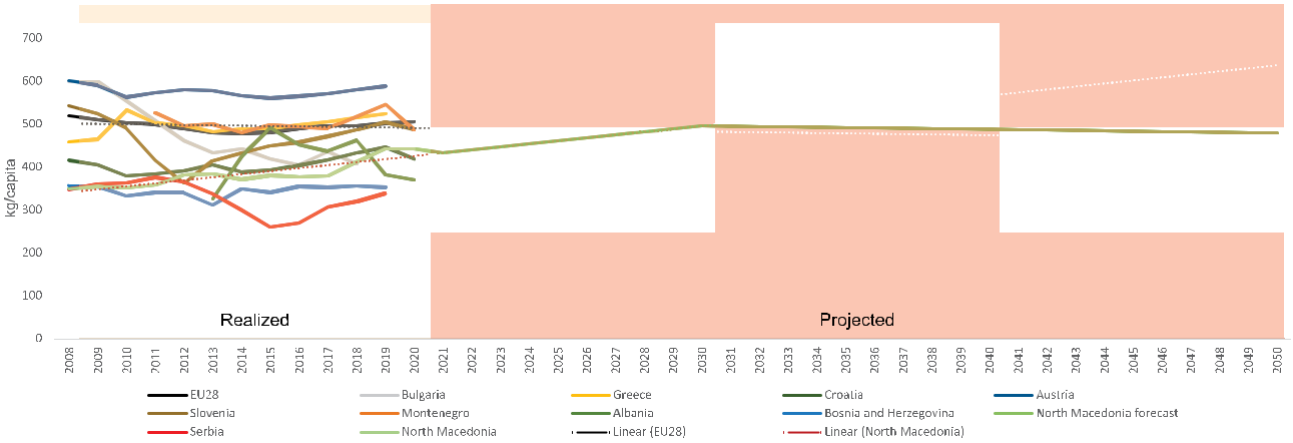


Figure 4-11. Quantity of municipal waste per capita in Macedonia, EU28 and countries in the SEE region (in kg/capita)

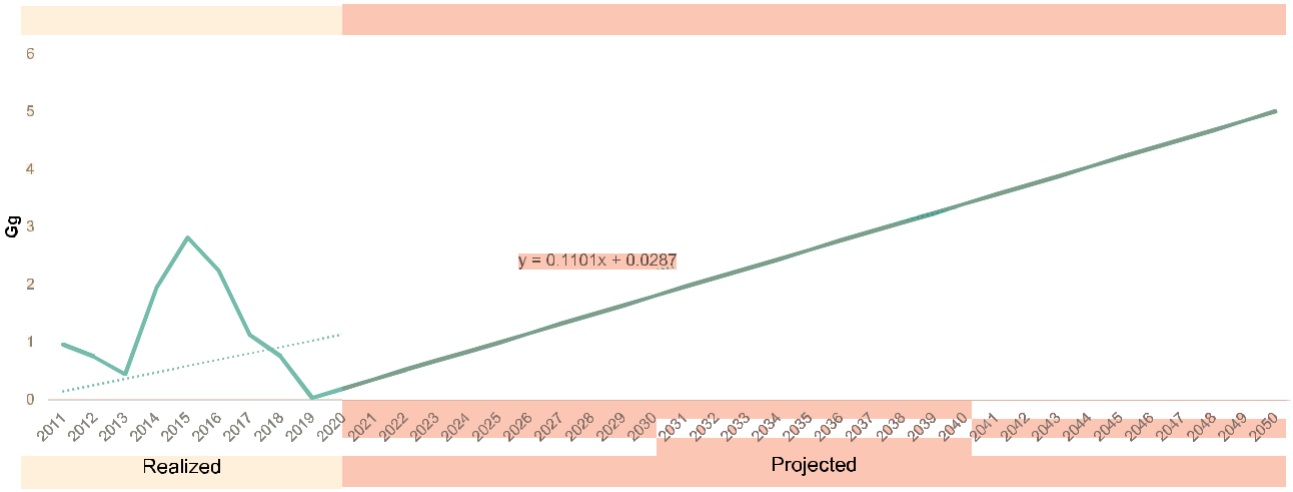


Figure 41-2. Calculation of waste treated by biological treatment facilities

The emissions from waste incineration are also considered in the WOM scenario, and again a trendline is calculated based on the available historical data for the period 2000-2019 (Figure 4-13). Using the trendline, emissions from incineration of waste up to 2050 are calculated.

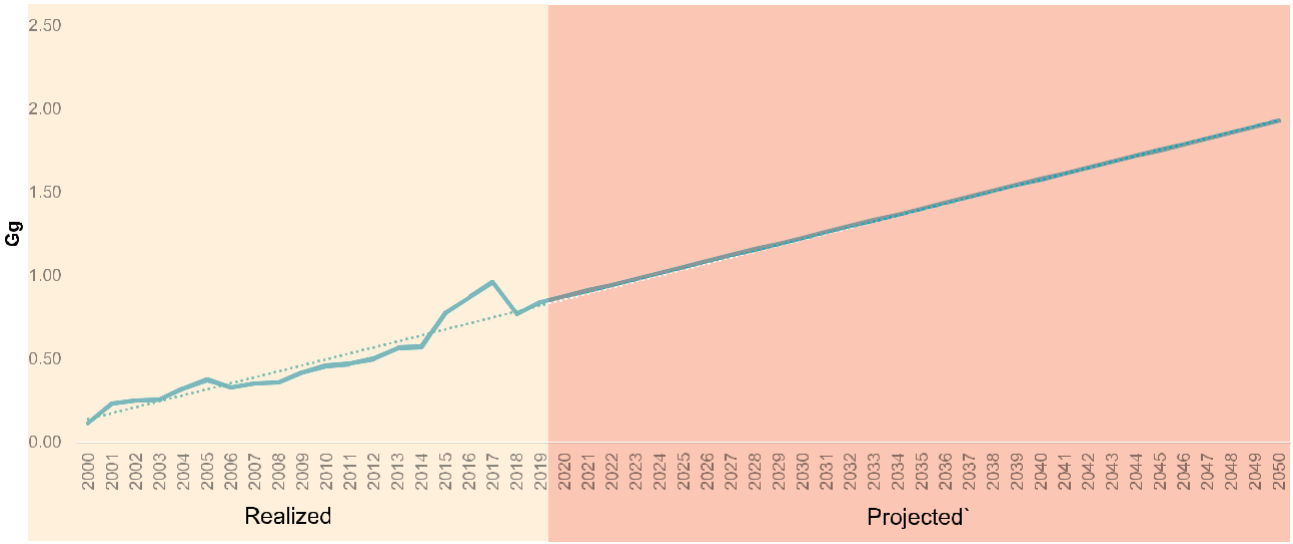


Figure 4-13. Calculation of the total amount of waste incinerated

To estimate the emissions from the industrial wastewater sector, a correlation is made between the Total organic degradable material in wastewater with the value added in the industry for the period from 2008-2018 (Figure 4-14). The derived equation for the correlation is used to calculate the total organic degradable material in wastewater for the period up to 2050 (Figure 4-15).

Figure 4-14. Correlation between the total organic degradable material in wastewater and value added in the industry for the period 2014-2018

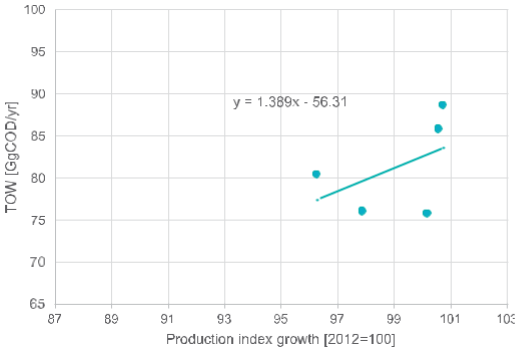
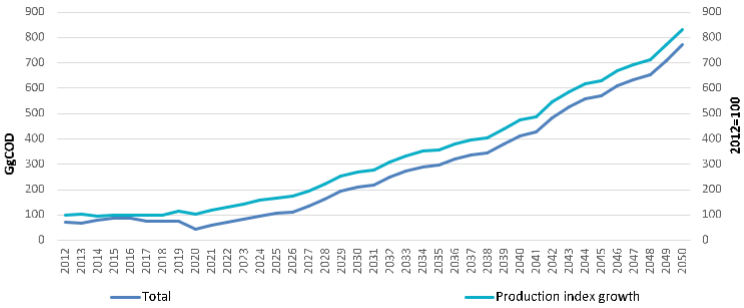


Figure 4-15. Total organic degradable material in wastewater and value added in the industry for the period 2012-2050



The following results from the analysis are of note:

The results for the Waste sector in the WOM scenario show that the total GHG emissions from this sector will increase by 137% in 2050 (873 Gg CO_2-eq) compared to 2019 (Figure 4-16). The subcategory with the largest share of emissions (63% in 2050) remains the Solid waste disposal for the whole period, followed by the subcategory Industrial Wastewater (32% in 2050) and Domestic Wastewater (4% in 2050). Concerning the emissions by gases, by far the largest amount is from CH_4, with a share of 97% in 2050 (Figure 4-17).

Figure 4-16. Total GHG emissions in the Waste sector by subcategories (in Gg CO_2-eq)

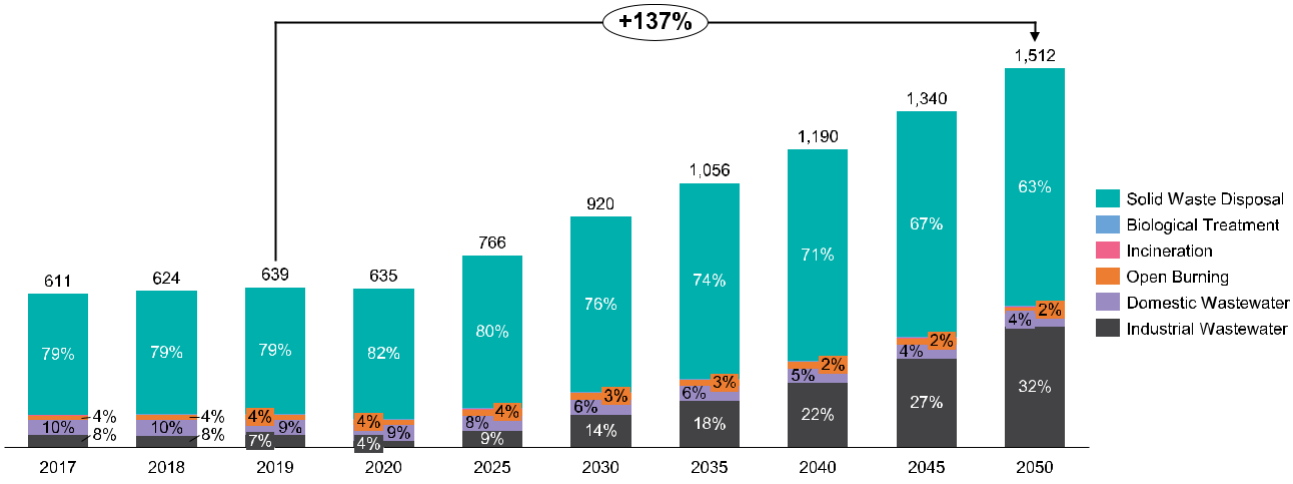
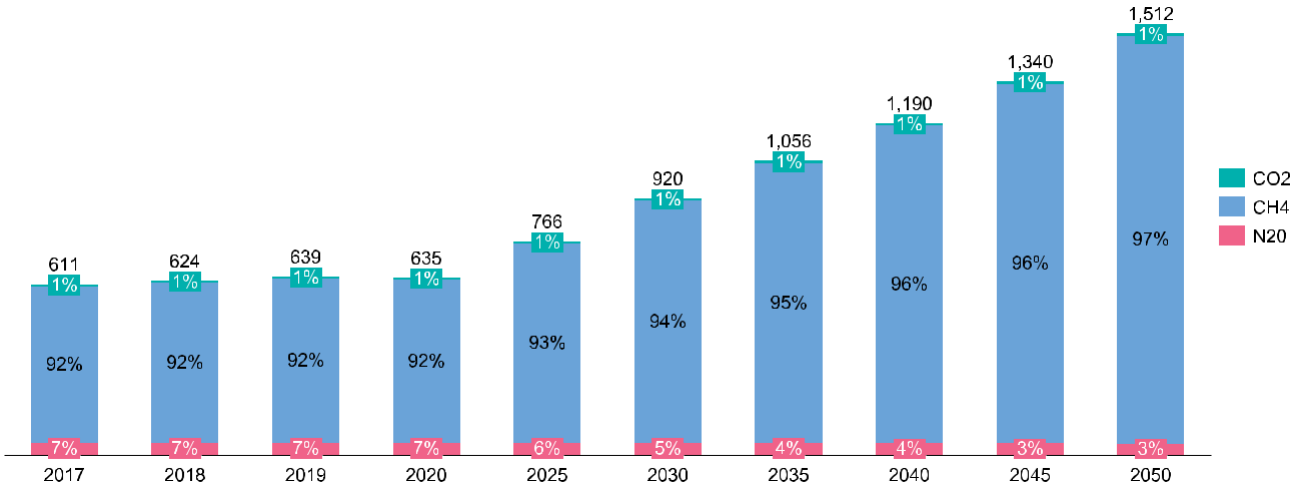


Figure 4-17. Total GHG emissions in the Waste sector by gasses (in Gg CO_2-eq)



4.2.4.2 Mitigation measures in the waste sector

The mitigation actions in the waste sector focus on landfill gas, which have the most significant potential for greenhouse gas emissions reduction and incorporating circular economy criteria into waste management. Although circular practices concern the major industrial and manufacturing supply chains in rich countries, in countries like North Macedonia where the rate of industrialisation is currently rather low and imports of manufactured materials are the main way to acquire them, the starting point for a shift to circular practices should be the waste management sector. By shifting the management of specific waste streams to circular practices, not only substantial environmental and economic benefits are achieved, but the waste management sector can act as a catalyst for the whole economy of the country[8].

The overall GHG emission reduction to be achieved via the mitigation actions in the waste sector, which is expected to be **705.5 Gg CO_2-eq** in 2030 and 1,635.5 Gg CO2-eq in 2050 compared to 1990.

The mitigation actions identified will lead to sub-sector transformation contributing to GHG mitigation in waste sector, and can be implemented in the short-, medium-, and long-term (2030 - 2050). These mitigation actions include:

8 UNDP, 2021. Circular Economy and Climate Change. https://api.klimatskipromeni.mk/data/rest/file/download/aa1b3c206704e248e911fa297b99a65a40 0ea9f13b1b76adf5ebd5433b608cba.pdf

PAM 45 Landfill gas flaring

PAM 45 Landfill gas flaring

Main objective: Environmental protection and meeting the highest European standards

Description: Rehabilitation of the existing landfills and illegal ("wild") dumpsites with very high, high and medium risk in each of the eight waste management regions, as well as opening of regional landfills. The rehabilitation includes covering on the existing non-compliant landfills, supplemented by gas extraction and flaring.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical	Waste – Solid waste disposal	CO_2, CH_4	Regional

Relevant planning documents, legal and regulatory acts	National Waste Management Plan 2021-2031 Strategy for Waste Management in the Republic of Macedonia Regional Waste Management Plans (Northeast, East, Southeast, Southwest, Pelagonia, Polog, Vardar and Skopje region)
Methodology	Regression model, IPCC methodology
Assumptions	Closing of existing and opening of new landfills by waste management regions in the following order: Skopje – 2025 East and Northeast – 2026 Polog – 2027 Southeast – 2030 Pelagonia and Southeast – 2030 Vardar 2030
Status of implementation	Planning phase
Steps taken	Regional waste management plans developed and adopted, EU funds provided for construction of a regional landfill for the East and Northeast planning region provided, construction of six transfer stations and closing of all non-compliant landfills. Discussions started with EBRD for involvement in financing regional waste management projects.
Steps envisaged	Obtaining funds for the other regions Starting the construction of the new regional landfill for the East and Northeast planning region Covering on the existing non-compliant landfills and installation of gas flaring systems where it is feasible

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2018	2030	2040	2050
Progress	Amount of CH4 burned (kt)	0	24.8	29.1	18.7

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	561.3	655.0	823.5

Finance	Budget	10.5 mil. EUR
	Source of finance	Local self-government through Public Utilities, Public Private Partnership, EU funds, IFIs
Implementing entity		Ministry of Environment and Physical Planning Municipalities (Public municipal enterprises for waste management) Regional waste management companies / Inter-Municipal Waste Management Board
Monitoring entity		Ministry of Environment and Physical Planning State Environmental Inspectorate Authorized Inspectors of Environment (Municipalities)

PAM 46 Mechanical and biological treatment (MBT) in new landfills with composting

PAM 46 Mechanical and biological treatment (MBT) in new landfills with composting					
Main objective: Environmental protection and meeting the highest European standards **Description:** Opening of new regional landfills in all waste management regions with installed system for mechanical and biological treatment and composting. This includes treatment of the garden and food municipal waste. This measure will help achieve the goals for recycling of municipal solid waste of 25% in 2025, 45% in 2035 and 65% in 2045, as defined in the National Waste Management Plan 2021-2031.					
Timeframe		Type	Sector	Gases	Scope
2030 – 2050		Technical	Waste – Solid waste disposal	CO_2, CH_4, N_2O	Regional
Relevant planning documents, legal and regulatory acts		National Waste Management Plan 2021-2031 Strategy for Waste Management in the Republic of Macedonia Regional Waste Management Plans (Northeast, East, Southeast, Southwest, Pelagonia, Polog, Vardar and Skopje region) – final and draft versions			
Methodology [for estimating the emissions]		Regression model, IPCC methodology			
Assumptions		Opening of the regional landfills in the following order: Skopje – 2025 East and Northeast – 2026 Polog – 2027 Southeast – 2030 Pelagonia and Southeast – 2030 Vardar 2030 Reduction of the amount of not treated biodegradable components of municipal waste on an annual level, expressed as a reduction of the percentage of biodegradable components in municipal waste generated, is assumed with a rate as defined in Table 8 of the National Waste Management Plan 2021-2031.			
Status of implementation [idea, planning phase, under implementation]		Planning phase			
Steps taken		Regional waste management plans developed and developed EU funds provided for construction of a regional landfill for the East and Northeast planning region provided, construction of six transfer stations and closing of all non-compliant landfills.			
Steps envisaged		Obtaining funds for the other regions Starting the construction of the new regional landfill for the East and Northeast planning region			
Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2018	2030	2040	2050
Progress	Amount of compost (kt)	0	68	93	86
Emissions reduction (Gg CO_2-eq)		2030	2040	2050	
		35.2	145.2	216.1	
Finance	Budget	36.1 mil. EUR			
	Source of finance	Local self-government through Public Utilities, Public Private Partnership, EU funds			
Implementing entity		Ministry of Environment and Physical Planning Municipalities / Public municipal enterprises for waste management Regional waste mgmt companies / Inter-Municipal Waste Management Board			
Monitoring entity		Ministry of Environment and Physical Planning State Environmental Inspectorate Authorized Inspectors of Environment (Municipalities)			

* Total reduction when including the emissions realized after 2040

PAM 47 Selection of waste

PAM 47 Selection of waste

Main objective: Environmental protection and meeting the highest European standards

Description: Installation of containers for collection of selected waste, mainly paper, but also wood, textile, nappies, plastic and other inert waste. This measure will help achieve the goals for recycling of municipal solid waste of 25% in 2025, 45% in 2035 and 65% in 2045, as defined in the National Waste Management Plan 2021-2031.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Technical	Waste – Solid waste disposal	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	National Waste Management Plan 2021-2031 Strategy for Waste Management in the Republic of Macedonia Regional Waste Management Plans (Northeast, East, Southeast, Southwest, Pelagonia, Polog, Vardar and Skopje region)
Methodology [for estimating the emissions]	Regression model, IPCC methodology
Assumptions	Gradual increase, compared to WOM of paper selection reaching 82% in 2050 wood selection reaching 36% in 2050 textile selection reaching 32% in 2050 nappies selection reaching 50% in 2050 plastic and other inert waste reaching 69% in 2050
Status of implementation [idea, planning phase, under implementation]	Planning phase
Steps taken	Regional waste management plans developed Containers for waste selection installed in several cities in Macedonia, mostly in Skopje. Private companies – digitalization of information (bills) realized
Steps envisaged	Installation of containers for waste selection in all cities in Macedonia. Promoting the reduction of paper consumption and dematerialization of the information using ICT (Information and Communication Technologies)

Indicators		Indicator value in the last reporting year	Indicative trajectory		Indicator target value
		2018	2030	2040	2050
Progress	Amount of municipal waste selected (kt)		121	231	319

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	30.2	75.1	129.6

Finance	Budget	2 mil. EUR
	Source of finance	Local self-government through Public Utilities, Public Private Partnership, EU funds
Implementing entity		Ministry of Environment and Physical Planning Public municipal enterprises for waste management State Environmental Inspectorate Inter-Municipal Waste Management Board Authorized Inspectors of Environment (Municipalities)
Monitoring entity		Ministry of Environment and Physical Planning

PAM 48 Improved waste and materials management at industrial facilities

PAM 48 Improved waste and materials management at industrial facilities

Main objective: Set targets for reduction of generation, selection, reuse, recycling and treatment of waste at industrial installations

Description: This measure takes into account the Extended Producer Responsibility schemes, including the goals defined in the Law on Management of Packaging and Packaging Waste, which enables and contributes to achieving the goals of the circular economy.

On an individual assessment, each IPPC installation operator shall submit proposals for 1) waste generation, 2) waste selection, 3) waste reuse, 4) waste recycling, 5) waste treatment. Goals are set in integrated environmental permits.

Goals are set for a 5 year framework (progressive goals for each year) that will be updated as appropriate after the deadline.

Two levels of goals: mandatory and higher incentives (through tax or financial incentives).

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulation, Technical	Waste – Solid waste disposal	CO_2, CH_4	National

Relevant planning documents, legal and regulatory acts	National Waste Management Plan 2021-2031 Strategy for Waste Management in the Republic of Macedonia Law on Waste Management and bylaws Law on Management of Packaging and Packaging Waste Law on Extended Producer Responsibility for Waste Management Law on Finance and bylaws Regional Waste Management Plans (Northeast, East, Southeast, Southwest, Pelagonia, Polog, Vardar and Skopje region)
Methodology [for estimating the emissions]	Regression model, IPCC methodology
Assumptions	Conducted substantive analysis, international experiences analyzed. The percentage of industrial waste treatment will increase according to the goals defined in the Law on Management of Packaging and Packaging Waste, for each type of industrial waste.
Status of implementation [idea, planning phase, under implementation]	Planning phase
Steps taken	/
Steps envisaged	Analysis of possible tax and financial options to encourage the achievement of higher goals Analysis done; opportunities/mechanisms identified Modified and issued environmental permits Regular annual implementation oversight Regular annual reporting by IPPC operators

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2030	2040	2050
Progress – Industrial waste collected (kt)	/	1256 година	2101 година	3186

Emissions reduction (Gg CO_2-eq)	2030	2040	2050
	16.4	51.5	95.8

Finance – Budget	n/a
Finance – Source of finance	Ministry of Environment and Physical Planning, Municipalities and city of Skopje, Industrial facilities, EU funds
Implementing entity	Ministry of Environment and Physical Planning Public municipal enterprises for waste management State Environmental Inspectorate Inter-Municipal Waste Management Board Authorized Inspectors of Environment (Municipalities)
Monitoring entity	Ministry of Environment and Physical Planning

PAM 49 Improved industrial wastewater treatment

PAM 49 Improved industrial wastewater treatment						
Main objective: Increase the rate of industrial wastewater treatment, by reducing the sludge **Description:** This measure assumes industrial sludge treatment processes which includes mechanisms and processes used to treat waters that have been contaminated in some way by anthropogenic industrial or commercial activities prior to its release into the environment or its re-use. This measure, i.e. treatment of the industrial wastewater is also part of the integrated environmental permits of the industrial facilities.						
Timeframe		Type	Sector	Gases	Scope	
2030 – 2050		Regulation, Technical	Waste – Industrial wastewater	CH_4	National	
Relevant planning documents, legal and regulatory acts		National Waste Management Plan 2021-2031 Strategy for Waste Management in the Republic of Macedonia Law on Waste Management and bylaws Law on Management of Packaging and Packaging Waste Law on Extended Producer Responsibility for Waste Management Law on Finance and bylaws Regional Waste Management Plans (Northeast, East, Southeast, Southwest, Pelagonia, Polog, Vardar and Skopje region)				
Methodology [for estimating the emissions]		Regression model, IPCC methodology				
Assumptions		The emissions from industrial wastewater will be reduced by 50% in 2050 when compared to the emissions from this category in 2050 in the WOM scenario.				
Status of implementation [idea, planning phase, under implementation]		Planning phase				
Steps taken		/				
Steps envisaged		Modified and issued environmental permits Regular annual implementation oversight Regular annual reporting by IPPC operators				
Indicators		Indicator value in the last reporting year	Indicative trajectory			Indicator target value
		2018	2030	2040		2050
Progress	Sludge removed in each industry sector (kg COD/yr)	0	51.531.106	141.338.206		385.499.107
Emissions reduction (Gg CO_2-eq)		2030	2040	2050		
		62.4	163.5	370.5		
Finance	Budget	n/a				
	Source of finance	Ministry of Environment and Physical Planning, Industrial facilities, EU funds				
Implementing entity		Ministry of Environment and Physical Planning Public municipal enterprises for waste management State Environmental Inspectorate Inter-Municipal Waste Management Board Authorized Inspectors of Environment (Municipalities)				
Monitoring entity		Ministry of Environment and Physical Planning				

These mitigation measures are of long-term character and will contribute as well to reaching EU targets. The implementation of these measures does not require substantial financing and at the same time will results social and environmental benefits.

4.2.4.3 Measures overview and investment needs

From the Waste sector, four measures/policies are included (Table 4-6).

Table 4-6. Review of the measures/policies included in the Mitigation scenario of the Waste sector

	Policy/ measure	*Competent entity for realization*	*Budget (mil. €)*	*Source of finance*	*Indicative emissions reduction (Gg CO_2-eq)*		
					2030	**2040**	**2050**
1	Landfill gas flaring	Ministry of Environment and Physical Planning Public municipal enterprises for waste management State Environmental Inspectorate Inter-Municipal Waste Management Board Authorized Inspectors of Environment (Municipalities)	20.5	Local self-government through Public Utilities, Public Private Partnership, Grants from the EU	561.3	655.0	823.5
2	Mechanical and biological treatment (MBT) in new landfills with composting	Ministry of environment and physical planning Public utilities for waste management State Environmental Inspectorate Inter-municipal board for waste management Authorized Inspectors of Environment (Municipalities)	36.1	Local self-government through Public Utilities, Public Private Partnership, Grants from the EU	35.2	145.2	216.1
3	Selection of waste - paper	Ministry of environment and physical planning Public utilities for waste management State Environmental Inspectorate Inter-municipal board for waste management Authorized Inspectors of Environment (Municipalities)	2	Local self-government through Public Utilities, Public Private Partnership, Grants from the EU	30.2	75.1	129.6
4	Improved waste and materials management at industrial facilities	Ministry of Environment and Physical Planning Public utilities for waste management State Environmental Inspectorate Inter-Municipal Waste Management Board Authorized Inspectors of Environment (Municipalities)	/	Ministry of Environment and Physical Planning Municipalities and city of Skopje Industrial facilities	16.4	51.5	95.8
5	Improved industrial wastewater treatment	Ministry of Environment and Physical Planning Public utilities for waste management State Environmental Inspectorate Inter-Municipal Waste Management Board Authorized Inspectors of Environment (Municipalities)	/	Ministry of Environment and Physical Planning, Industrial facilities, EU funds	62.4	163.5	370.5

* Total reduction when including the emissions realized after 2050

For the implementation of the Mitigation scenario in the Waste sector, investments of 58.6 mil. € are needed, for the period from 2020 to 2050. All investments are covered by the central budget of Macedonia, the local self-governments and the City of Skopje and the private sector. A measure with the most significant potential for greenhouse gas emissions reduction is the Landfill gas flaring.

4.2.5 Additional mitigation measures

To effectively implement the mitigation measures and achieve the ambitious targets of the ENDC, it is important to create the enabling conditions such as regulatory, technical and research enablers. The ENDC has identified 16 additional measures to enable the concrete mitigation actions. These additional measures focus on enabling the transition of the energy sector to a low-carbon sustainable energy system.

A key measure is the introduction of the CO_2 tax, which will enable the government to set the desired market signals right away and allow for a gradual increase in the tax in support of Macedonian goals related to the Paris Agreement, Energy Community and EU accession. Implementing the tax would build experience in the country with carbon pricing and afford time to set up systems and build capacity needed to join the EU ETS later.

In addition, 16 measures are considered, that help in achieving the goals for reducing GHG emissions:

PAM 50 Introduction of CO_2 tax

PAM 50 Introduction of CO_2 tax

Main objective: Incentivize lowering CO2 emissions

Description: Introduction of CO2 tax in order to stimulate the investments in RES and to increase the penetration of energy efficiency measures

A carbon tax can support implementation of the Macedonian enhanced NDC by putting a price on activities based on their climate impacts[9]. Affected sources will have an incentive to reduce emissions where the mitigation actions cost less than the carbon tax. In this way, a carbon tax will harness the power of the market to facilitate implementation of the low-carbon measures identified in the enhanced NDC, while also encouraging industry and consumers to innovate in finding other low-cost ways to reduce their carbon footprints.

At the same time, as part of the accession process, Macedonia is expected to progressively advance its climate agenda to match the EU commitments such that the country could adopt the EUETS by the time of accession. A carbon tax offers a way to establish a gradual carbon price path to reach this goal in a way that offers certainty to investors and minimizes volatility and disruption.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on Energy Bylaws for renewable energy Law on Climate Change
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model. IPCC Methodology
Assumptions	Gradual introduction of CO2 tax (2023 in WAM) based on the projected prices from WEO 2017.
Status of implementation	Under implementation
Steps taken	Draft version of the Law on Climate Change Strategy for Energy Development of the Republic of Macedonia up to 2040
Steps envisaged	Adoption of the Law on Climate Change Adoption of the Strategy on Climate Action Adoption of the National Energy and Climate Plan

Indicators	Value in the last reporting year	Indicative trajectory		Target value
	2018	2020	2025	2030

Progress	2030	2040	2050
kt CO2 emissions paid under carbon tax			

Finance – Budget	n/a
Finance – Source of finance	n/a
Implementing entity	Government of the Republic of North Macedonia Ministry of Environment and Physical Planning Ministry of Economy, Energy Agency Ministry of Finance
Monitoring entity	Ministry of environment and physical planning

9 UNDP (2021) How Macedonia can use a carbon tax to realize national policy goals. https://api.klimatskipromeni.mk/data/rest/file/download/781d23f543_757076cfb83fc503760d24fa9a815b9b24137f4021a374ba418052.pdf

PAM 51 Program for just transition

PAM 51 Program for just transition

Main objective: Developing programs for socially responsible and just transition

Description: Depending on selected level of transition from conventional energy, it is important to develop programs for socially responsible and just transition to mitigate negative effects of associated job losses. Such programs should provide an answer how to redeploy employees to other jobs and stimulate new job opportunities by investing in low carbon technologies and services.

Timeframe	Type	Sector	Gases	Scope
2020 – 2030	Regulatory	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on Energy Documents from project which are working in this area
Methodology	TBC
Assumptions	Oslomej is decommissioned in 2021 Bitola is decommissioned in the period 2025-2027
Status of implementation	Under implementation
Steps taken	EBRD project of just transition in Oslomej region NGO project of just transition in Oslomej region 100 MW PV power plant in Oslomej 20 MW PV power plant in Oslomej 20 MW PV power plant in Bitola
Steps envisaged	

Indicators	Value in the last reporting year	Indicative trajectory		Target value
	2018	2020	2025	2030

Progress	Program adopted	2030	2040	2050
Finance	Budget	n/a		
	Source of finance	JSC ESM, state budget, donors		
Implementing entity		Government of the Republic of North Macedonia Ministry of Economy JSC Macedonian Power Plants (ESM AD) Ministry of labor and social policy		
Monitoring entity		Ministry of Economy		

PAM 52 Identification of the proper location for solar and wind power plants

PAM 52 Identification of the proper location for solar and wind power plants

Main objective: Development of methodology for selection of the most appropriate location foe solar and wind power plants

Description: Avoid excessive damage to nature, Government, energy companies and NGOs can prioritize land areas that have already been disturbed by industrial activity such as mines or quarries. In territories that have been historically dependent on coal production, depleted coal and other mines can be used for this purpose. In addition, for the wind warms it is important to find appropriate locations, not environmentally sensitive (e.g habitats of birds and bats).

Timeframe	Type	Sector	Gases	Scope
2020 – 2023	Technical	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts		Strategy for Energy Development of the Republic of Macedonia up to 2040 Law on Energy Law on environmental protection Documents from project which are working in this area			
Methodology		TBC			
Assumptions		Oslomej is decommissioned in 2021 Bitola is decommissioned in the period 2025-2027			
Status of implementation		Planning			
Steps taken		100 MW PV power plant in Oslomej 20 MW PV power plant in Oslomej 20 MW PV power plant in Bitola			
Steps envisaged					
Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2018	2020	2025	2030
Progress	Methodology developed	2030	2040	2050	
Finance	Budget	n/a			
	Source of finance	State budget, donors			
Implementing entity		Government of the Republic of North Macedonia Ministry of Economy JSC Macedonian Power Plants (ESM AD) Ministry of labor and social policy Donors			
Monitoring entity		Ministry of Economy			

PAM 53 Smart communities

PAM 53 Smart communities

Main objective: Develop pilots for smart communities

Description: Smart academic campuses could have an exemplary role where all advanced concepts and principles from smart energy systems can be tested with the goal for roll-out on larger scale.

Timeframe	Type	Sector	Gases	Scope
2020 – 2030	Education, Technical	Education, Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	/
Methodology	TBC
Assumptions	/
Status of implementation	Planning
Steps taken	PV power plants are installed at the Faculty of Electrical Engineering and Information Technologies
Steps envisaged	

Indicators	Value in the last reporting year	Indicative trajectory		Target value
	2018	2020	2025	2030

Progress – Number of smart communities	2030	2040	2050

Finance – Budget	Depends on the type of smart community
Finance – Source of finance	Donors Horizon 2020 and other research programs
Implementing entity	Universities (or high schools)
Monitoring entity	Ministry of Education and Science Ministry of Economy

PAM 54 Construction of 400 kV electricity transmission interconnection Macedonia-Albania (Bitola-Elbasan)

PAM 54 Construction of 400 kV electricity transmission interconnection Macedonia-Albania (Bitola-Elbasan)

Main objective: mprove the interconnectivity level

Description: this project is the last segment of the Corridor 8 for transmission of electricity between Bulgaria, Macedonia, Albania and Italy. The project is included in the List of Projects of Energy Community Interest (PECI).

Timeframe	Type	Sector	Gases	Scope
2020 – 2023	Technical	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	PECI list Plan for development of the transmission system, 2020-2029, MEPSO Infrastructure Capacity Project, Technical Assistance Window (IPA) Western Balkans
Methodology	Calculation of interconnectivity level, using MARKAL results from the Strategy for energy development up to 2040 and ENTSO-E Winter outlook
Assumptions	Interconnectivity level will be increased for at least 7%
Status of implementation	Under implementation
Steps taken	an agreement for construction signed
Steps envisaged	

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2018	2020	2025	2030
Progress	Interconnectivity level	2030	2040	2050	

Finance	Budget	34 Mil. €
	Source of finance	EBRD (17.2 Mil. €), Grand from Western Balkan Investment Fund (16.9 Mil. €)
Implementing entity		MEPSO
Monitoring entity		Ministry of economy

PAM 55 Develop natural gas cross-border infrastructure to diversify supply routes and increase market competitiveness

PAM 55 Develop natural gas cross-border infrastructure to diversify supply routes and increase market competitiveness

Main objective: Develop natural gas cross-border infrastructure to diversify supply routes and increase market competitiveness

Description: On 10 July 2015 the Republic of North Macedonia became a signatory to the Memorandum of understanding on a common approach to address the natural gas diversification and the challenges of security of supply within the Central and Southeastern Europe Gas Connectivity Initiative (CESEC).

NER JSC Skopje has started implementing the obligations under this Initiative aimed at promoting the diversification of natural gas supply and ensuring security in the supply of the region, which should take place by improving the regional infrastructure and integration of markets through the joint engagement of all EU Member States and Contracting Parties of the Energy Community. This initiative should provide the supply of the necessary quantities of natural gas to all consumers in the region of Central and South-Eastern Europe (CESEC), including the Republic of North Macedonia.

In addition, there are two other initiatives - pipelines to Kosovo* and Serbia. The pipeline to Serbia could provide additional alternative source and transit opportunity to the Macedonian system, while the connection with Kosovo* could provide transit opportunity. Both can increase the utilization rate of the system, thus have the potential to decrease tariffs and help the gasification efforts in Macedonia. The projects for gas pipelines to Kosovo* and Serbia are on the preliminary PECI 2020 list that should be adopted by the Ministerial council at the end on 2020, while the gas project to Greece is already included on the PMI list, verified on 14 October 2016 by the Ministerial council of the Energy Community.

Furthermore, Macedonia and Albania have signed a Memorandum of understanding and a working group is established and it is expected that by the end of 2020 more concrete activities will start.

Timeframe	Type	Sector	Gases	Scope
2020 – 2025	Technical, Regulatory	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	List of Projects of Mutual Interest List of Project of Energy Community Interest
Methodology	/
Assumptions	/
Status of implementation	Under implementation
Steps taken	Macedonia – Greece pipeline Project application after the fourth open call for co-financing of infrastructure projects within the IPA instrument Investment Framework of the Western Balkans, November 2018 and update of the same in April 2019. The investment grant application has a positive screening status and the final decision was made in December 2019; A letter was submitted with a request for expression of interest for financing the Project submitted to the European Investment Bank (EIB), October 2018. The EIB submitted a positive response to this request in November 2018. Intensive negotiations have started for the financing procedure. Mutual Feasibility Study is prepared by DESFA and NER in January 2019 and it is submitted and accepted by EIB A request for technical assistance (100% grant) has been submitted for the preparation of an Environmental Impact Assessment Study and a general design project to Connect (Technical Assistance for Connectivity in the Western Balkans). The application was approved in January 2019. The study and the general design project are being prepared by Konnekta. According to the plans, the Study (EIA) has already been prepared and submitted to the EIB for comments, while the project documentation should be completed by the middle of 2020. A request for technical assistance (100% grant) for preparation of tender documentation for construction and construction supervision has been submitted. The same has been approved, but due to the coronavirus situation it is postponed. Macedonia – Kosovo* pipeline Memorandum of Understanding is signed, February 2019 A letter with a request for expression of interest for financing the Project was submitted to the EBRD. At the beginning of 2019, the EBRD submitted a positive response to this request and the bank supported the implementation of this project; A project application was submitted after the 21st open call for technical assistance for preparation of a Feasibility Study and Environmental Impact Assessment Study within the IPA Instrument Investment Framework of the Western Balkans, November 2018 and update of the same in April 2019. The technical assistance application was approved in July 2019; The TOR (Terms of Reference) has been developed. A Feasibility Study and an Environmental Impact Assessment Study are expected to be completed by the middle of 2020. Macedonia – Serbia pipeline: Activities for signing a Memorandum of Understanding.
Steps envisaged	Start with the construction of Macedonia-Greece pipeline

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2018	2020	2025	2030
Progress	Natural gas interconnection capacity (Mill. Nm^3)	2030	2040	2050	
Finance	Budget	n/a			
	Source of finance	Grant – 10 Mil. €, Central government budget			
Implementing entity		National Energy Resources of Macedonia			
Monitoring entity		Ministry of Economy			

PAM 56 Develop gas transmission network

PAM 56 Develop gas transmission network

Main objective: Increase the access to the transmission network

Description: Macedonia has an ambitious gasification plan and a detailed list of planned infrastructure project of the gas network in Macedonia with timeline is given in Chapter 4, Energy transmission infrastructure. The increased level of transmission network access is especially aimed at the industrial consumers (which are most affected by the green scenario), as natural gas is one of the fuels that will significantly contribute to the energy transition in the industry sector. In addition, with the implementation of this measure the air quality will be significantly improved.

Timeframe	Type	Sector	Gases	Scope
2020 – 2025	Technical	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Gasification plan of Macedonia
Methodology	Bottom-up modeling and least-cost optimization using the MARKAL model.
Assumptions	/
Status of implementation	Under implementation
Steps taken	Klechovce-Valve station 5(Stip), with length of 61 km and diameter of 500mm, finished in 2016 (light blue line in Figure 78), and Valve station 5(Stip)-Negotino, with length of 38 km and diameter of 500mm, finished in 2019 (purple line in Figure 78).
Steps envisaged	Negotino (Kavadarci)-Bitola, with length of 92 km and diameter of 500mm, 90% realized up to June 2020 (green line in Figure 78) Skopje-Tetovo-Gostivar, with length of 76 km and diameter of 500mm, and additional branch to Tetovo with length of 10 km and diameter of 150 mm, 53.1% realized at the beginning of November 2019 (yellow line in Figure 78). It is expected that in the near future the construction of three additional gas pipelines will be started: Gostivar-Kicevo, with length of 34 km, in a process of obtaining building permit (to be finished by 2022) Sveti Nikole – Veles, with length of 32 km, in a process of preparing project documentation (to be finished by 2023) Kicevo-Ohrid (to be finished by 2025) Bitola – Ohrid (to be finished by 2025) Valve station 5 (Stip)-Radovis-Strumica, with length of 60 km

Indicators		Value in the last reporting year	Indicative trajectory		Target value
		2018	2020	2025	2030
Progress	Final energy consumption of natural gas in Industry (ktoe)	2030	2040	2050	
Finance	Budget	~200 Mil. €			
	Source of finance	State budget			
Implementing entity		National Energy Resources of Macedonia			
Monitoring entity		Ministry of Economy			

PAM 57 Develop a gas distribution network

PAM 57 Develop a gas distribution network							
Main objective: Diversification of the energy resources **Description:** Macedonia has an ambitious gasification plan and natural gas is one of the fuels that will significantly contribute to the energy transition up to 2040. In addition, with the implementation of this measure the air quality will be significantly improved.							
Timeframe		Type	Sector	Gases	Scope		
2020 – 2025		Technical	Energy	CO_2, CH_4, N_2O	National		
Relevant planning documents, legal and regulatory acts		Gasification plan of Macedonia Feasibility study about gasification (revised version in 2020)					
Methodology		Bottom-up modeling and least-cost optimization using the MARKAL model.					
Assumptions		Development of a cost benefit analyses for each city					
Status of implementation		Under implementation					
Steps taken		Tender announced EBRD support for procurement and installation of household equipment (50 mill. EUR) Tender for technical and legal support for preparation and implementation of a tender procedure is announced in June 2020 by EBRD					
Steps envisaged							
Indicators		Value in the last reporting year	Indicative trajectory			Target value	
		2018	2020	2025		2030	
Progress	Final energy consumption of natural gas except Industry (ktoe)	2030	2040		2050		
Finance	Budget	/					
	Source of finance	Grant, Central governmental budget, Local self-government budgets					
Implementing entity		Ministry of economy, National Energy Resources of Macedonia, Local self-government					
Monitoring entity		Ministry of Economy					

PAM 58 Pursue regional electricity market integration

PAM 58 Pursue regional electricity market integration

Main objective: Increase the electricity price competitiveness and affordability.

Description: It is anticipated that day ahead market coupling, and development of power exchange is playing an important role in the future for North Macedonia and EnC market integration initiatives (WB6). Future potential domestic capacities for electricity generation are considered in the context of integrated regional and European market. In addition, a well-integrated regional market will serve as a control indicator for price competitiveness and steer future capital investment decisions.

In order to have competitive natural gas market in Macedonia, the interconnection agreement between Macedonian and Bulgarian TSOs is of crucial importance.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Energy Law and bylaws
Methodology	/
Assumptions	/
Status of implementation	Under implementation
Steps taken	The decree for the operation of the organized electricity market and the necessary technical, staff and financial conditions that should be fulfilled, is adopted by the Government
Steps envisaged	

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	Coupled with Bulgaria Macedonian and Bulgarian gas TSOs agreement signed	2030	2040	2050
Finance	Budget	/		
	Source of finance	National electricity market operator (MEMO), GAMA		
Implementing entity		National electricity market operator (MEMO), GAMA		
Monitoring entity		Energy Regulatory Commission		

PAM 59 Develop further distribution system network to integrate more RES, including prosumers and more electric vehicles (EVs), as well as continuously improve network reliability

PAM 59 Develop further distribution system network to integrate more RES, including prosumers and more electric vehicles (EVs), as well as continuously improve network reliability

Main objective: Develop further distribution system network to integrate more RES, as well as continuously improve network reliability..

Description: The RES policies and measures envisage a huge number of solar PVs up to 1,400 MW, out of which 250 – 400 MW being rooftop PVs. Such trend indicates an important role of the distribution network system to service growing decentralised systems. In addition, European practice shows that regulators are imposing additional pressure and incentive to improve the operational performance and results of distribution system operators. The key changes that should be considered in the future are related in introducing new quality indicators in the tariff methodology (voltage quality, quality of supply, customer relationship quality etc.), as well as additional revisions on investment decisions (CAPEX and regulated asset base), operating efficiency and expected returns for distribution system operators. These changes in the regulatory framework will indirectly contribute to improvements in asset management, workforce management, automation and roll out of "behind the meter" services in the future.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory, technical	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Energy Law and bylaws Plan for development of the distribution network
Methodology	/
Assumptions	The potential for distributed RES, prosumers and electric vehicles will be increased
Status of implementation	Under implementation
Steps taken	Chargers for Electric vehicles are being installed Old meters are being replaced with smart meters
Steps envisaged	

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	2030	2040	2050
Number of prosumers Capacity of distributed PV Number of electric vehicles			

Finance – Budget	/
Finance – Source of finance	EVN, consumers through their electricity bills
Implementing entity	EVN Energy Regulatory Commission
Monitoring entity	Energy Regulatory Commission

PAM 60 Price signal demand response

PAM 60 Price signal demand response

Main objective: Introduce price signals to consumers in order to implement demand response.

Description: Demand response is one of the main methods that are used in order to reduce the maximum electricity consumption in the system, and thus reduce its peak load and integrate higher level of RES in the system. Price signalling provided by the electricity suppliers can significantly contribute towards achieving these goals. By implementing the new Energy Law, and by the liberalized market it is envisioned that the role of the universal supplier will be reduced, and that the concurrency of the suppliers will be increased. Therefore, each of them may introduce different pricing signals for different type of consumers.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Energy Law and bylaws Study on automated demand response, MEPSO
Methodology	/
Assumptions	Price signal demand response will reduce the peak load and enable higher integration of RES
Status of implementation	Under implementation
Steps taken	/
Steps envisaged	

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	Number of suppliers on the market with price signals	2030	2040	2050

Finance	Budget	/
	Source of finance	Electricity suppliers/traders, Consumers
Implementing entity		Electricity suppliers/traders Consumers
Monitoring entity		Energy Regulatory Commission

PAM 61 Adoption of annual program for vulnerable consumers

PAM 61 Adoption of annual program for vulnerable consumers

Main objective: Protect vulnerable customers .

Description: The Implementation of the GHG and RES targets will increase the price of electricity as it is described in Chapter 4 Internal energy market. Having this in mind a program for vulnerable costumers is needed that will protect them from the price shocks.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Regulatory	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Energy law Separate rules for electricity, gas and heat supply Program for vulnerable consumers for 2020
Methodology	/
Assumptions	This early program should define the categories of vulnerable costumers and associated measures, including financial supports and responsible institutions for realization of the program.
Status of implementation	The first program is adopted by the Government
Steps taken	/
Steps envisaged	

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	Program adopted	2030	2040	2050
Finance	Budget	Different for each year		
	Source of finance	Budget and potential donors		
Implementing entity		Ministry of economy Suppliers of electricity, gas and heat		
Monitoring entity		Energy Regulatory Commission		

PAM 62 Participation in development of energy transition technologies and measures

PAM 62 Participation in development of energy transition technologies and measures

Main objective: Streamline energy transition technologies and measures into national R&I priorities

Description: The development of sectoral strategies and plans for science and R&I should be realized in cooperation between Ministry of Education and Science and relevant energy stakeholders, in order to prioritize energy transition technologies and measures. Same is needed for the programmes in the Fund for Innovation and Technology Development.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Research	Energy, Research, Economy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Innovation Strategy, 2012-2020 Law on Innovation Activity Annual programs of the Fund for Innovation and Technology Development
Methodology	/
Assumptions	/
Status of implementation	The Fund for Innovation and Technology Development has already announced two public calls for research in climate change and local pollution
Steps taken	/
Steps envisaged	/

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	Number of research projects development of energy transition technologies and measures	2030	2040	2050
Finance	Budget	/		
	Source of finance	Fund for Innovation and Technology Development Horizon 2020 Donors		
Implementing entity		Ministry of Education and Science Fund for Innovation and Technology Development Chamber of Commerce		
Monitoring entity		Ministry of Education and Science		

PAM 63 Increased level of education of sustainable energy needs

PAM 63 Increased level of education of sustainable energy needs

Main objective: Adjust energy related curricula at all educational levels to make them responsive to energy transition trends

Description: The development of consciousness for sustainable energy needs to be addressed from the earliest education levels and incorporated in the curricula of all primary, secondary and tertiary educational levels. Moreover, stimulating science and education in energy transition will help mobilization of the existing and building of new research capacities, as well as better integration into European Research Area (ERA) in energy themes.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Education, Regulatory	Education	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Law on primary education Law on secondary education Law on higher education
Methodology	/
Assumptions	/
Status of implementation	/
Steps taken	/
Steps envisaged	/

Indicators	Indicator value in the last reporting year		Indicative trajectory	Indicator target value
	2018	2020	2025	2030

Progress	Number of curricula for sustainable energy needs	2030	2040	2050
Finance	Budget	/		
	Source of finance	/		
Implementing entity		Universities, High and Primary schools		
Monitoring entity		Ministry of Education and Science		

PAM 64 Inter-sectoral and geographical mobility of researchers

PAM 64 Inter-sectoral and geographical mobility of researchers

Main objective: Encourage inter-sectoral and geographical mobility of researchers

Description: Knowledge and experience transfer among researchers from industry and academia, as well as incoming and outgoing mobility is needed to build internal capacities. For example, at highest educational level, industrial doctorates can be promoted as a tool to support industry driven science.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Education, Regulatory	Education, Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	Law on primary education Law on secondary education Law on higher education
Methodology	/
Assumptions	/
Status of implementation	Faculty of Electrical Engineering and Information Technologies has established INNOFEIT, which is a place where the faculty staff, students and company representatives can interact, network and transfer technologies and innovations. The goal of INNOFEIT is to improve, strengthen and stimulate the transfer of knowledge.
Steps taken	/
Steps envisaged	/

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	Number of industrial doctorates	2030	2040	2050
Finance	Budget	/		
	Source of finance	Industry companies Donors		
Implementing entity		Universities Industry companies		
Monitoring entity		Ministry of Education and Science Ministry of Economy		

PAM 65 Increase the role of SME sector in energy transition

PAM 65 Increase the role of SME sector in energy transition

Main objective: Encourage SME sector to diversify their portfolio of services and products in RES and EE

Description: To support greater involvement of local SME in energy transition, it is necessary to promote further expansion of RES projects and EE measures overall, especially via financial mechanisms, as well as green public procurement for innovative products. Private investments in RES and EEwill be encouraged by structuring financing instruments with grant components to lower the risk of private investments in untested but promising clean energy technologies or business models. In addition, provision of technical assistance for SMEs in order to facilitate the access of enterprises to external services is needed. This covers the areas of external research and development, testing, design, instruction and training, market research, business consulting, etc.

Timeframe	Type	Sector	Gases	Scope
2030 – 2050	Research, Technical, Voluntary	Energy	CO_2, CH_4, N_2O	National

Relevant planning documents, legal and regulatory acts	/
Methodology	/
Assumptions	/
Status of implementation	/
Steps taken	/
Steps envisaged	/

Indicators	Indicator value in the last reporting year	Indicative trajectory		Indicator target value
	2018	2020	2025	2030

Progress	2030	2040	2050
Number of innovations/ patents in the field of clean energy			

Finance – Budget	/
Finance – Source of finance	Grants Private investments
Implementing entity	SMEs
Monitoring entity	Ministry of Economy

4.2.5.1 Measures overview and investment needs

In addition, 16 measures are considered, that help in achieving the goals for reducing GHG emissions (Table 4-7).

Table 4-7. Review of the additional measures/policies included in the Mitigation scenario

	Policy/ measure	Competent entity for realization	Budget (mil. €)	Source of finance	Indicative emissions reduction ($Gg\ CO_2$-eq)	#	Policy/ measure
1	Introduction of CO_2 tax	• Government of the Republic of North Macedonia • Ministry of Environment and Physical Planning • Ministry of Economy, Energy Agency • Ministry of Finance	n/a	n/a	n/a	n/a	n/a
2	Program for just transition	• Government of the Republic of North Macedonia • Ministry of Economy • JSC Macedonian Power Plants (ESM AD) • Ministry of labor and social policy	n/a	JSC ESM, state budget, donors	n/a	n/a	n/a
3	Identification of the proper location for solar and wind power plants	• Government of the Republic of North Macedonia • Ministry of Economy • JSC Macedonian Power Plants (ESM AD) • Ministry of labor and social policy • Donors	n/a	State budget, donors	n/a	n/a	n/a
4	Smart communities	• Universities (or high schools)	n/a	Donors Horizon 2020 and other research programs	n/a	n/a	n/a
5	Construction of 400 kV electricity transmission interconnection Macedonia-Albania (Bitola-Elbasan)	• MEPSO	34	EBRD (17.2 Mil. €), Grand from Western Balkan Investment Fund (16.9 Mil. €)	n/a	n/a	n/a
6	Develop natural gas cross-border infrastructure to diversify supply routes and increase market competitiveness	• National Energy Resources of Macedonia	n/a	Grant – 10 Mil. €, Central government budget	n/a	n/a	n/a
7	Develop gas transmission network	• National Energy Resources of Macedonia	200	State budget			
8	Develop a gas distribution network	• Ministry of economy, • National Energy Resources of Macedonia, • Local self-government	n/a	Grant, Central governmental budget, Local self-government budgets	n/a	n/a	n/a
9	Pursue regional electricity market integration	• National electricity market operator (MEMO), • GAMA	n/a	National electricity market operator (MEMO), GAMA	n/a	n/a	n/a
10	Develop further distribution system network to integrate more RES, including prosumers and more electric vehicles (EVs), as well as continuously improve network reliability	• EVN • Energy Regulatory Commission	n/a	EVN, consumers through their electricity bills	n/a	n/a	n/a

	Policy/ measure	Competent entity for realization	Budget (mil. €)	Source of finance	Indicative emissions reduction (Gg CO_2-eq)	#	Policy/ measure
11	Price signal demand response	• Electricity suppliers/traders • Consumers	n/a	Electricity suppliers/traders Consumers	n/a	n/a	n/a
12	Adoption of annual program for vulnerable consumers	• Ministry of economy • Suppliers of electricity, gas and heat	n/a	Budget and potential donors	n/a	n/a	n/a
13	Participation in development of energy transition technologies and measures	• Ministry of Education and Science • Fund for Innovation and Technology Development • Chamber of Commerce	n/a	Fund for Innovation and Technology Development Horizon 2020 Donors	n/a	n/a	n/a
14	*Increased level of education of sustainable energy needs*	• *Universities, High and Primary schools*	n/a		n/a	n/a	n/a
15	Inter-sectoral and geographical mobility of researchers	• Universities • Industry companies	n/a	Industry companies Donors	n/a	n/a	n/a
16	Increase the role of SME sector in energy transition	• SMEs	n/a	Grants Private investments	n/a	n/a	n/a

4.3 Summary of GHG emissions projections

4.3.1 WOM scenario

The total net GHG emissions from all sectors in the **WOM scenario** is expected to increase by 113% in 2050 compared to 1990, **reaching 23,227 Gg CO2-eq** (Figure 4-18). Compared to 2040, the net emissions are increased by 73%. When analysing the total GHG emissions without the FOLU sector, this increase is also noticeable, i.e.+75% in 2040 and +108% in 2050 compared to 1990 (Figure 4-19). From these emissions, the largest amount is from the Energy sector, which increases its share by up to 82% in 2050. Additionally, the fastest growing sector in terms of emissions is the Waste sector, where the emissions in 2050 are 4 times larger than in 1990. On the other hand, the only sector that is absorbing CO_2 emissions (has negative emissions) is the FOLU sector, and the amount of emissions absorbed is increased by about 50% in 2050, compared to 2018.

The IPCC methodology does not include emissions from electricity imports, as well as from international aviation. To compare the results with the GHG inventory of Macedonia, but also with the results from the other countries, in this report the results without electricity import and international aviation (MEMO) are also presented (Figure 4-20). Using this approach, in 2040 the GHG emissions are increased by 63%, while in 2050 by 84.4% compared to 1990. The difference between these two approaches is mainly due to the import of electricity, which in the IPCC approach reduces the GHG emissions.

Figure 4-18. Comparison of total GHG emissions from all sectors in WOM, WEM, WAM and e-WAM scenarios, 2030 [Gg Co_2-eq]

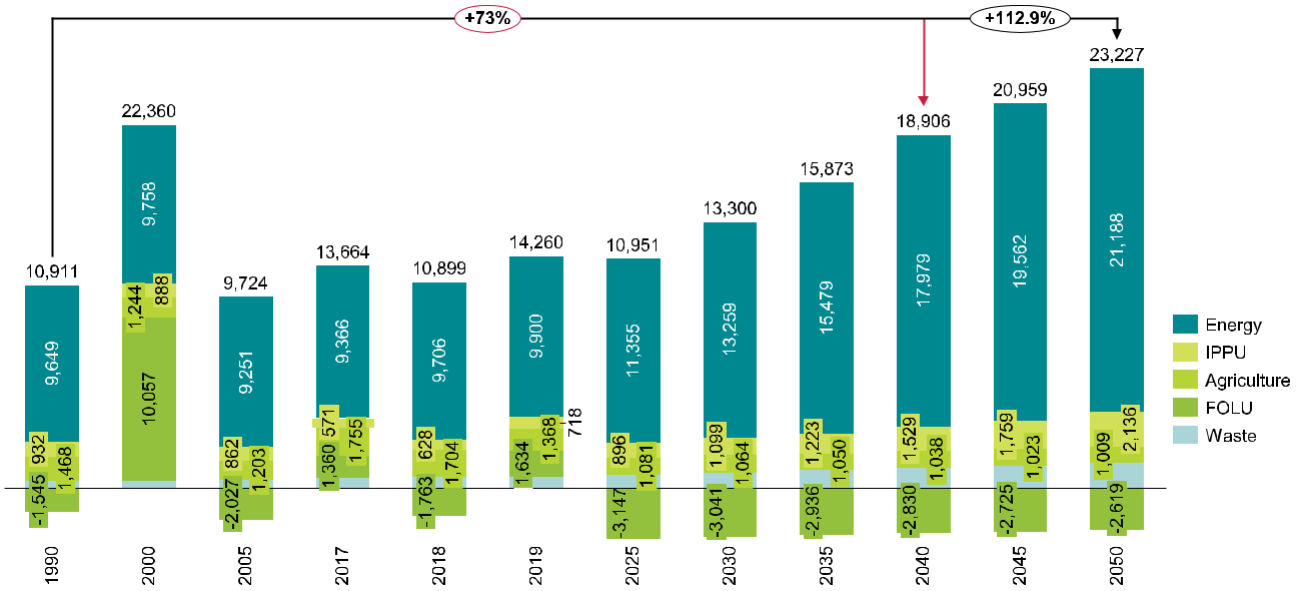


Figure 4-19. Comparison of total GHG emissions from all sectors without MEMO in WOM, WEM, WAM and e-WAM scenarios, 2030 [Gg Co_2-eq]

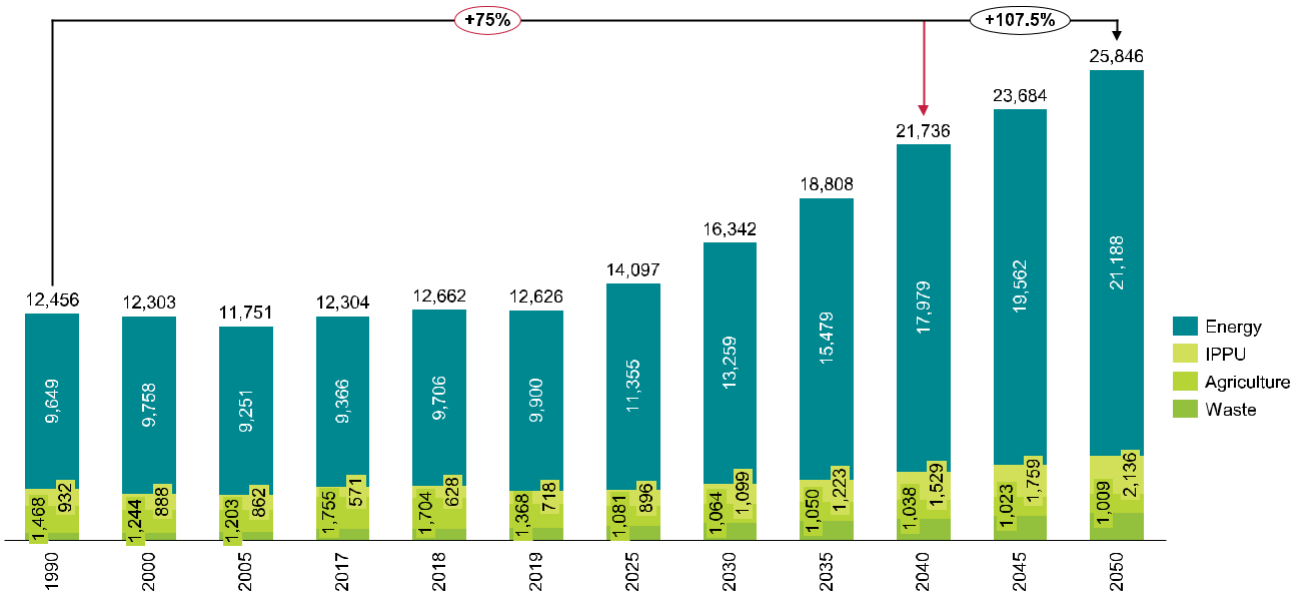
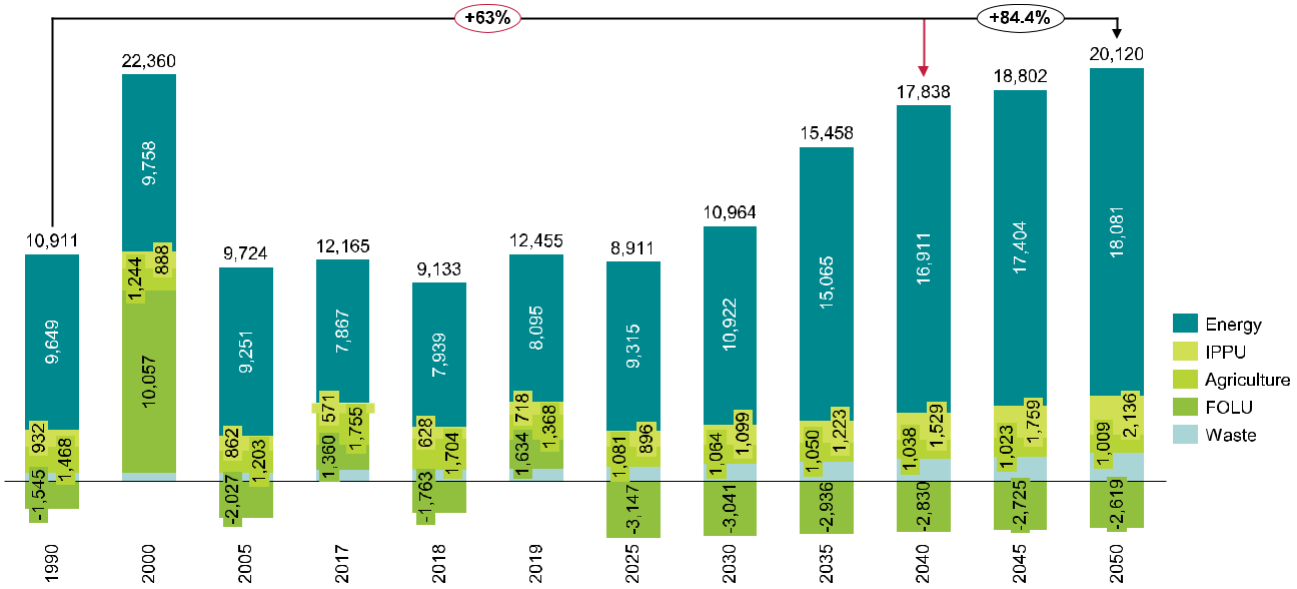


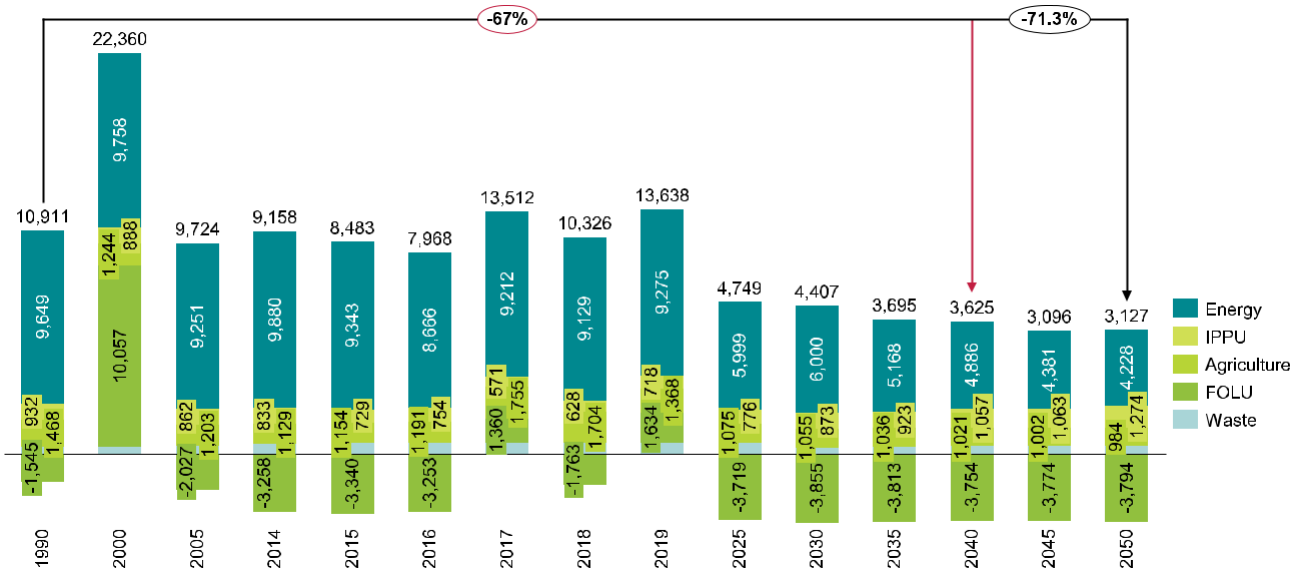
Figure 4-20. **Total GHG emissions by sectors without MEMO - WOM scenario (in Gg CO_2-eq)**



4.3.2 WAM scenario

The overall emissions of all sectors, when adding all of the measures that are part of the WAM scenario, show that there is a reduction in the total net GHG emissions by 67% in 2040 and 71% in 2050 compared to 1990, **reaching 3,127 Gg CO2-eq** (Figure 4-21). The largest amount of emissions remains in the Energy sector, with a share of 54% in 2050 (excluding the FOLU sector, where sinks occur). During the whole planning period up to 2050, the FOLU category has an absorption of emissions, which is increasing by 16% compared to 2016 (or around 2 times compared to 1990).

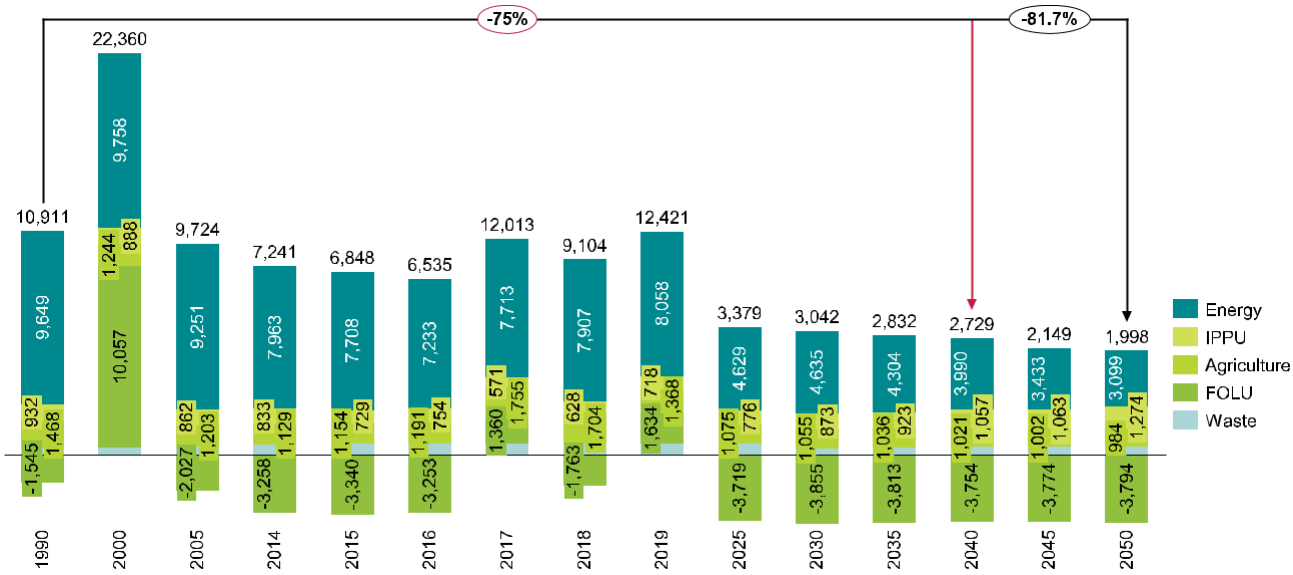
Figure 4-21. **Total GHG emissions by sectors – WAM scenario (in Gg CO_2-eq)**



Note: Due to the large area affected by fires in 2000, FOLU instead of sinks, contributed to the increase of the GHG emissions.

The results for the emissions without MEMO are also presented (Figure 4-22) and they show even higher reduction in the total net emissions by 75 in 2040 and 82 in 2050 compared to 1990. This higher reduction is again mainly caused by the exclusion of the emissions coming from the import of electricity.

Figure 4-22. Total GHG emissions by sectors without MEMO – WAM scenario (in Gg CO_2-eq)



Note: Due to the large area affected by fires in 2000, FOLU instead of sinks, contributed to the increase of the GHG emissions

The actions presented for the Mitigation Scenario, organised for financing in the Roadmap, considered three timescales: short-term (2020 - 2022), mid-term (2022 – 2025) and long-term (2025 – 2030). Financing requirements for the North Macedonia ENDC exceed EUR 20 billion through 2030.

The mitigation measures can be financed by a combination of financing mechanisms including blended finance, risk reduction, long-term loans, third party finance with free energy audits, among others. Key actors for the financing of the measures include banks (e.g. EIB and EBRD), subsidies from central and local governments, and the private sector. Table 4-8 provides an overview of the proposed financial mechanisms and key actors for the financing of the sub-sector mitigation actions.

Table 4-8. Overview of the sources of funding for the mitigation actions per sector and in total

	Source of Funding	Total amount (ml EURO)	%
Energy	All	24,863	100%
	Government ONLY	925	4%
	Other source of financing ONLY (No government)	10,527	42%
	Mixed financing (government +private sector, donors, consumer)	13,411	54%
Agriculture	All	110	100%
	Government ONLY	0	0%
	Other source of financing ONLY (No government)	110	100%
	Mixed financing (government +private sector, donors, consumer)	0	0%
Waste	All	58,6	100%
	Government ONLY	0	0%
	Other source of inancing ONLY (No government)	58,6	100%
	Mixed financing (government + private sector, donors, consumer)	0	0%
Total	All	25,031	100%
	Government ONLY	925	4%
	Other source of financing ONLY (No government)	10,696	43%
	Mixed financing (government + other (private sector, donors, consumer)	13,411	54%

For the implementation of the mitigation measures under the ENDC, there is a need to engage diverse actors (central government, the private sector, development banks) and a mix of financial instruments. Most of the mitigation measures can be financed through diverse financing instruments including private capital, international blended capital structures, for-profit vehicles such as energy efficiency funds, or low interest capital sourced from the international capital markets, such as green bonds. Private carbon funds and offset aggregators, which develop zero emission projects in anticipation of sale of offsets and removal credits can support these efforts, especially in the nature-based finance category. The Financing

Strategy for the Macedonian enhanced NDC to Climate Change highlights that:

- Most of the measures, except regulatory measures, can be financed through private capital.
- Sources include international blended capital structures, for-profit vehicles such as EBRD energy efficiency funds, or low-interest capital sourced from the international capital markets, such as green bonds.
- Private carbon funds and offset aggregators which develop zero emission projects in anticipation of sale of offsets and removal credits can also support these efforts, especially in the nature-based finance category.
- Large renewable energy projects already benefit from government guarantee mechanisms to offset payment risk.
- A national or regional green bank could act as a repository of capital and expertise to assist in accelerating transition.
- New technologies and projects need to be developed as “shovel ready” investor opportunities to create a long-term competitive advantage for North Macedonia.

Further financing instruments include large renewable energy projects which benefit from government or international guarantee mechanisms, as well as a national or regional green bank, which could act as a repository of capital and expertise to assist in accelerating transition. New technologies need to be developed as “shovel ready” investor opportunities.

Though North Macedonia has made progress in implementing financial instruments and gaining support for energy sector investments in the past, the scale of investments needed for the implementation of the Roadmap outpaces North Macedonia’s current ability to finance the transformational change envisioned by the ENDC. Therefore, new or significantly expanded financial instruments and support are needed. Example of such instruments are carbon tax and green bonds.

4.3.3 Economic and environmental aspects

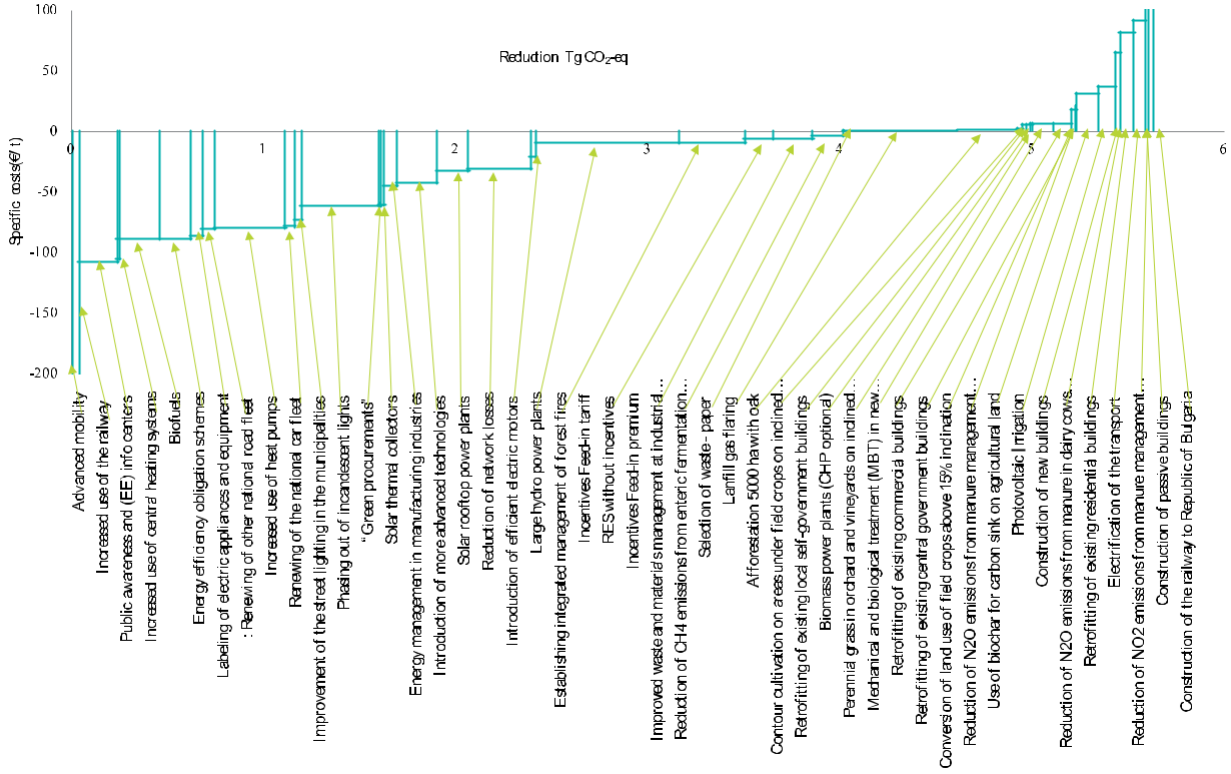
The economic and environmental aspects of the climate change mitigation policies and measures are analysed through the following two parameters:

- Economic effectiveness or specific cost - shows the number of investments required in order to reduce 1 t CO_2-eq by applying the specific policy/measure and it is expressed in €/t CO_2-eq.
- Environmental effectiveness or mitigation potential - indicates the extent to which emission reductions are achieved by applying the specific policy/measure and it is expressed in t CO_2-eq.

The combined presentation of these two parameters results in the so-called Marginal Abatement Cost Curve (MAC curve) which serves as a tool for determining priorities in the implementation of mitigation policies and measures.

The MAC curve is created for the WAM scenario for 2030 (as target year) and it shows that the total reduction from the proposed measures is estimated to around 5.6 Tg CO_2-eq (Figure 4-23) 70% of the reduction can be achieved with a “win-win” policies and measures, which means that these measures are reducing the emissions by a negative specific costs (total cost of the proposed measure are lower compared to the costs of the WOM scenario). Furthermore, additional 20% of the reduction is realized by measures with specific costs in range from 0-5 €/t CO_2-eq. It is crucial to underline that this is not the total amount of GHG emission reduction, because there is one more measure which is very important, but its independent contribution cannot the estimated. This measure is the Introduction of CO_2 tax, which depends to a high extent on the other measures (such as the measures for RES, energy efficiency, fuel switch etc.) which are needed to replace the CO_2 emitters.

Figure 4-23. The marginal abatement cost curve for 2030



From a reduction point of view the best measure is the construction of Large hydropower plants (including all hydropower plants that are part from the measure), which in 2030 can reduce the emissions for 741 Gg CO_2-eq (Figure 4-24). On the second place is Landfill gas flaring with a reduction of 490 Gg CO2-eq. On the other hand, Advance mobility and Increased use of railway are measures with lower specific costs (Figure 4-24).

Figure 4-24. Reduction of CO_2-eq emissions in 2030 (in Gg)

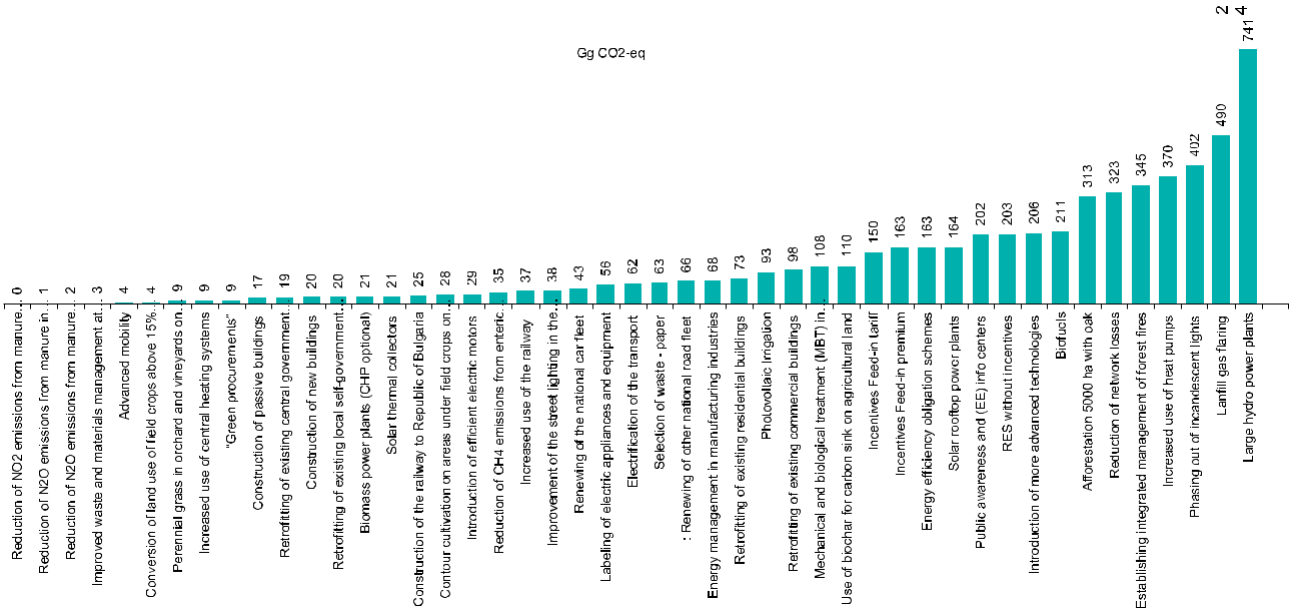
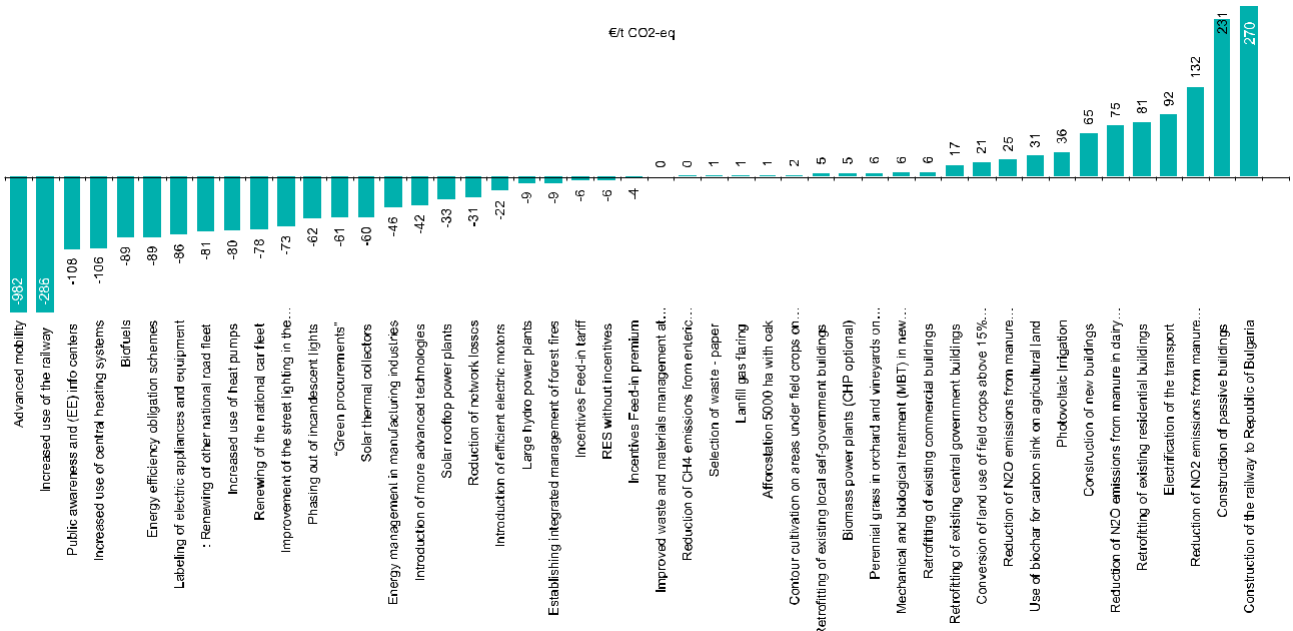


Figure 4-25. Specific costs for 2030 (in EUR/tCO$_2$-eq)



4.3.4 Social aspects

In addition to the economic and environmental effectiveness of the proposed policies and measures, their social aspect is also very important and should be considered for the overall process of sustainable development. In this study, the social aspect is analysed through the number of newly created green jobs. The methodology that was developed for the Intended Nationally Determined Contributions and used in the FBUR and SBUR, TBUR is implemented in 4NC too.

The number of green jobs in each year depends on the time (year) of implementation of the policies and measures in each scenario. In general, in all scenarios the share of green jobs the field of Energy efficiency green jobs is higher compared to RES green jobs (Figure 4-26). The maximal number in the WAM scenario is in 2050 with 10,725 green jobs, from which 64% are from the energy efficiency and the remaining are from RES.

Furthermore, the technologies which contribute most to the creation of new domestic green jobs is Retrofitting with around 40% in 2040 in WAM scenario, followed by installation of PV (20%), Building of new houses, including passive houses (17%), and Solar thermal collectors (10%). After 2040 there is a decrease in the creation of domestic green jobs mainly because of the reduced number of building retrofit (Figure 4-27).

Figure 4-26. Number of domestic green jobs from RES and energy efficiency, by scenario

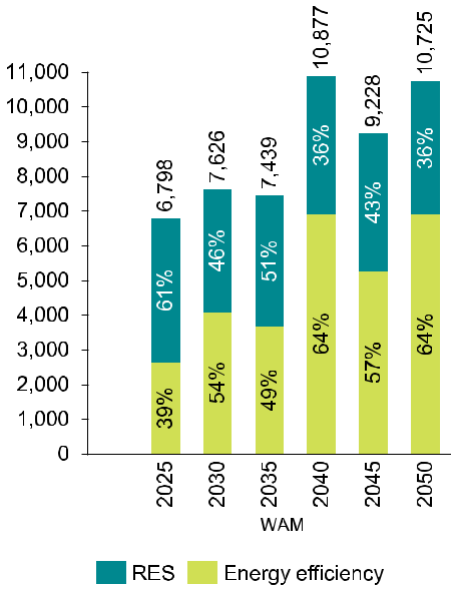
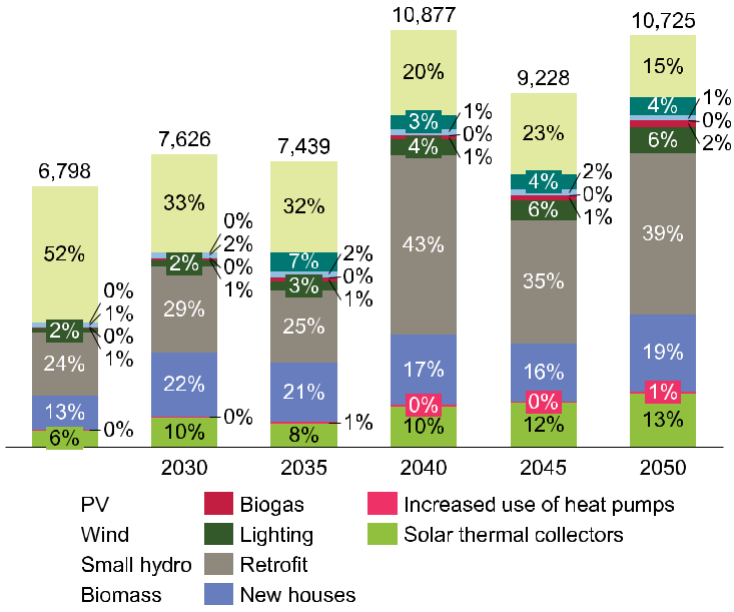


Figure 4-27. Number of domestic green jobs by technologies in WAM



Regarding the contribution by measures, the ones that have the highest share in the number of new domestic green jobs are: Retrofit of existing residential buildings (26%), Construction of passive houses (15%), RES without incentives (13%) and Solar thermal collectors (13%), in the WAM scenario in 2050 (Figure 4-28). It is found that at least around 28% of the maximum number of job positions in 2050 can be assigned to women.

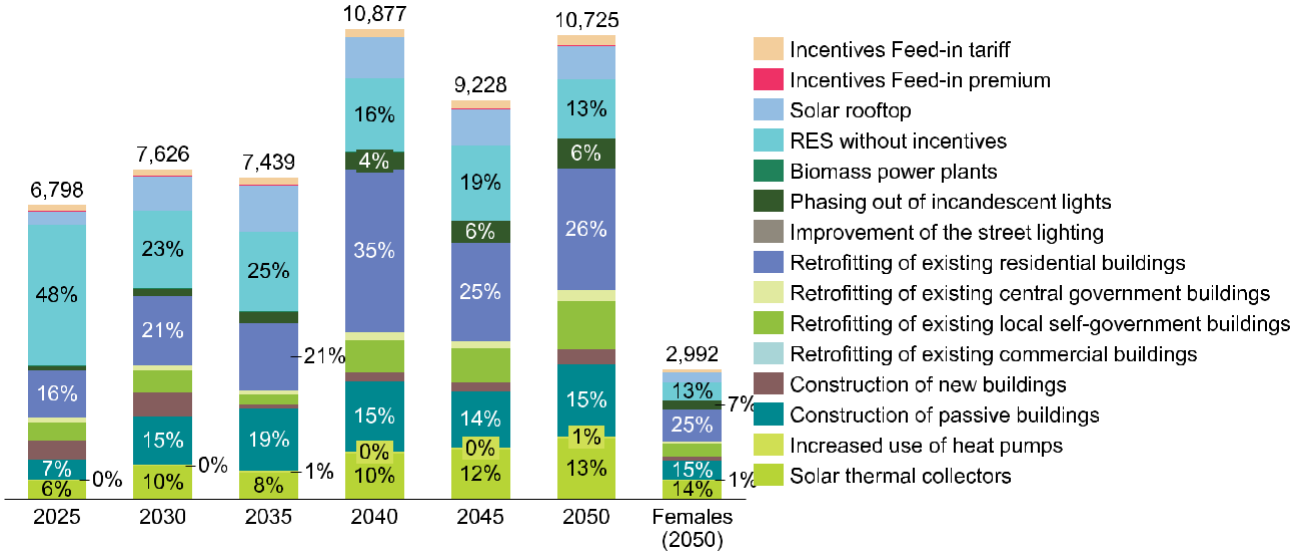


Figure 4-28. Number of domestic green jobs by measure in WAM

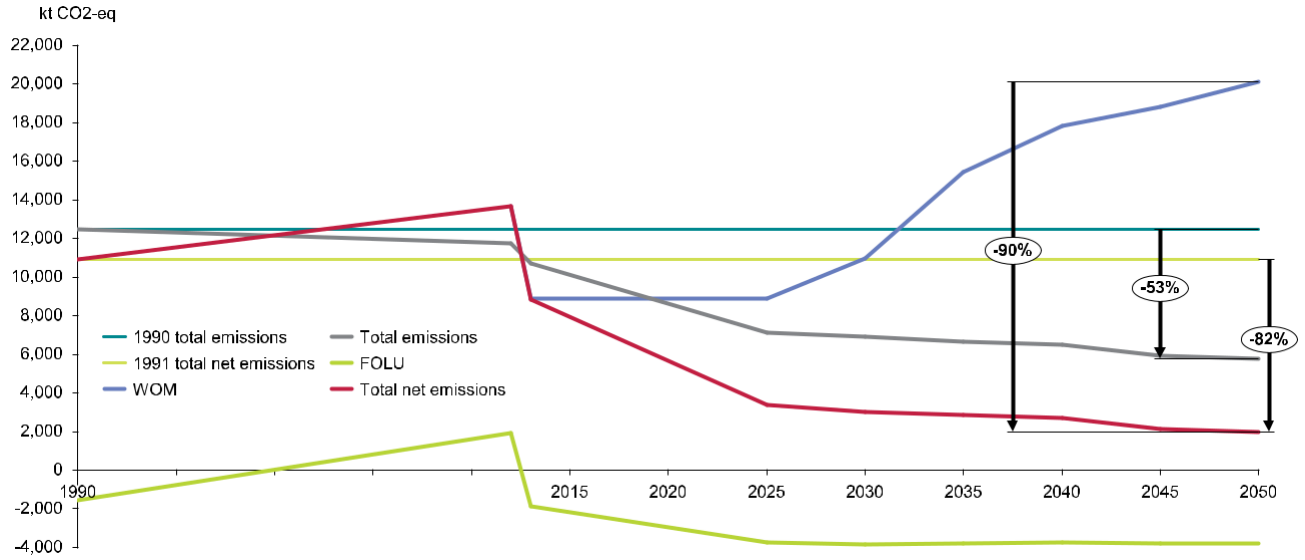
4.4 Overall and sectoral targets

As it was mentioned in the introduction to this chapter, fhe target for climate change mitigation in Macedonia is expressed as a reduction of greenhouse gas emissions and a reduction of net greenhouse gas emissions. The difference is that the FOLU sector is included in the GHG net emissions. The targets are expressed in relation to 1990, as a base year and are:

- **53% GHG emissions reduction**
- **82% net GHG emissions reduction**

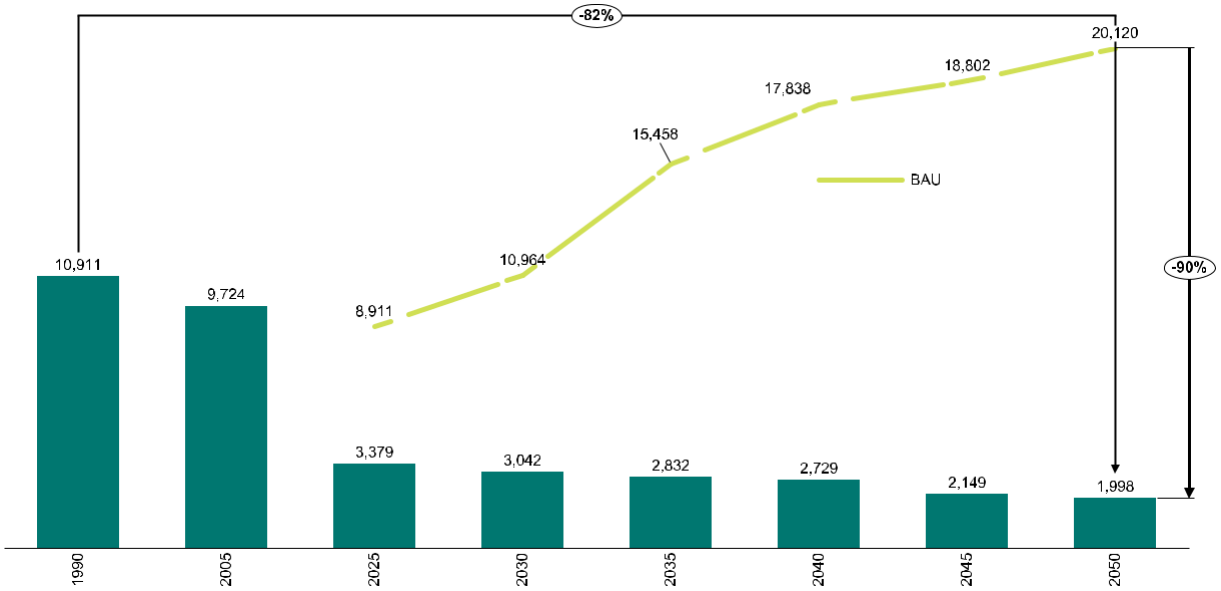
Additionally, compared to the WOM scenario the economy-wide GHG emission reduction target for Macedonia is 90% in 2050 (Figure 4-29). The indicative trajectory shows that by 2025, Macedonia will reach 70% of the total GHG reduction target in 2030 and 31% of the target in 2050 (Figure 430). After 2030, there is an increase in the GHG emissions in WOM scenario, that are mainly result of the transport sector (increase in the transport of goods).

Figure 4-29. Trajectory of GHG emissions (in Gg CO2-eq) and indicative reduction targets (in %)



Note: 2000 is removed from the figure for better presentation of the results

Figure 4-30. Trajectory of net GHG emissions (in Gg CO_2-eq) and indicative reduction targets (in %)

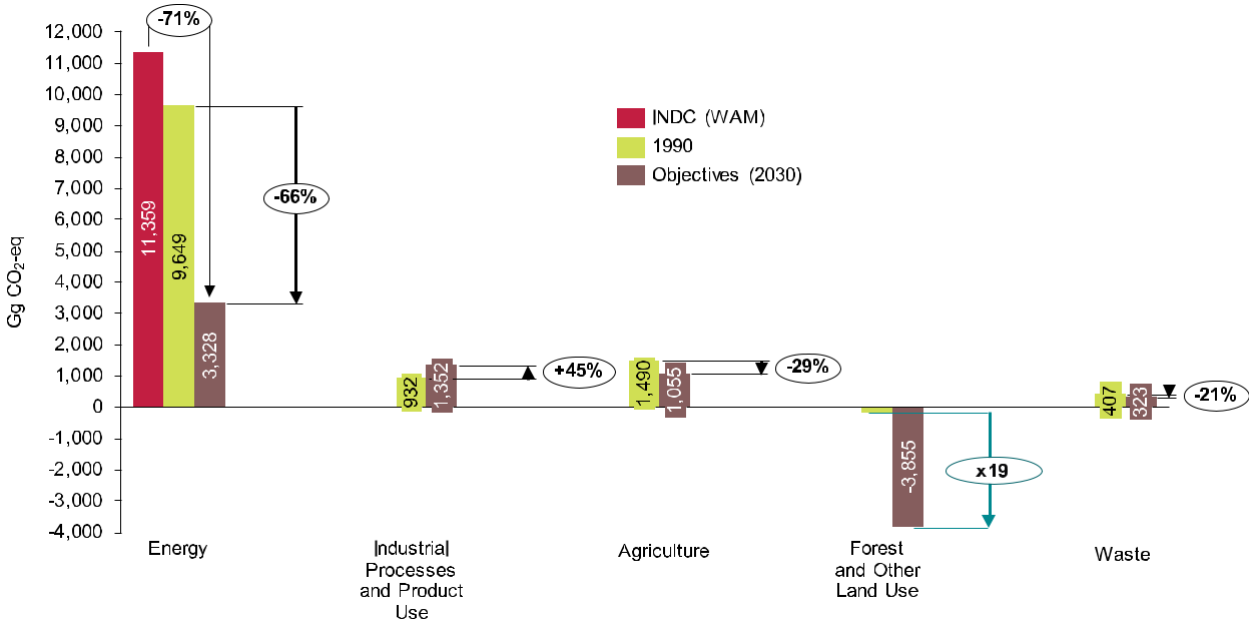


Source: Results from the Strategy for energy development up to 2040 and TBUR, project team analyses

The GHG goal for 2030 calculated as a part of the NDC and TBUR was based on 1990 figures. In order to achieve the target for GHG emissions reduction in 2030 defined in these two documents, sectoral **objectives** were set for each sector (Figure 4-30):

- Energy sector – 66% (6,321 Gg CO_2-eq) GHG emissions reduction (mainly through decommissioning of coal-fired TPP Oslomej in 2021 and TPP Bitola up to 2027)
- Industrial Processes and Product Use – 45% (420 Gg CO_2-eq) GHG emissions increase
- Agriculture – 29% (435 Gg CO_2-eq) GHG emissions reduction
- Forest and Other Land Use – 19 times (2,647 Gg CO_2-eq) GHG removals increase
- Waste – 21% (84 Gg CO_2-eq) GHG emissions reduction

Figure 4-31. Sectoral objectives for 2030 relative to 1990 level, and comparison with INDC target



Source: Results from the Strategy for energy development up to 2040 and TBUR, project team analyses

In the latest National inventory on climate change, 1990 was revised and it was found that the value for the Forestry sector should be more than seven times higher compared to the previous value (sink of 200 kt CO_2-eq was replaced with 1540 kt CO2-eq). This has a big impact on the net GHG emission reduction for 2030. This report takes into account the new figure for Forestry sector in 1990. The changes in the other sector are minor.

At the same time, the emissions from the energy sector in 2018 decreased by 23% compared to 1990, as a result of the reduced electricity production from coal, almost complete removal of the use of heavy fuel oil for electricity generation and the introduction of natural gas.

Because there are significant changes in greenhouse gas emissions during the years 1990-2018, and in order to be clearer to the general public, the emissions and net emissions targets in 2030, in addition to 1990 are expressed in relation to other years. In this document, the emission reduction are expressed relative to 2005, 2014 and 2016 (Figure 4-32, Figure 4-33).

Figure 4-32. 2050 GHG emission target compared to 1990, 2005, 2014 and 2016

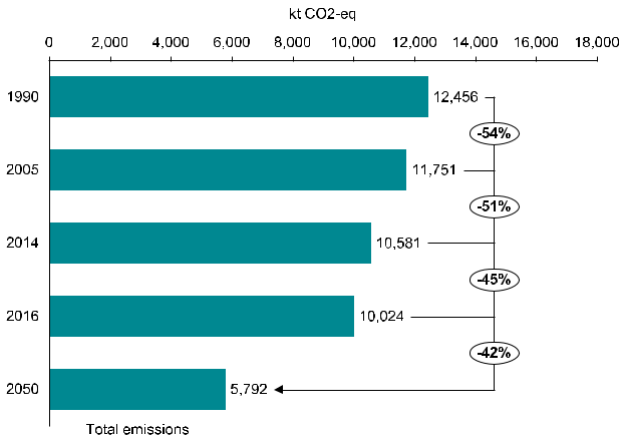
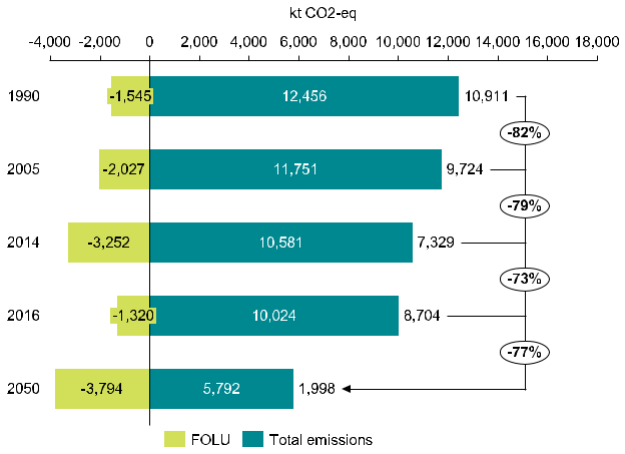


Figure 4-33. 2050 net GHG emission target compared to 1990, 2005, 2014 and 2016



If comparisons are made with 1990 in terms of net emissions, it should be noted that in 2014 about 60% of the target for 2030 has already been achieved. The comparison in terms of only emissions shows that in 2014 about 72% of the goal was achieved.

Figure 434. Achievement in 2014 compared to 2050 target – net GHG emissions

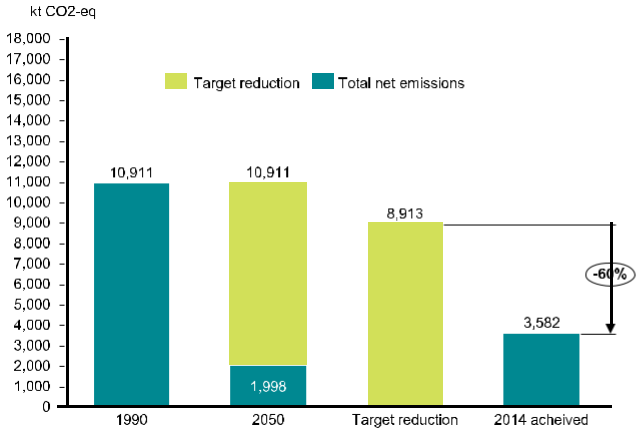
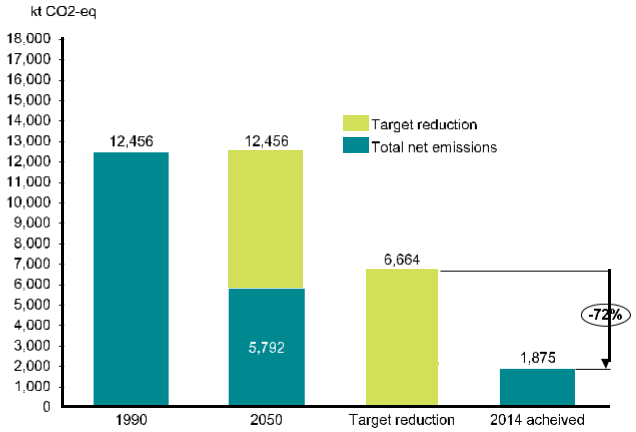


Figure 435. Achievement in 2014 compared to 2050 target – emissions



Regardless of the year in which the comparisons of emissions and net emissions are made, what is important is that a **green agenda** is planned that will contribute to the continuation of the downward trend of emissions that has already begun and additionally intensify it, especially in the period after 2025. Particular attention needs to be paid to sectors where emissions are expected to increase, such as the Transport sector.

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5 Vulnerability and Adaptation to Climate Change

5.1 Climate change profile for North Macedonia

The evidence of climate change is unequivocal and the consequences are increasingly being felt in Republic of North Macedonia and worldwide. The impact of climate change on manmade systems has a large component of uncertainty, given that the future climatic scenarios mainly depend on the evolution of the global CO_2 drivers.

The most likely pathways for drivers' concentrations depend on mitigation scenarios and deadlines for the implementation of policies to reduce greenhouse gas emissions, like the Kyoto Protocol. These scenarios, globally, show further warming and change in the water cycle, but locally, the trends can be very different and even opposite from the global average.

According to the results obtained, it is expected that the climate in North Macedonia will be warmer and drier and the amplitude of change will be initially related to future concentrations of greenhouse gases. Namely, the obtained results signal that extreme precipitation in future, in the upper limit, gives 60% probability for increase in the number of days with precipitation over 40mm/day and 20% increase of the maximum daily precipitation, which indicates that further analysis is needed because local daily changes may not condition a change in the return period of the characteristic values analyzed during the development of the climate maps.

5.1.1 Observed climate change trends

The last decade of the 20th century and the beginning of the 21st century are climatically the warmest periods in the world. These are the most specific periods in terms of weather and climate in the Republic of North Macedonia as well. Under the influence of natural conditions as well as under the influence of human activities in the last thirty years, climate change has taken hold around the world, and Southeast Europe and the Republic of North Macedonia are no exception. Climate change can be clearly detected in long-term climate data and is primarily characterized by rising air temperatures, changes in precipitation patterns, as well as by a higher frequency of extreme weather events and periods of extreme climatic conditions.

5.1.1.1 Methodology

Knowing the climate and adapting human activities to its impacts is a general national interest of every country and every society. The National Hydrometeorological Service (NHMS) as an entity in the Ministry of Agriculture, Forestry and Water Economy (MAFWE) is responsible for meteorological measurements and observations in the Republic of North Macedonia, in line with the standards of the World Meteorological Organization (WMO).

These European standards provide recommendations for determining the characteristic values for snow load, wind load and maximum and minimum air temperatures, which are an important component affecting buildings and other structures. Of particular interest is the impact assessment in order to avoid major material and human damages, which may occur due to demolition of certain structures because of miscalculated or underestimated load value, but equally important is to control the cost of construction by not overestimating the load values.

Air temperature: data on annual absolute maximum and annual absolute minimum air temperature from 21 meteorological stations were used, selected to meet the spatial geographical distribution of the entire territory. The network of meteorological stations is shown in Figure 5-1.

Figure 5-1: Meteorological station network used to develop climate maps

To ensure efficient weather and climate services as well as sustainable meteorological and hydrological monitoring and infrastructure, the NHMS must be supported by much stronger logistics from the Government of the Republic North Macedonia and other key stakeholders. The value and quality of services to the Government, institutions and citizens depends on real-time monitoring and modeling of atmospheric processes that form the basis of all weather, climate and water forecasts. NHMS, as the only service with such an activity, performs numerous tasks of different nature.

NHMS is a professional-technical organization, which scientifically performs the following activities needed by state bodies, public services, economic and scientific organizations, citizens, international communities and other users:

- meteorological and hydrological monitoring of parameters and phenomena
- monitoring of surface water and water bodies
- analysis and forecast of weather and watercourses
- warning about meteorological and hydrological disasters and excessive environmental pollution
- receiving, processing and archiving data related to its scope of work
- International exchange of data and products related to its scope of work.

To show these changes, an analysis of the variability of the main climatic elements: air temperature, precipitation and snow cover was performed. The analysis used data from the period 1926-2020 measured at the meteorological stations Bitola, Prilep and Shtip (as measuring stations with the longest data series in the Republic of North Macedonia). Data from the period 1951-2020 was conducted annually and seasonally for regions with shorter data series such as Demir Kapija, Strumica, Gevgelija, Kriva Palanka, Berovo, Ohrid and Lazaropole.

A comparative analysis of the three series for a 30-year period was also made, i.e. a comparison of the periods 1971-2000, 1981-2010 and 1991-2020 with the period 1961-1990 and an analysis of the decadal values for the period 1951-2020 in comparison to the period 1961-1990.

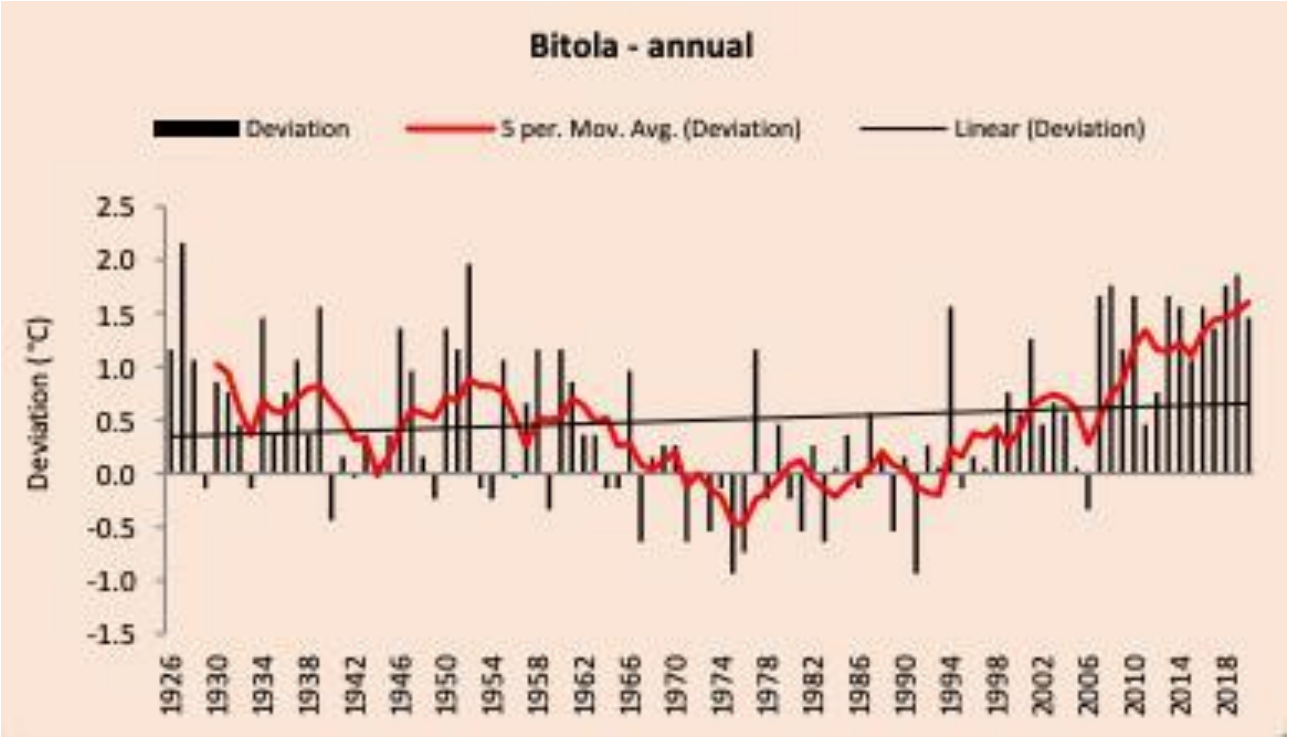
5.1.1.2 Temperature Analysis

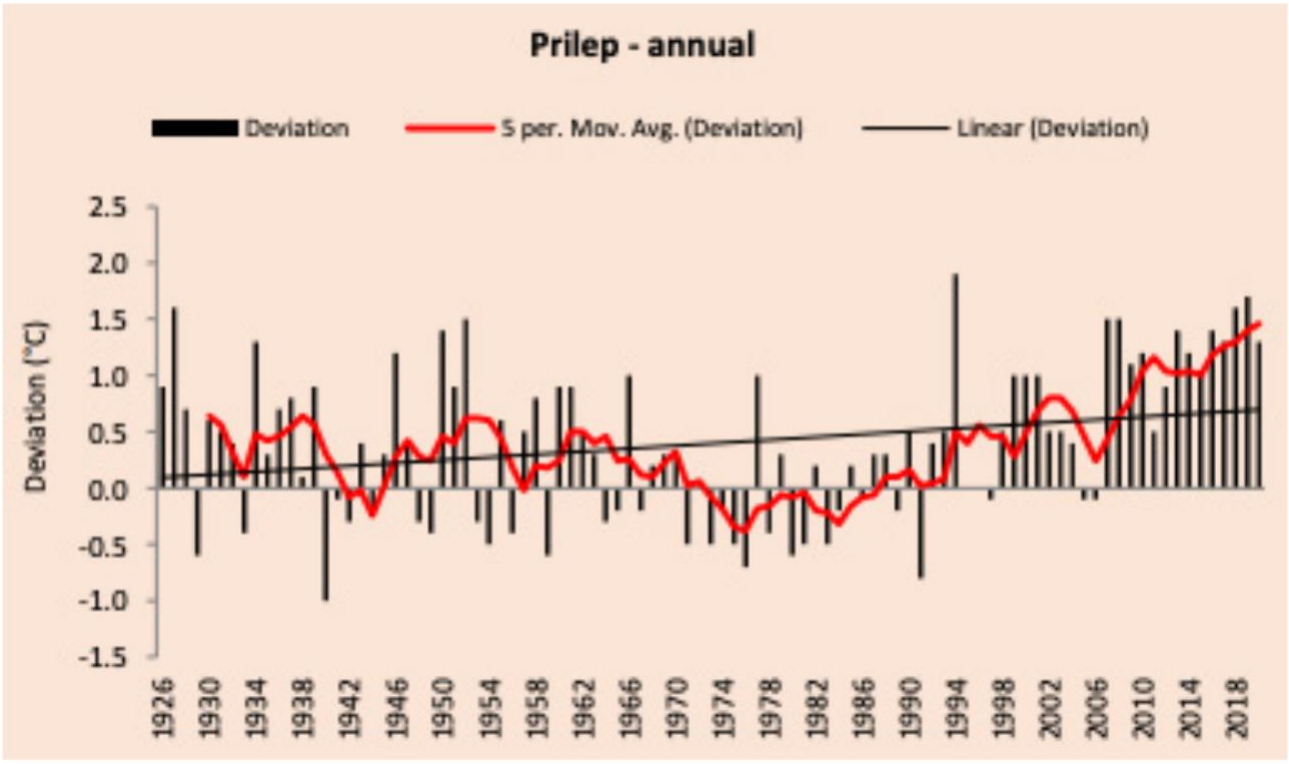
The analysis of the multi-year change in the mean annual air temperature (Figure 5-2), shows that during the fifties of the 20th century, relatively higher air temperatures were measured, followed by a colder period from 1971 to 1993. In the period from 2007 to 2020, the mean annual air temperature is continuously higher than the average for the period 1961-1990. Due to the lack of measurements and data before 1926 it is impossible to calculate a relevant multiyear temperature trend and compare it with regional or global temperature trends based on measurements from the beginning of the instrumental period until today (1850-2020).

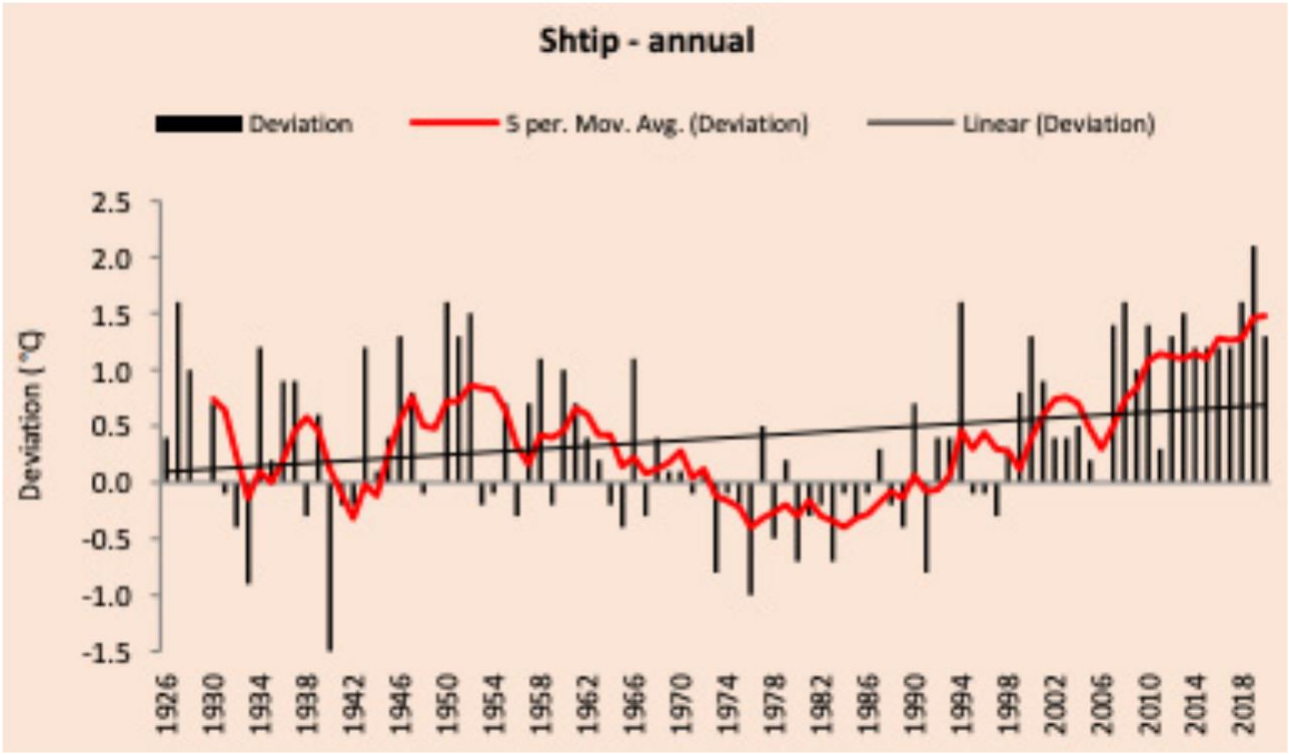
The multi-year variation of the mean annual air temperature during the 95-year period ranges from 10.1°C to 13.2°C for Bitola, from 10.1°C to 13.0°C for Prilep and from 11.2°C to 14.8°C for Shtip. The average annual air temperatures for the standard thirty-year climatic period (1961-1990) are 11.0°C for Bitola, 11.1°C for Prilep and 12.6°C for Shtip. The difference of the average annual air temperature for the whole period (1926-2020) in comparison to the average annual temperature for the period 1961-1990 is 0.4°C for Prilep and 0.5°C for Bitola and Shtip.

The warmest years recorded on the territory of the Republic of North Macedonia for the period 1951-2020, for which data are available for all meteorological stations, are 2019, 2018, 1994 and 1952. The last fourteen consecutive years (2007-2020), with the exception of 2011, are years in which the seven highest values of annual air temperature (period 1951-2020) have been recorded. The coldest years are observed in the colder twenty-year period, with 1991, 1983, 1980, 1976 and 1973 standing out.

Figure 5-2: Deviation of annual air temperature from the average for the average period 1961-1990

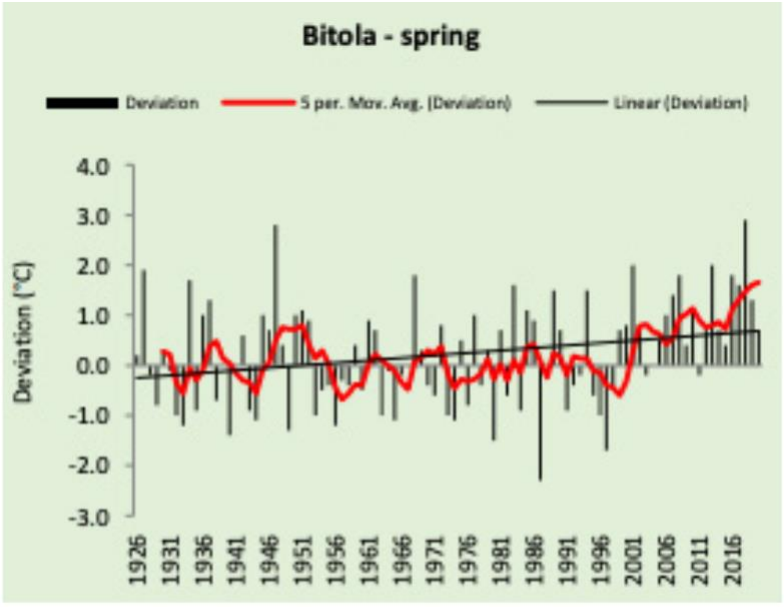


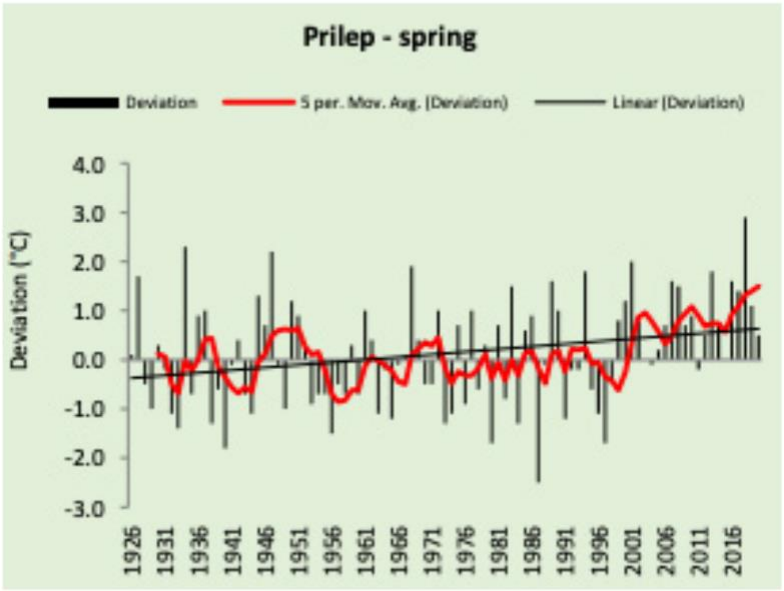


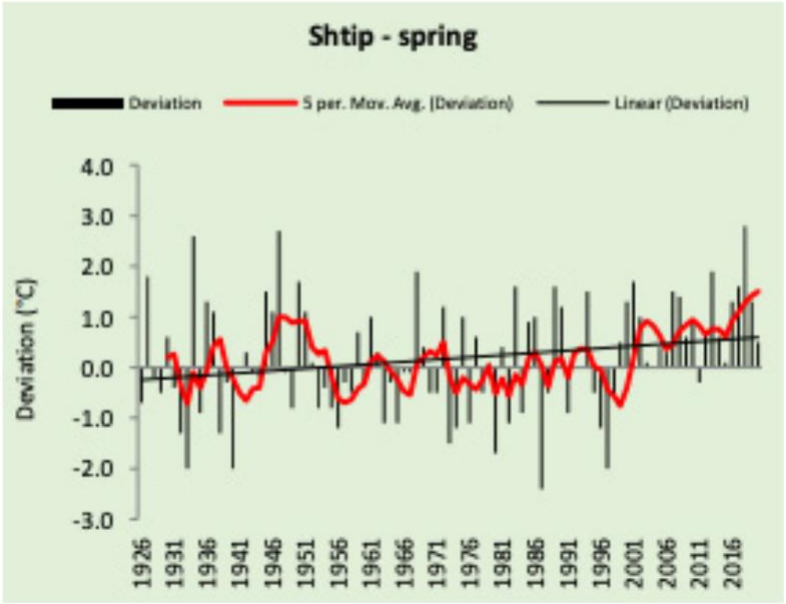


The spring air temperature for the period 1926-2020 ranges from 8.7°C to 13.9°C for Bitola, from 8.3°C to 13.7°C for Prilep and from 10.1°C to 15.3°C for Shtip. The difference of the average spring air temperature for the whole period in comparison to the average temperature for the period 1961-1990 is 0.1°C for Prilep and 0.2°C for Bitola and Shtip. In the last twenty years (Figure 53)there is a gradual increase in spring air temperatures. From the data on the spring air temperature (period 1951-2020) it can be concluded that the highest values were observed in 2018, 2017, 2013, 2007, 2001, 1994 and 1968, and the lowest values in 1980, 1987 and 1997.

Figure 5-3: **Deviation of the Spring air temperature from the average for the period 1961-1990**





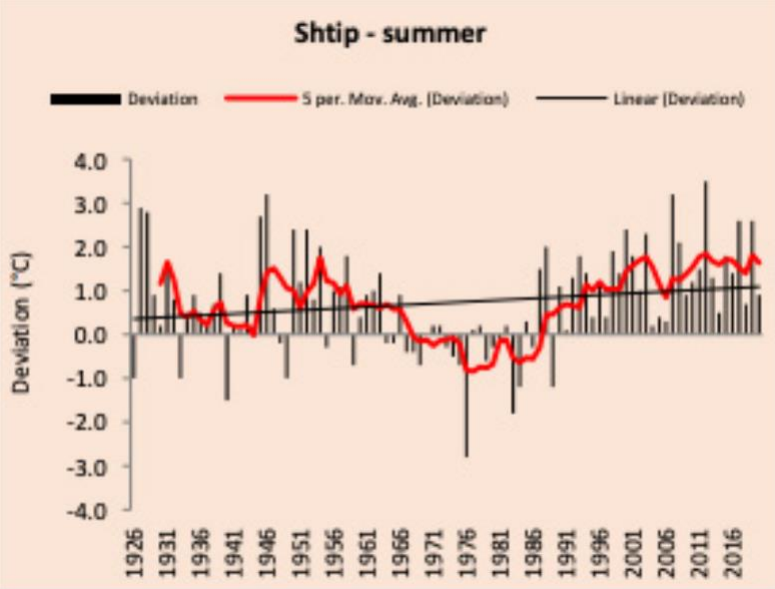


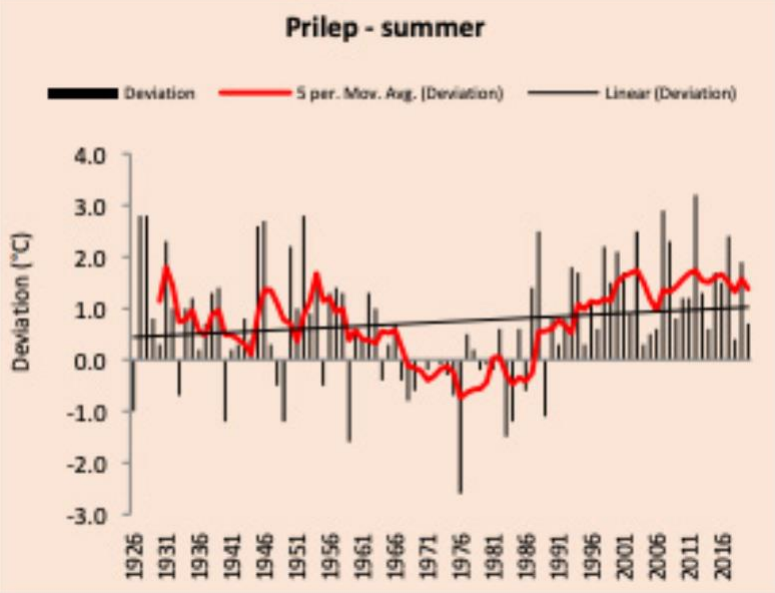
Summer air temperature (period 1926-2020) ranges from 18.0°C to 24.3°C for Bitola, from 18.1°C to 23.9°C for Prilep and from 19.8°C to 26.1°C for Shtip. The average values of summer air temperatures for the period 1961-1990 are 20.7°C for Prilep, 20.8°C for Bitola and 22.5°C for Shtip.

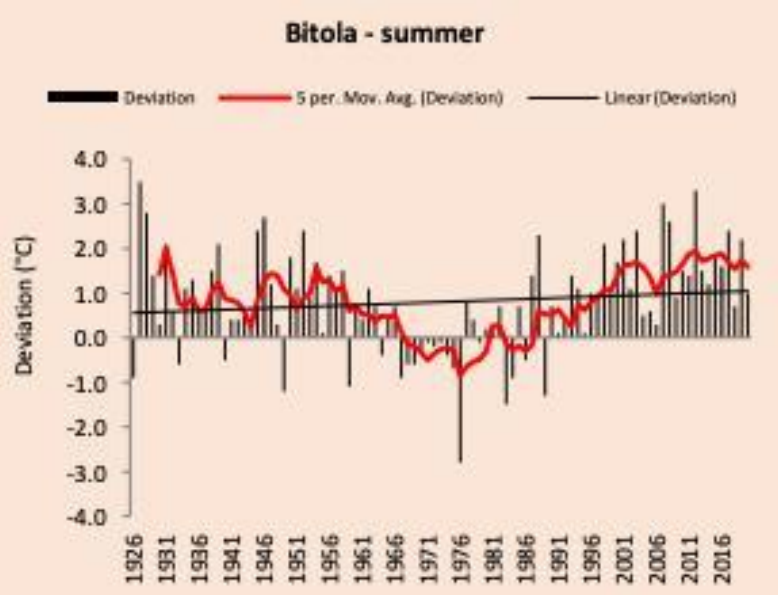
During the summer in the last years of the 20th century and in the beginning of the 21st century (Figure 5-4) there are significantly higher values of air temperature, especially from 1990 to 2020. The difference between the average summer air temperature for the whole period (1926-2020) and the average temperature for the period 1961-1990 is 0.7°C for Prilep and 0.8°C for Bitola and Shtip. The hottest summers in the period 1951-2020 have been recorded in the last twenty years. The highest values of summer temperatures were recorded in 1952, 2003, 2017, 2019, and the most extreme were 2012 and 2007. The coldest summers were recorded in 1976 and 1983.

During the summer part of the year, more precisely in July, the highest values of air temperature during the year are registered. The highest maximum air temperatures in the Republic of North Macedonia at the meteorological stations Shtip, Demir Kapija, Gevgelija, Berovo, Kriva Palanka and Ohrid were measured on July 24, 2007, while at the meteorological stations Bitola, Prilep, Strumica and Lazaropole on July 6 and 7, 1988. At the meteorological station Demir Kapija on July 24, 2007 a record 45.7°C were measured, which is the highest measured maximum air temperature since the beginning of the meteorological measurements.

Figure 5-4: Deviation of the summer air temperature from the average for the period 1961-1990.

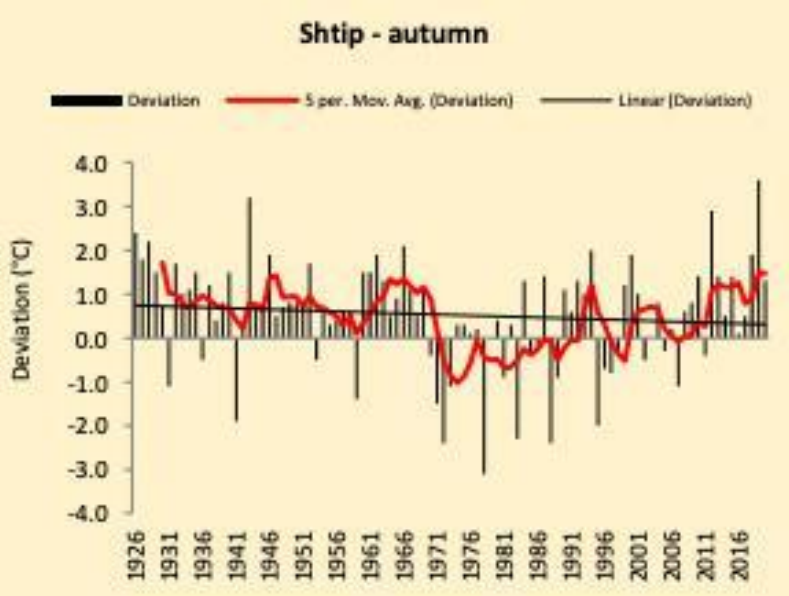


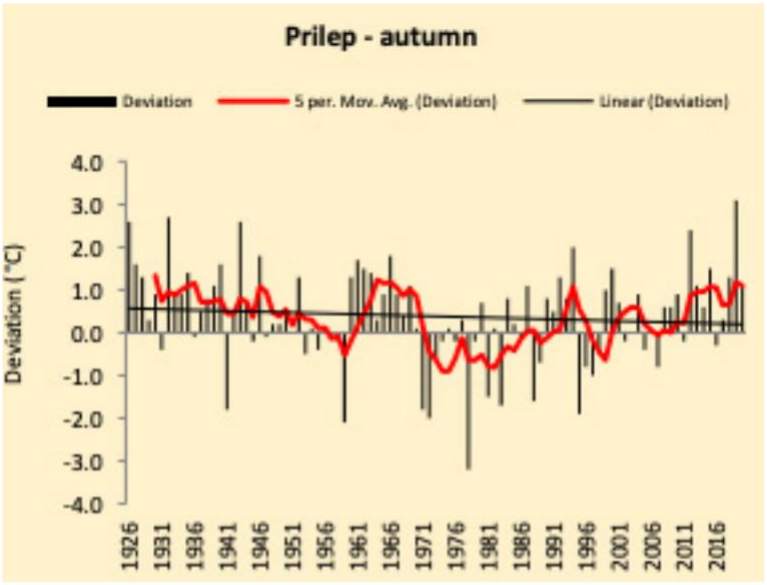


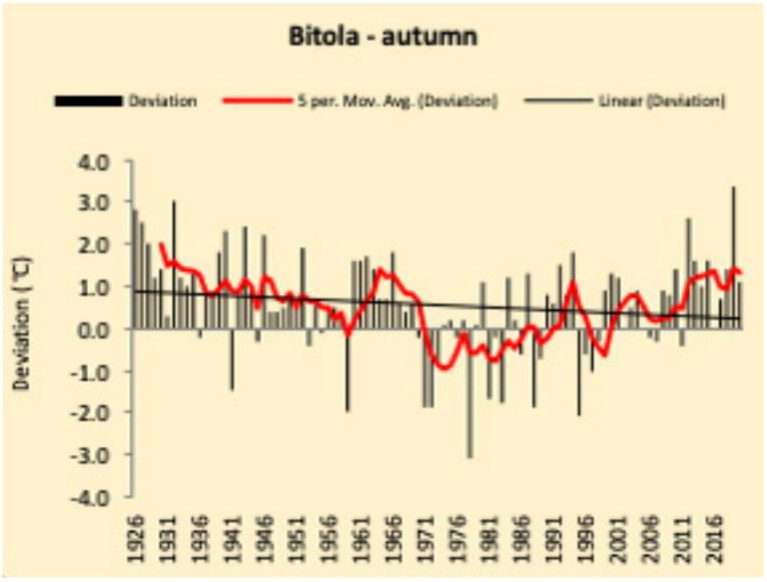


Autumn air temperature (period 1926-2020) ranges from 8.5°C to 15.0°C for Bitola, from 8.7°C to 15.0°C for Prilep and from 10.2°C to 16.9°C for Shtip. The difference of the average autumn air temperature for the whole period (1926-2020) compared to the average for the period 1961-1990 is 0.4°C for Prilep, 0.5°C for Shtip and 0.6°C for Bitola. As it can be seen (Figure 5-5), the trend of decreasing autumn air temperature is evident. However, despite the declining trend, the highest values of the autumn temperature were measured in 2019 and 2012, and the lowest values in 1978.

Figure 5-5: Deviation of the autumn air temperature for the period 1926-2020 from the average for 1961-1990

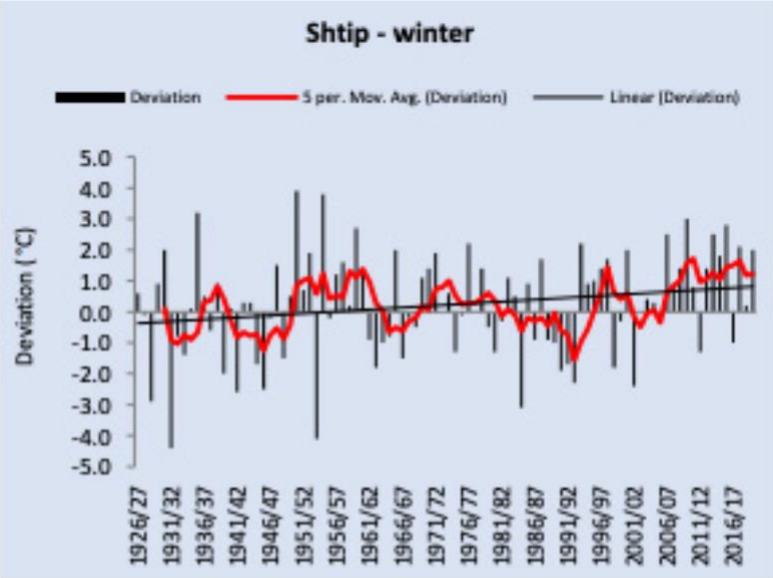


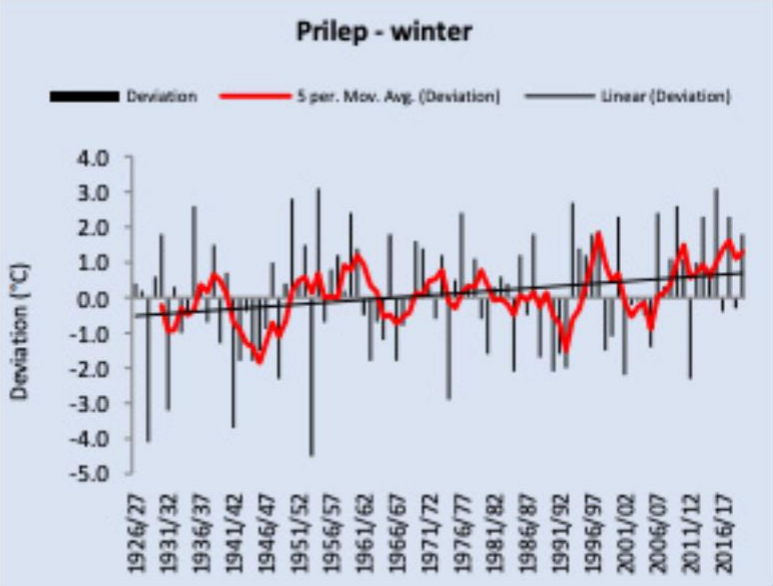


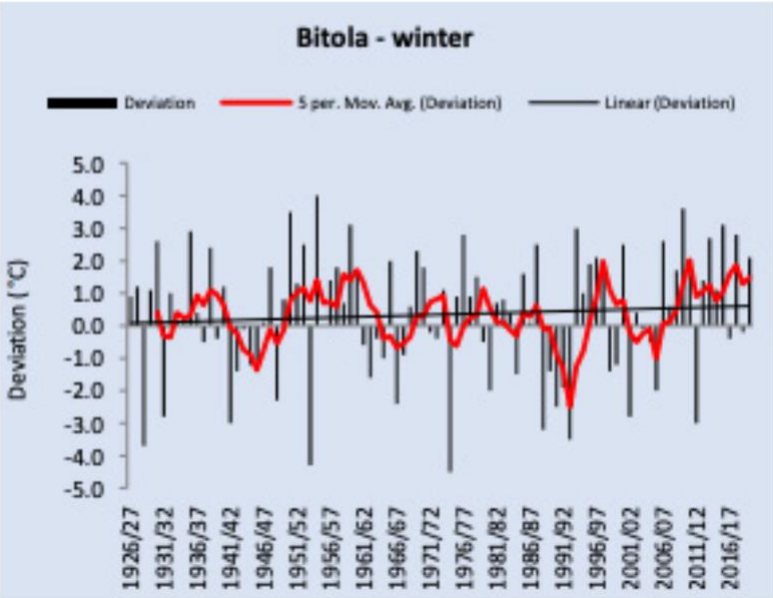


Winter air temperature (period 1926-2020) ranges from -3.8°C to 4.8°C for Bitola, from -3.3°C to 4.3°C for Prilep and from -2.1°C to 6.2°C for Shtip. The difference of the average winter air temperature for the whole period (1926-2020) compared to the average for the period 1961- 1990 is 0.1°C for Prilep, 0.2°C for Shtip and 0.3°C for Bitola. There is a slight trend of increasing winter air temperature (Figure 5-6), while the individual values by years continuously vary in positive and negative values around the thirty-year average (1961-1990). The warmest winters (period 1951-2020) were recorded in 1954/1955, 2006/2007, 2009/2010, 2013/2014 and 2015/2016. The lowest air temperatures during the year were registered in the winter months of the year. The absolute minimum air temperatures at all meteorological stations, with the exception of Lazaropole, were measured in January. The lowest value of the minimum air temperature on the territory of the Republic of North Macedonia -31.5°C was measured in Berovo on January 27, 1954.

Figure 5-6: **Deviation of the winter air temperature from the average for the period 1961-1990**

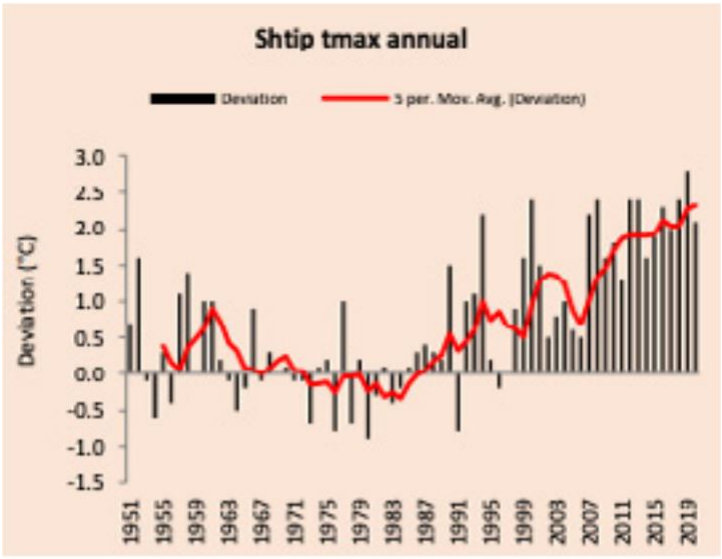


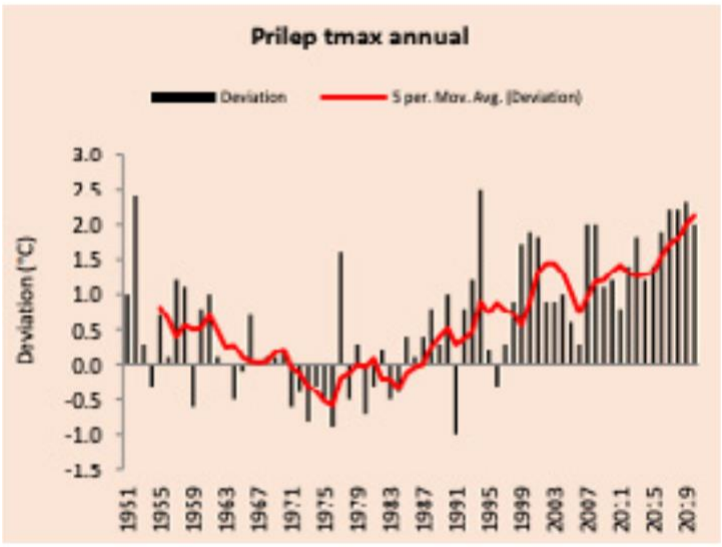




The analysis of the mean annual maximum and minimum air temperature for the period 1951- 2020 shows an increasing trend. The increase in the maximum temperature is larger than the increase in the minimum temperature (Figure 5-7 and Figure 58). The difference of the average values for the period 1951-2020 compared to the average for the period 1961-1990 ranges from 0.1°C to 0.4°C for the minimum temperature and from 0.5°C to 0.7°C for the maximum temperature.

Figure 5-7: Deviation of the mean annual maximum air temperature from the average for the period 1961-1990





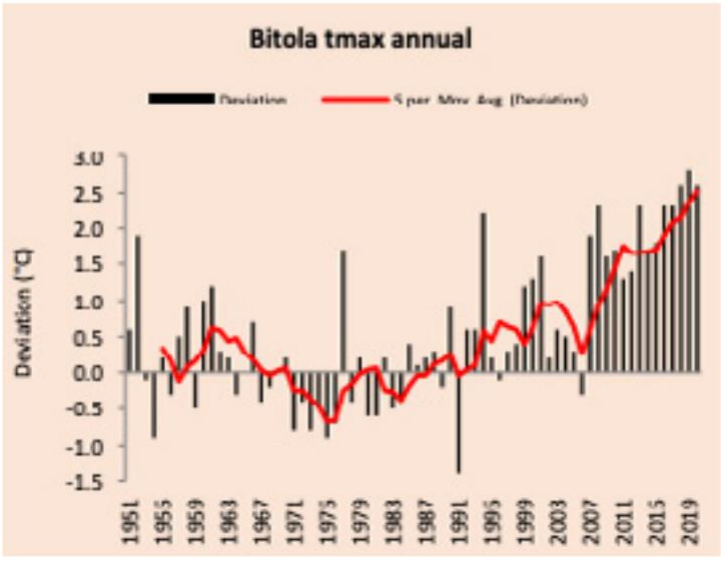
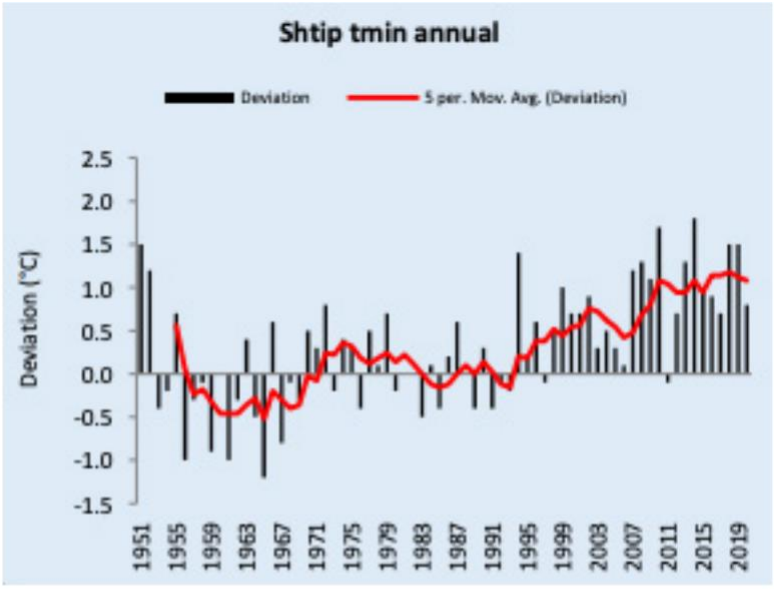
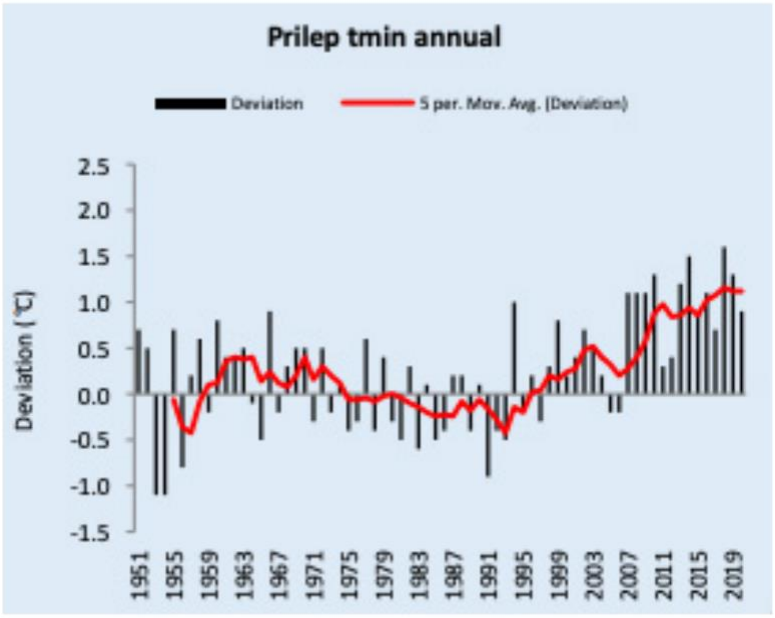
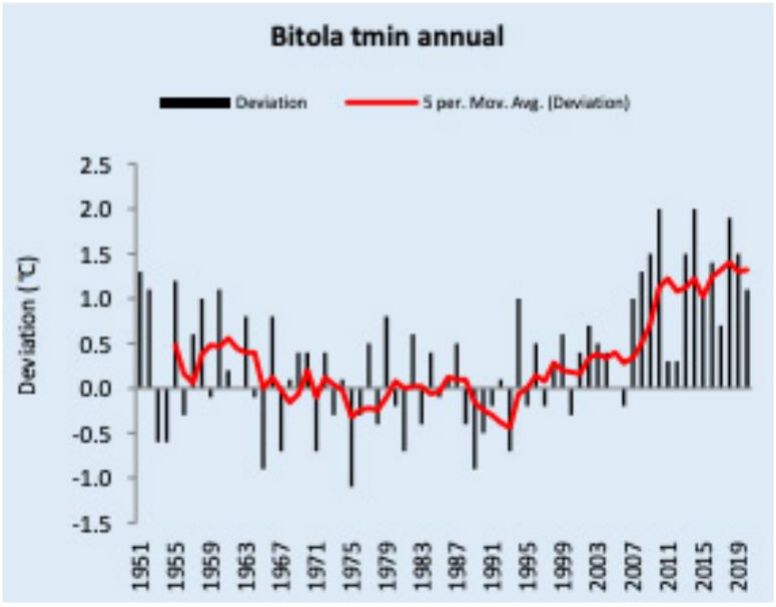


Figure 5-8: **Deviation of the mean annual minimum air temperature from the average for the period 1961-1990.**



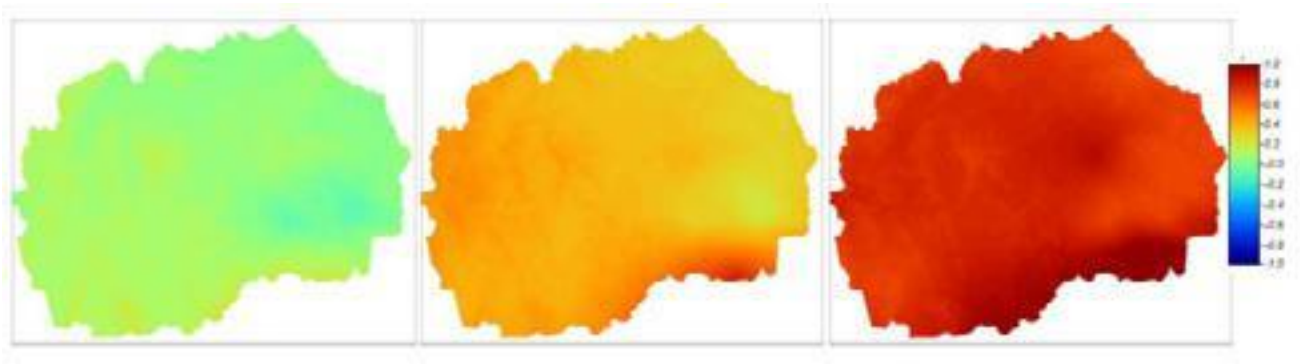




The analysis of the spatial distribution of the changes in the air temperature is shown through the deviations of the average annual and seasonal temperature for the periods 1971-2000, 1981-2010 and 1991-2020 and the decadal averages for the period 1951-2020 in relation to the reference thirty-year period 1961-1990. In the past fifty years, the largest deviation of the average annual temperature from the average for 1961-1990 is in the period 1991-2020 (Figure 5-9).

During the period 1991-2020, the average annual temperature is higher on the whole territory in the range of 0.7°C to 1.4°C. Higher values were also observed for the period 1981-2010 (0.2°C-0.8°C), while for the period 1971-2000 the annual temperature is within the average values for the period 1961-1990. The analysis of deviations of average seasonal temperatures from the average for 1961-1990 also show that the highest values are in the period 1991-2020, with the largest increase in the summer temperatures with deviations ranging from 1.2°C to 2.2°C.

Figure 5-9: Deviation of the 30-year averages of the annual air temperature (1971-2000, 1981-2020 and 1991-2020) from the average for 1961-1990.



Similar conclusions are reached by analyzing the values of mean minimum and maximum temperatures for the same periods. The change in mean minimum temperature is less than the change in mean maximum temperature. The deviations of the mean minimum temperature for the period 1991-2020 compared to the reference period range from -0.1°C to 1.3°C, while the deviations of the mean maximum temperature range from 1.1°C to 1.7°C (Figure 5-10 and Figure 5-11).

Figure 5-10: Deviation of the 30-year averages of the annual minimum air temperature for the period 1971-2020 from the 1961-1990 average

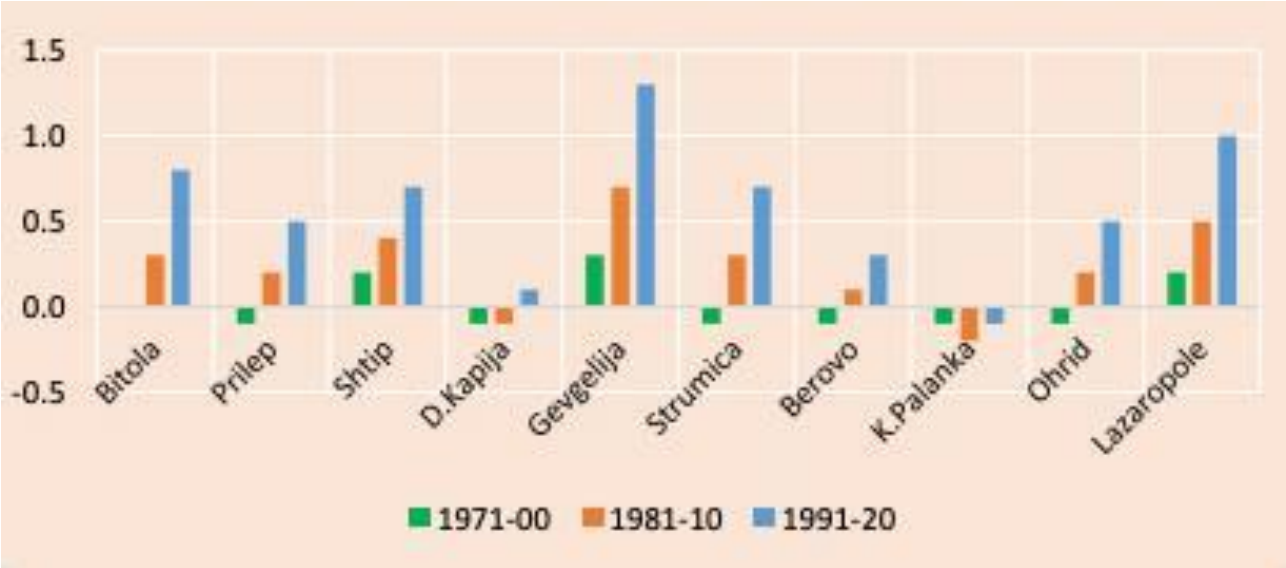
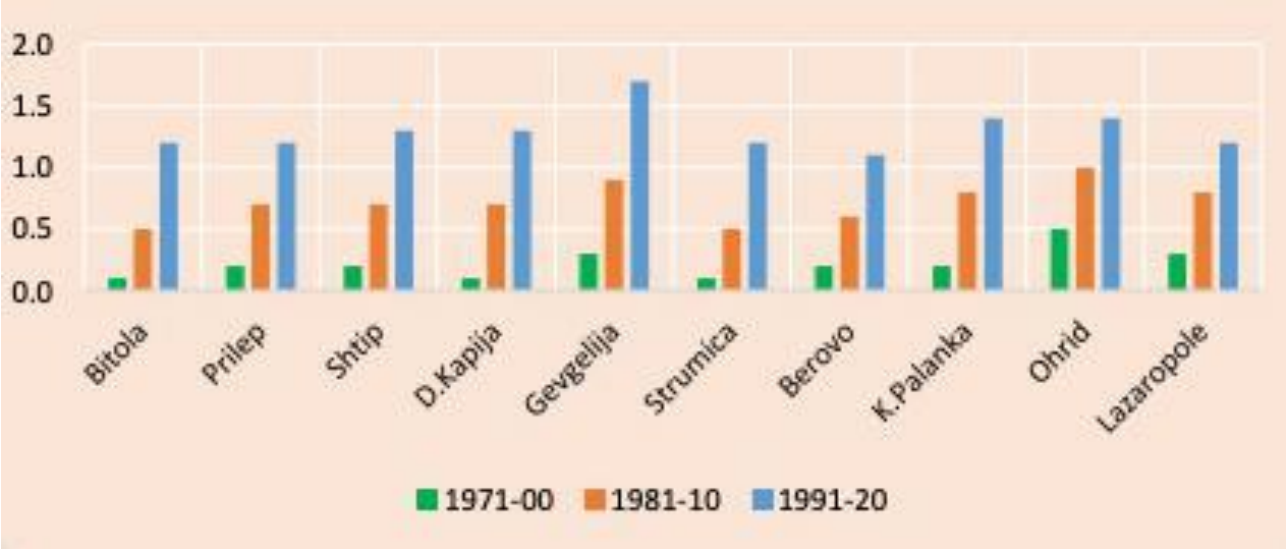
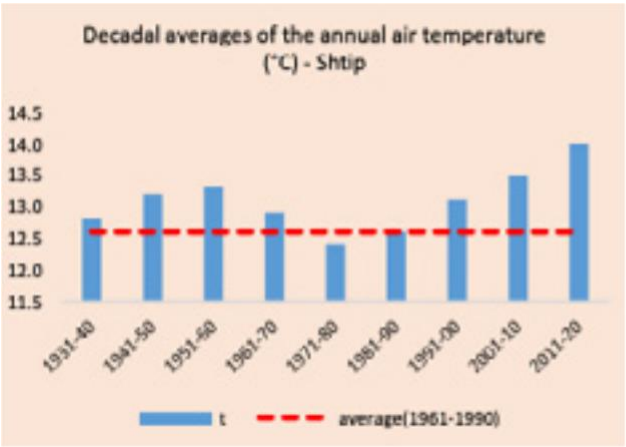


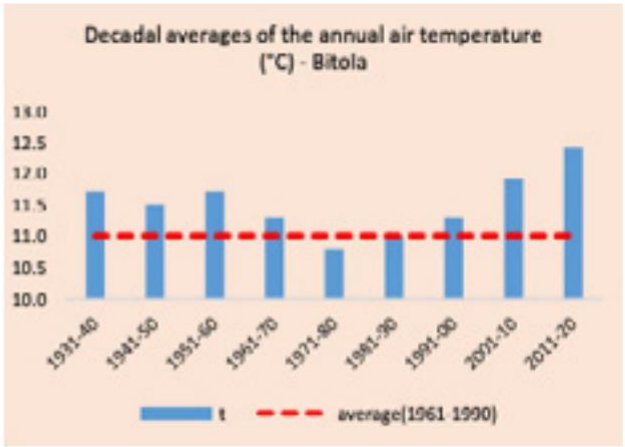
Figure 5-11: Deviation of the 30-year averages of the annual maximum air temperature for the period 1971-2020 from the 1961-1990 average



Research conducted on the decadal averages of the annual air temperature shows that the last decade (2011-2020) is the warmest decade since the beginning of meteorological measurements on the territory of the Republic of North Macedonia (Figure 5-12).

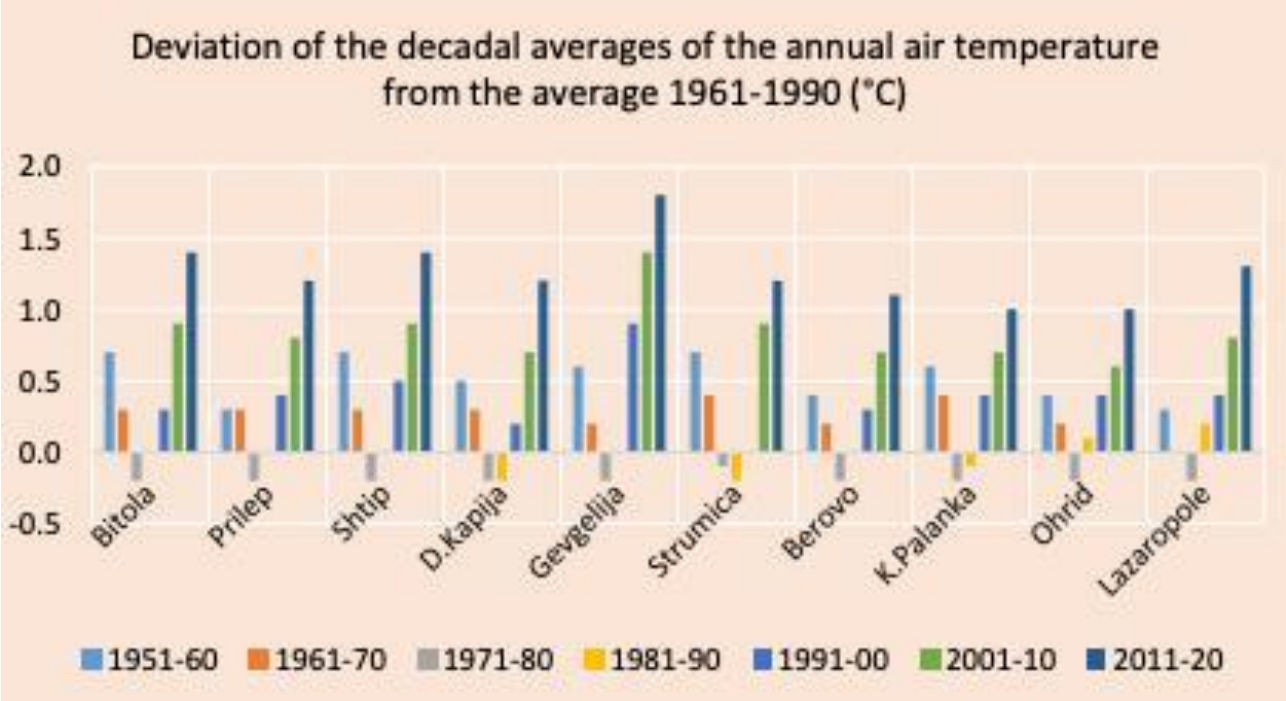
Figure 5-12: Deviation of the decadal averages of the annual air temperature for the period 1931-2020 from the average 1961-1990





In this decade, nine years (2012-2020) are in the rank of the seven highest values of the annual air temperature for the period 1951-2020, and for the meteorological stations Gevgelija, Demir Kapija, Strumica, Shtip and Lazaropole 2019 is the warmest year so far. The deviations of the decadal value for 2011-2020 compared to the average for 1961-1990 range from 1.0°C to 1.8°C (Figure 5-13). The last decade (2011-2020) is the warmest also on a seasonal level with the largest deviation from the average of the summer season (1.3°C-2.5°C). For the winter period, the decade 1951-1960 stands out, for which the values of the annual air temperature are similar to the decade 2011-2020.

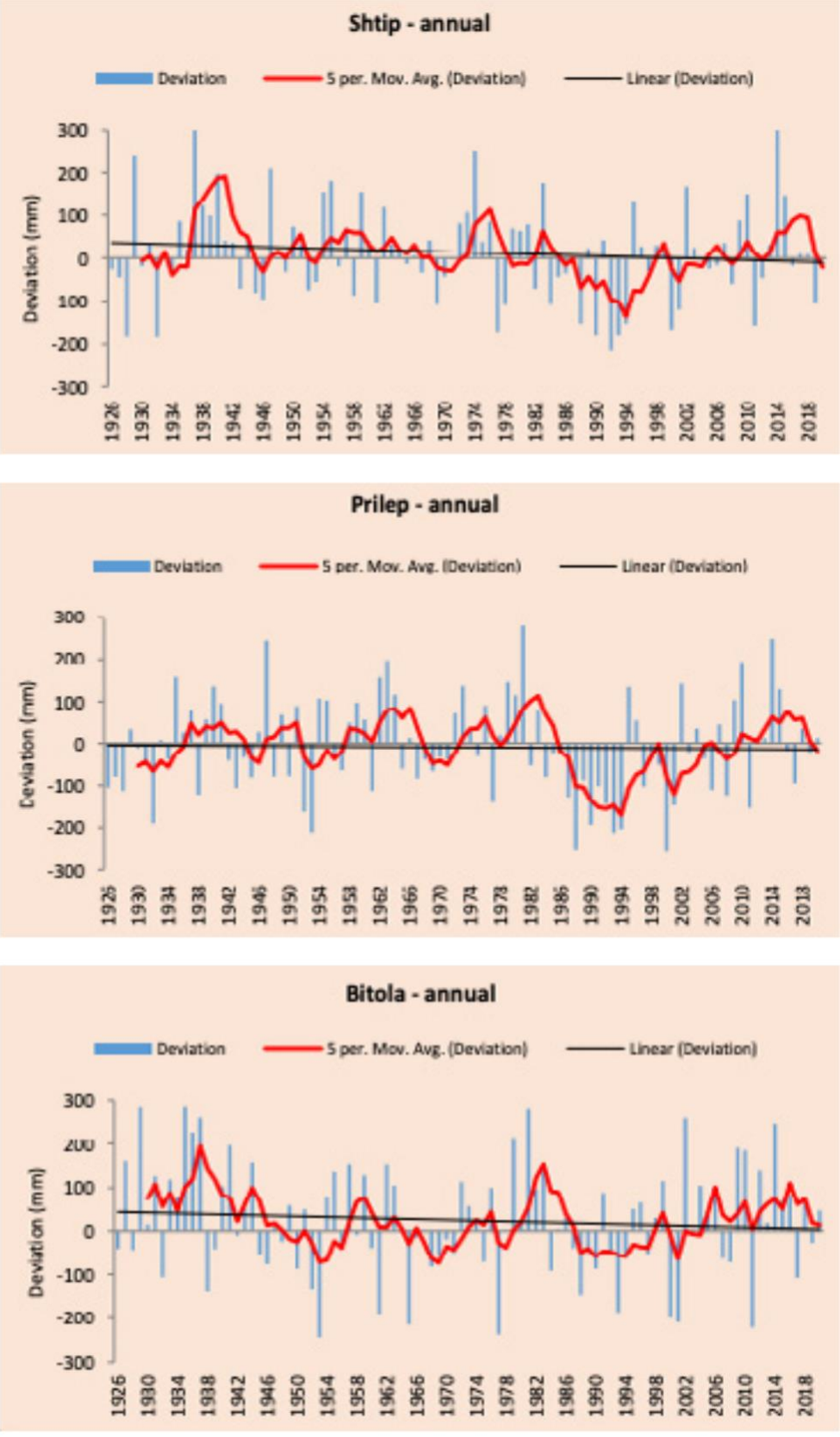
Figure 5-13: **Deviation of the decadal averages of the annual air temperature for the period 1951-2020 from the average 1961-1990**



5.1.1.3 Precipitation analysis

The analysis of the annual and seasonal precipitation for the previously mentioned meteorological stations was performed in an identical way. The multi-year change in the annual sum of precipitation (Figure 5-14) indicates a general trend of decrease in precipitation, however, due to the rapid changes in the amount of precipitation from year to year, the level of the decrease cannot be explicitly determined.

Figure 5-14: Deviation of the annual sum of precipitation from the average 1961-1990

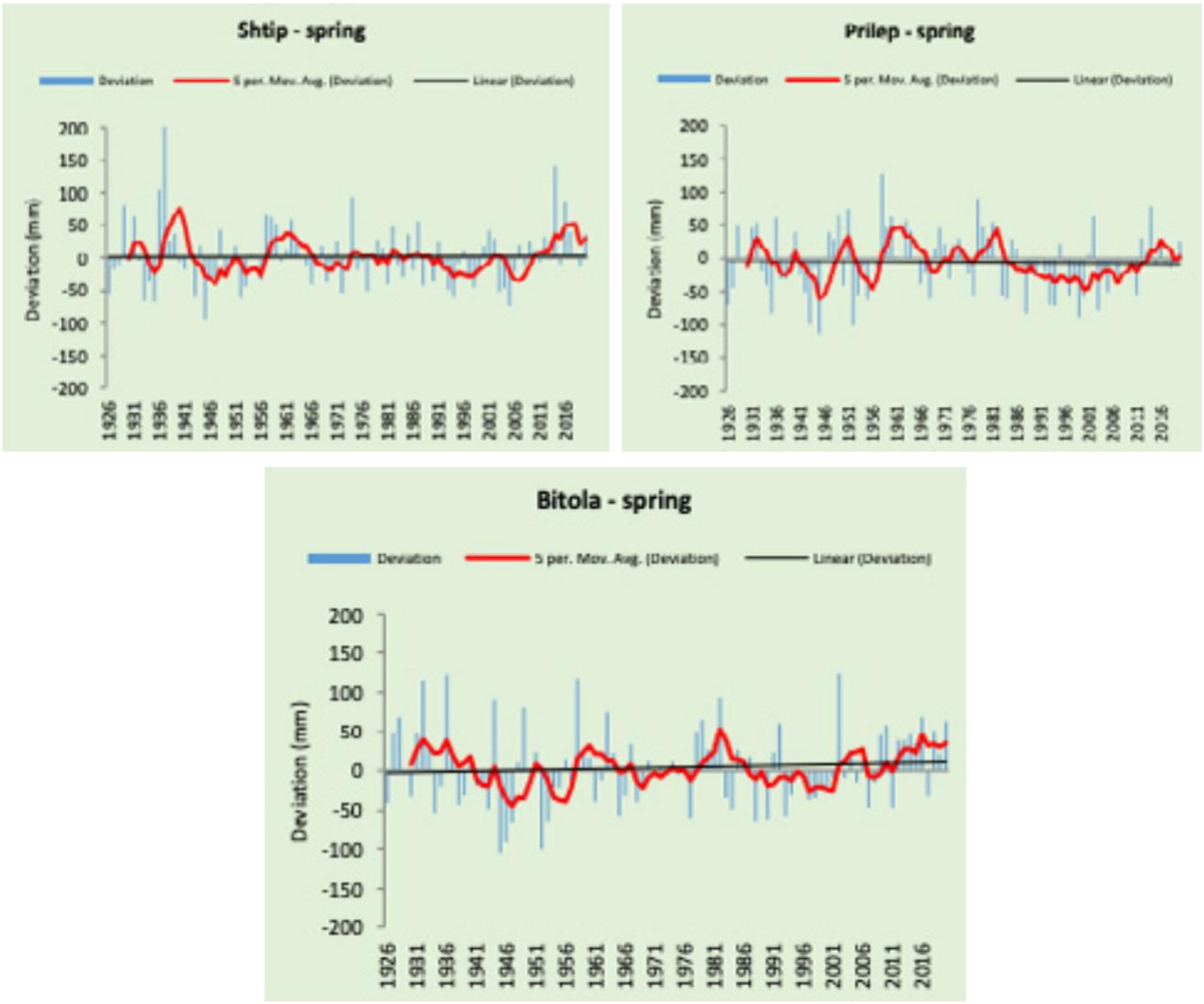


The decrease of precipitation in the last forty years compared to the period 1961-1990 on an annual level is especially pronounced in the period from 1987 to 1994, as well as in 2000, 2001 and 2011. The driest years for the period 1951-2020 and also years for which most meteorological stations recorded the largest deviations of precipitation from the average are 1993, 2000 and 2011. It is characteristic that in the years between these periods, annual recorded sum of precipitation was higher than the average values, and 2014, 2010 and 2002 stand out. Absolute daily maximum precipitation for the period 1951-1990 is 201.0 mm and was recorded in Gevgelija on June 5, 2004, and the largest monthly sum of precipitation (389.6 mm) was measured in November 1985 at the meteorological station Lazaropole.

From the multi-year variation of the seasonal precipitations shown in graphs 9, 10, 11 and 12, a decrease in the autumn and winter precipitations is evident, while for the spring and summer the trend of the variations cannot be generally determined. The trend of the spring sum of precipitation for Bitola shows an increase, while for Prilep and Shtip a decrease, and the trend of the summer sum of precipitation for Bitola shows a decrease in the precipitation unlike Prilep and Shtip.

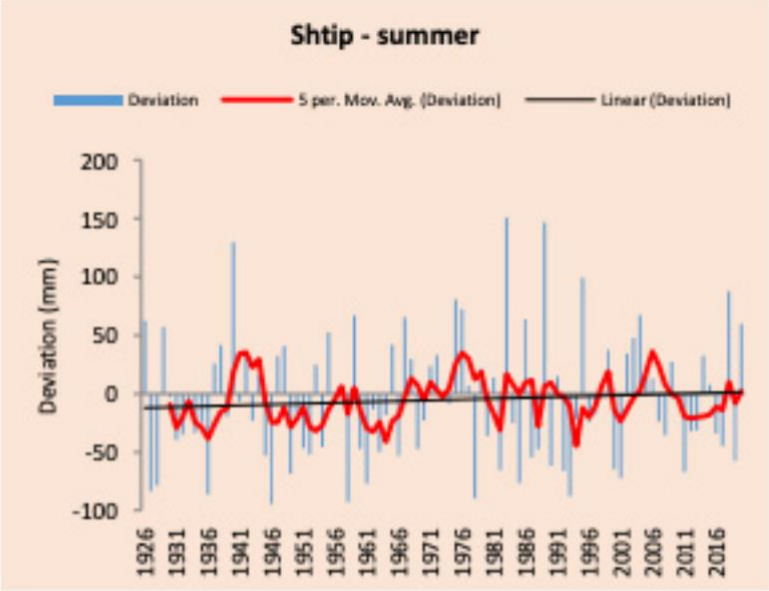
Characteristic of the spring sum of precipitation is that the last decade 2010-2020 has the highest average decadal value compared to other decades for the period 1951-2020. During this period, 2012, 2014 and 2016 are the years that have the five highest values of the spring sum of precipitation recorded at most of the meteorological stations.

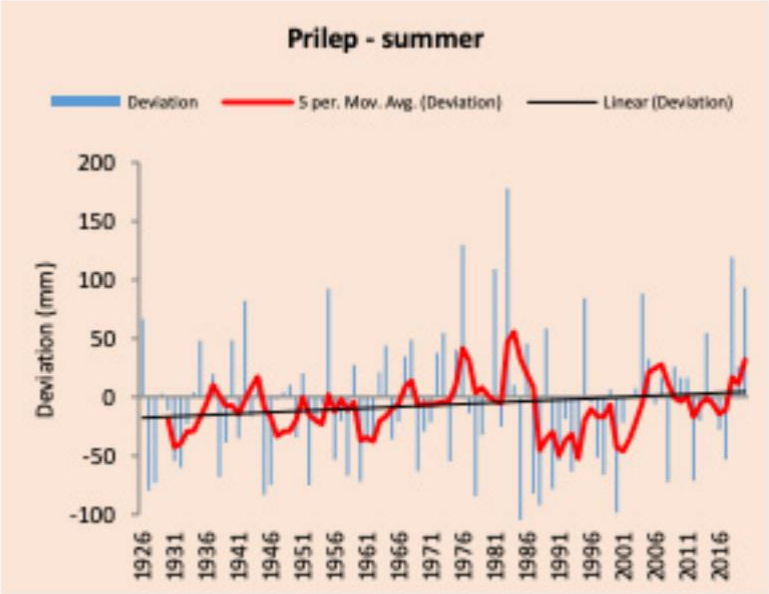
Figure 5-15: Deviation of the spring sum of precipitation from the average 1961-1990

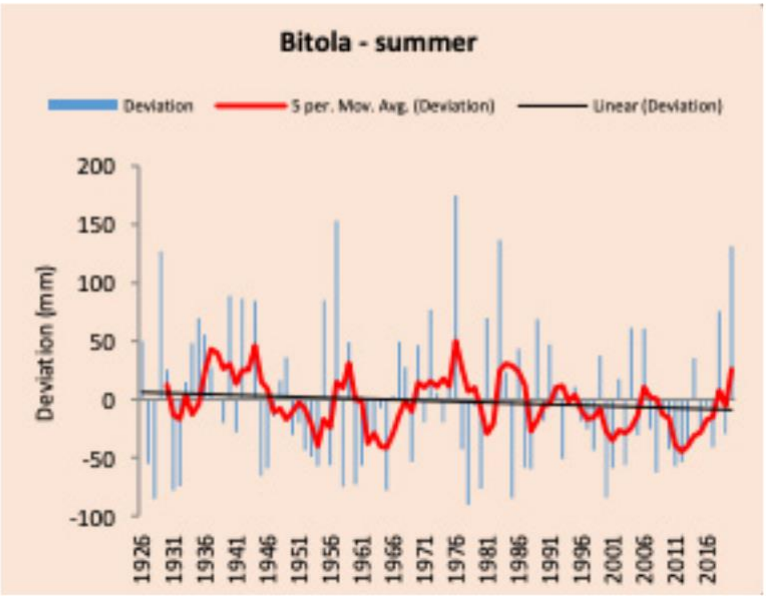


The change of seasonal sum of precipitation throughout the year can be best noticed in the extreme seasonal sum of summer and autumn precipitation. In the five years with the highest values of the summer sum of precipitation for the period 1951-2020, for Bitola and Prilep 2020 stands out, and for Berovo 2020 is the year with the highest value of the summer sum of precipitation. Characteristic for the extreme values of the autumn sum of precipitation is that 2020 for the meteorological stations Bitola, Prilep, Demir Kapija, Gevgelija, Berovo and Ohrid is in the range of years with the five lowest values of the autumn sum of precipitation (period 1951-2020).

Figure 5-16: **Deviation of the summer sun of precipitation from the average 1961-1990**

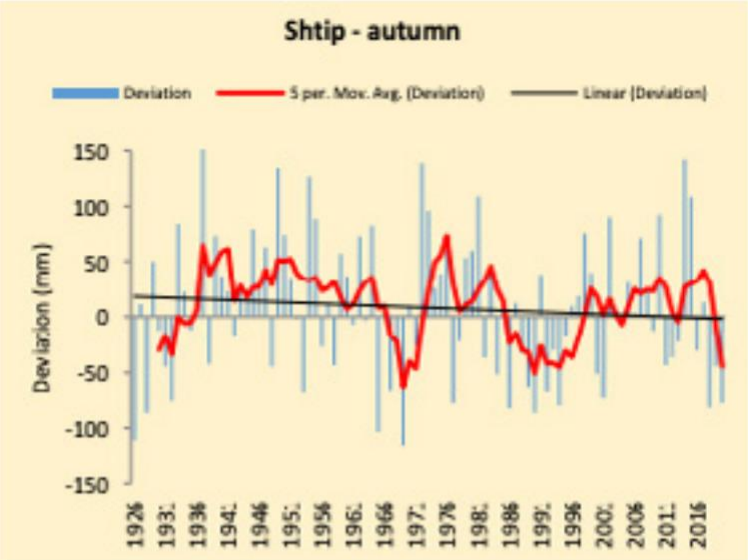


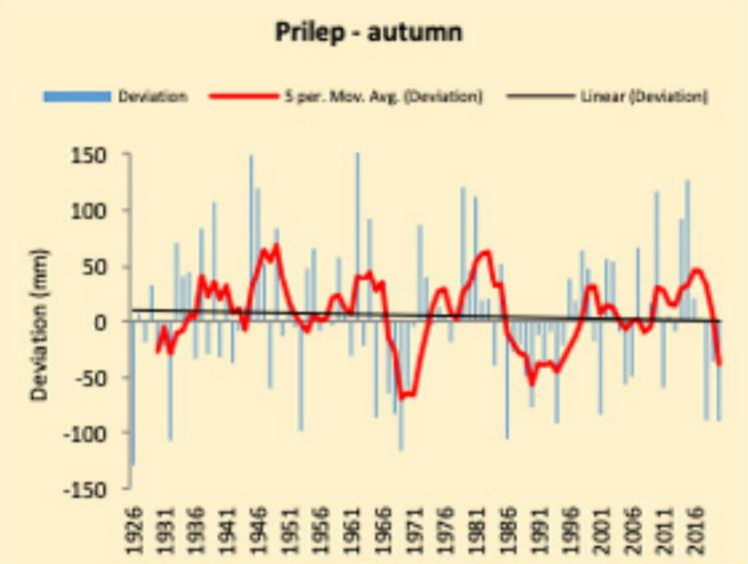




The most extreme year with the lowest sum of winter precipitation (period 1951-2020) for all stations is 1991/1992. The interannual change of the extreme seasonal sum of precipitation is noticed in the winter sum of precipitation for Bitola and Strumica where 1990/1991 stands out as the winter with the highest value of the sum of precipitation.

Figure 5-17: Deviation of the autumn sum of precipitation from the average 1961-1990





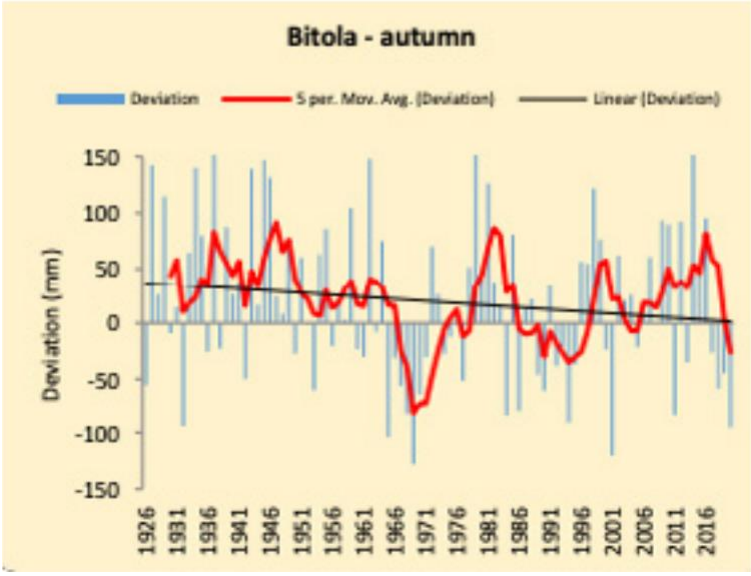
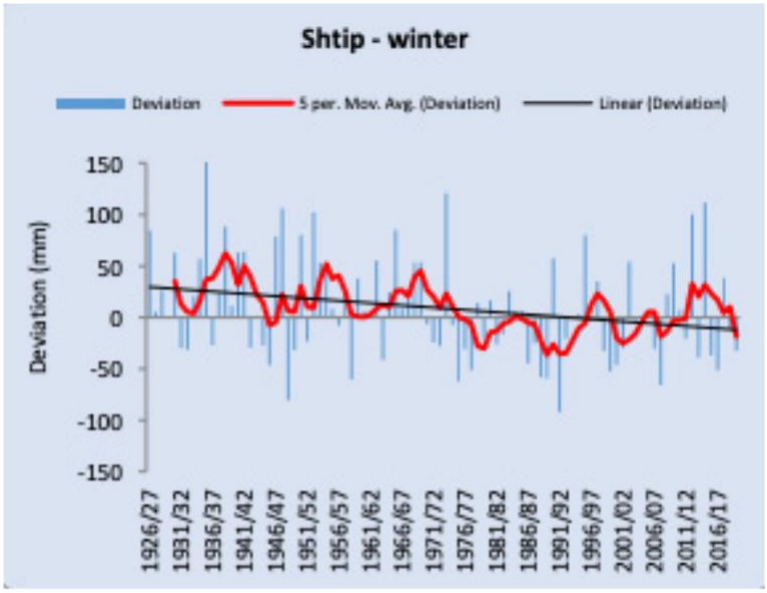
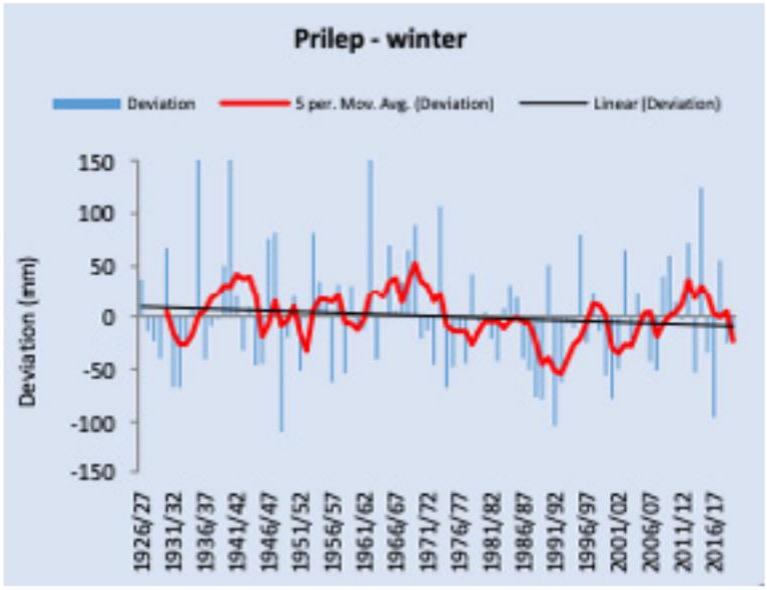
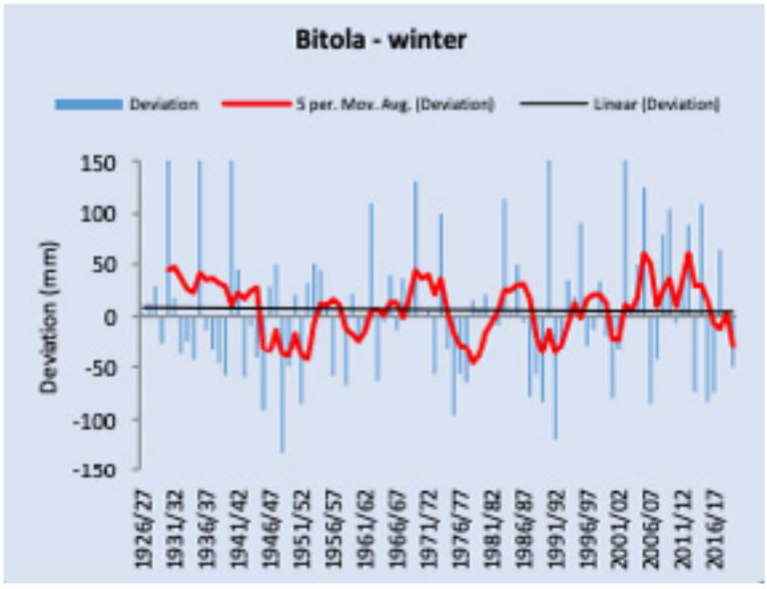


Figure 5-18: **Deviation of the winter sum of precipitation from the average 1961-1990**

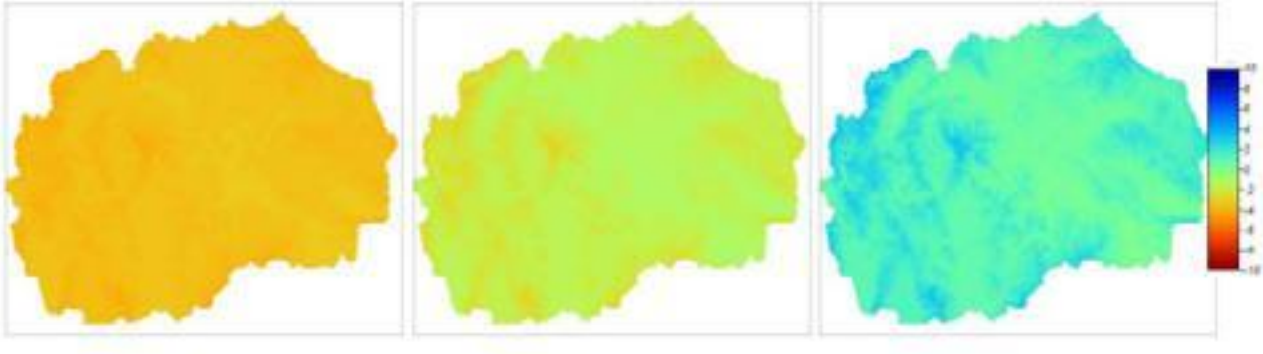






Precipitation does not have a pronounced and unambiguous trend in the spatial and temporal analysis as is the case with the variations in air temperature. The analysis of the annual sum of precipitation shows a decrease for the period 1971-2000 compared to the reference period, values around the average for the period 1981-2010 and an increase in the annual amount of precipitation at most meteorological stations for the period 1991-2020 (up to 6%).

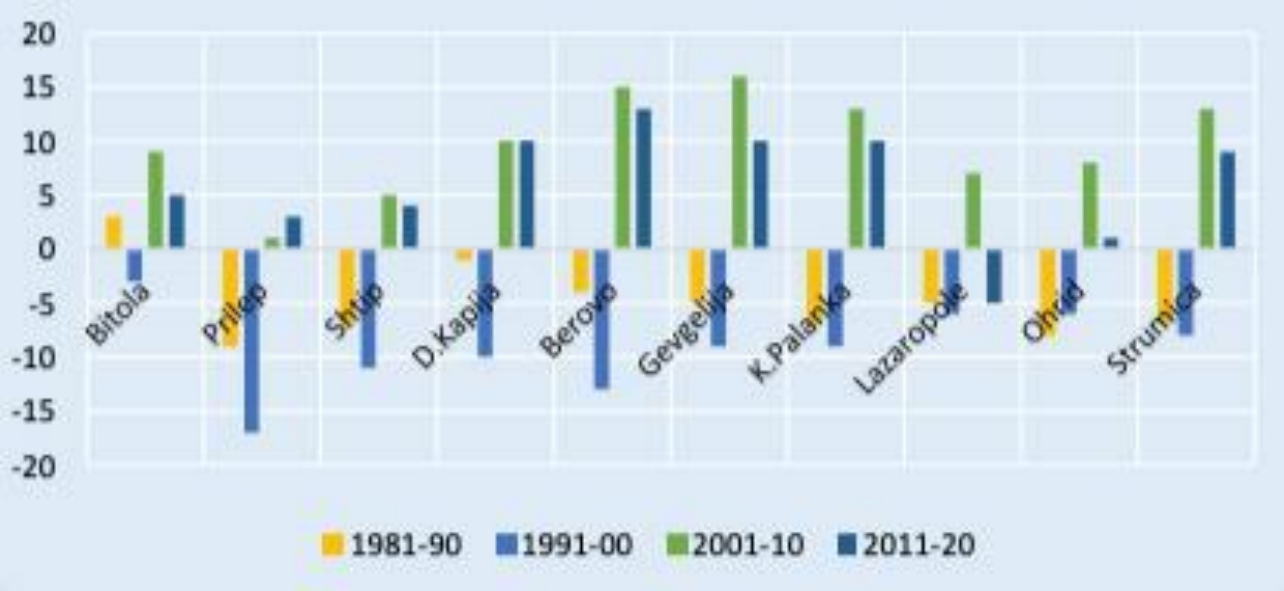
Figure 51-9: Deviation of the 30-year averages of the annual sum of precipitation (1971-2000, 1981-2010 and 1991-2020) from the average for 1961-1990.



From the seasonal sums of precipitation, the most characteristic is the autumn sum with a positive deviation from the average for all three periods, and the largest is for the period 1991- 2020 (1-11%). The amount of spring precipitation is generally below average for all periods, with the exception of the period 1991-2020 for the meteorological stations Bitola, Shtip, Demir Kapija, Berovo, Kriva Palanka and Ohrid, where an increase in precipitation was observed (2- 7%). Increase in precipitation for the summer season was observed for Strumica, Lazaropole Berovo and Gevgelija (up to 7%) for the period 1981-2010 and for Kriva Palanka, Gevgelija, Strumica, Demir Kapija and Berovo (up to 12%) for the period 1991-2020 . In the winter season, the deviations from the average 1961-1990 are below the average for the period 1971-2000, while for the other periods different deviations were noticed. Higher than average values are observed for Demir Kapija, Kriva Palanka, Ohrid, Bitola, Strumica and Gevgelija for the period 1981-2010 (2-11%) and in Demir Kapija, Berovo, Ohrid, Strumica, Bitola and Gevgelija for 1991- 2020 (2-16%).

Analysis done on the decadal averages of the annual sum of precipitation show a decrease in precipitation for the two consecutive decades 1981-1990 and 1991-2000 compared to the average 1961-1990 (up to 17%), followed by two decades 2001-2010 and 2011-2020 with higher than average precipitation (Figure 520). In these decades there are a larger number of years that are in the range of years with higher annual sum of precipitation, with 2014, 2010 and 2002 standing out which are in the group of several most extreme years. It is evident that the wettest decade is 2001-2010 with an increase in the annual sum of precipitation of up to 16% compared to the average and for most meteorological stations for the autumn season with an increase of up to 30%. Increase of precipitation at all meteorological stations compared to the reference period was registered compared to the spring sum of precipitation for the decade 2011-2020 (4% -24%).

Figure 5-20: **Deviation of the decadal averages of the annual sum of precipitation from the average for the period 1961-1990 (%)**



5.1.1.4 Snow and snow cover

Snow and snow cover are analyzed through the number of days with snow cover on a decadal and a thirty-year level (Graphs 18 and 19). There is a decrease in the annual number of days with snow cover compared to the average for the period 1961-1990 for all three periods 1971- 2000, 1981-2010 and 1991-2020 (Figure 5-21), with a slight increase for the meteorological stations Shtip and Strumica for the period 1971-2000. The largest decrease in the annual number of days with snow cover (from 3 to 12 days) is registered for the period 1991-2020. In the last 4 decades, the annual number of days with snow cover has decreased compared to the average, and the largest decrease (from 3 to 28 days) is registered for the decade 2011-2020 (Figure 5-22).

Figure 5-21: **Deviation of 30-year averages of annual number of days with snow cover from the average for 1961-1990**

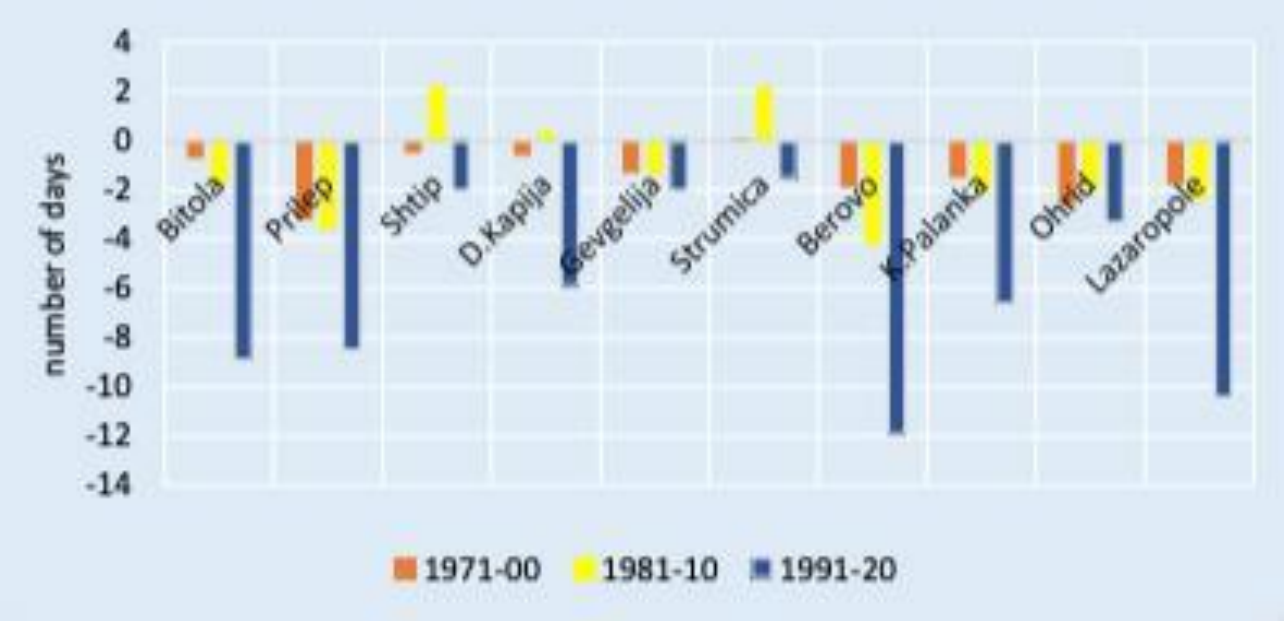
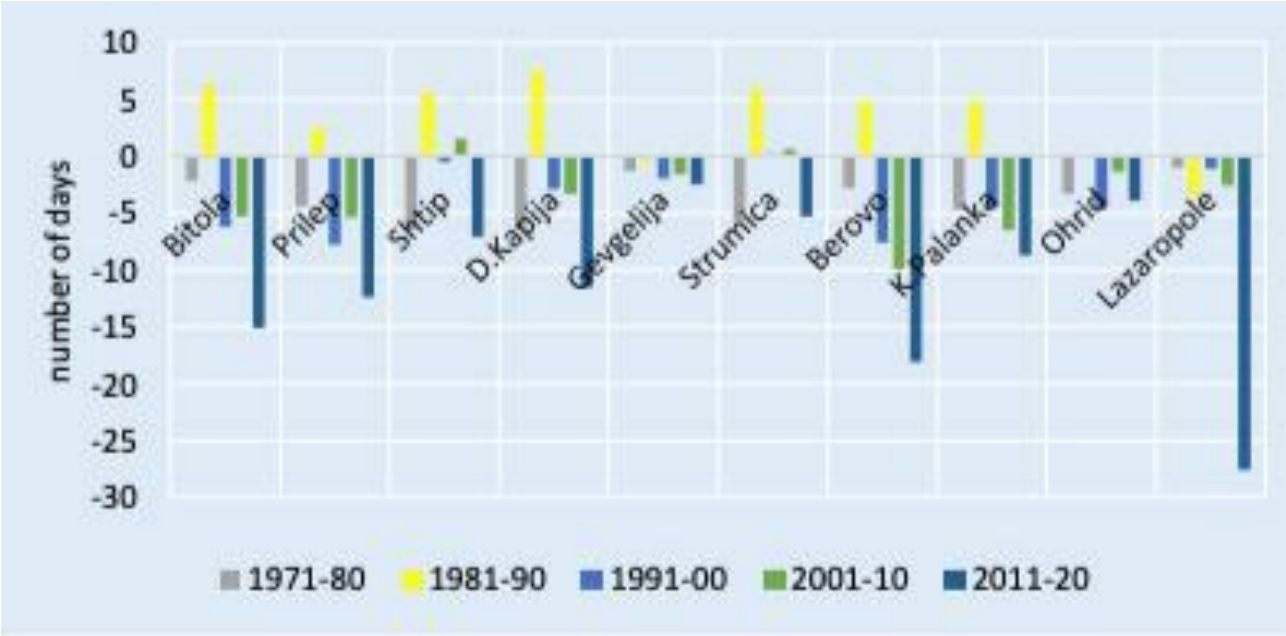


Figure 5-22: **Deviation of decadal averages of annual number of days with snow cover from the average for 1961-1990**



5.1.1.5 Climate Indices

The analysis of temperature indices shows how much the observed increase in air temperature affects the decrease in frequency and duration of cold and increase in hot periods, which can cause adverse effects. In the past fifty years, the largest decrease in the average annual number of frost days (days when the minimum air temperature is lower than 0°C) and the number of icing days (days when the maximum air temperature is lower than 0°C) compared to the average for 1961-1990 is registered in the period 1991-2020. During this period on the territory of the country there was a decrease in frost days from 1 to 17 days, with the exception of meteorological stations Demir Kapija and Kriva Palanka where an increase of 2 and 4 days was observed. Icing days are less common than frost days so their reduction compared to the reference period is lower (from 1 to 4 days).

The same thirty-year period also saw the largest increase in the average annual number of tropical nights (days when the minimum air temperature is higher than 20°C) and the average annual number of summer days (days when the maximum air temperature is higher than 25°C) in comparison to the reference period. Tropical nights are a rarer occurrence that in some places at higher altitudes such as Berovo and Lazaropole has not been observed at all in the past. The largest increase in tropical nights of 18 days was observed at the meteorological station Gevgelija, while for the other stations Bitola, Prilep, Strumica, Demir Kapija and Shtip the increase is from 1 to 5 days. The increase of the summer days is from 11 to 24 days, so the biggest deviation from the reference period is noticed at higher altitude.

Research conducted on the decadal averages shows that the largest change in the annual number of frost days, icing days, summer days and tropical nights compared to the reference period was observed in the last decade (2011-2020). Frost days have reduced from 3 to 23 days, and icing days up to 8 days. The biggest decrease, especially in the number of frost days, was observed at the meteorological station Lazaropole. The largest increase in tropical nights of 28 days was observed at the meteorological station Gevgelija, while for the other stations Bitola, Ohrid, Prilep, Strumica, Demir Kapija and Shtip the increase is from 1 to 6 days. The increase of summer days on the entire territory of the country is greater than 18 days, and the largest increase of 28 days was observed in Berovo and Kriva Palanka.

With regard to risks for various sectors caused by high air temperatures, the frequency and duration of the excessive or prolonged heat during the year is especially important. The duration index of a warm period (spell) is calculated with the number of days with at least 6 consecutive days when the maximum daily temperature is greater than the 90th percentile for the calendar day calculated for a five-day window centered on each calendar day for the reference period 1961-1990. The largest increase in the frequency and in the number of days with heat spells annually compared to the reference period is in the period 1991-2020 and in 2011-2020. In the period 1991-2020, the annual increase is from 9 days (in Prilep) to 20 days (in Gevgelija), while in 2011-2020 the increase for the entire territory of the country is more than 14 days with heat spells. In the last decade in Demir Kapija and Strumica there has been an increase of 30 days, and in Gevgelija even 41 days more compared to the reference period. For proper growth and development of plants, in addition to the previously mentioned

temperature indices, the growing season length is of particular importance. The length of the growing season is defined by the number of days between the beginning of the first period with at least 6 days with daily mean temperature higher than 5°C and the beginning of the first period in the second half of the year with daily mean temperature lower than 5°C. The largest extension of the growing season length compared to the reference period was observed for the period 1991-2020 with a maximum of 16 days in Gevgelija. A slight decrease in the length of the growing season was observed in Demir Kapija and Berovo, where the growing season was shorter for 2 and 4 days. Research conducted on the decadal averages shows that in the last decades, 2001-2020 and 2011-2020, the largest change in the length of the growing season was observed. During the last ten years, a shorter and longer extension of the growing season has been recorded. The largest extensions of 21 days and 22 days were observed in Lazaropole and in Gevgelija. Greater length of the vegetation period was observed in the period 2001-2010 when the length of the growing season in the whole country was extended by more than 10 days, with a maximum of 23 days in Bitola, Gevgelija, Shtip and Demir Kapija and 24 days in Strumica. The only reduction in the growing season length of 5 days was observed in Berovo.

The analysis of precipitation indices shows a change in the precipitation regime with an increase in the frequency of heavy and very heavy precipitation. Days with heavy precipitation are days during which the daily quantity of precipitation is greater or equal to 10mm, while days with very heavy precipitation are those during which the daily quantity of precipitation is greater or equal to 20 mm. In the last 30-year period, in most meteorological stations there is an increase in the number of days with heavy and very heavy precipitation for 1 day to 2 days, in comparison to the reference average. In the last two decades there is an increase in the number of days with heavy and very heavy precipitation for 3 (2001-2010) and 4 days (2011- 2020) on the whole territory of the country, with the exception of Lazaropole, where this number has been reduced for 1 (2001-2010) and 2 days (2011-2020).

5.1.1.6 Extreme temperatures

Changes in extreme weather and climate events have significant impact and are among the most serious challenges for our society, especially in addressing climate change (CCSP, 2008). As a result of the predictions that some extreme events will become more frequent, more widespread or more intense during the 21st century (IPCC, 2007), the demand for information services for weather and climate extremes is increasing. The sustainability of economic development and living conditions depends on our ability to deal with the risks associated with extreme events.

Many practical problems require knowledge of the behaviour of extreme values. In particular, the infrastructure on which we depend for food, water, energy, shelter and transport is sensitive to high or low values of meteorological variables. The motivation for extreme events analysis is often to find the optimal balance between on one hand, adopting high safety standards that are very expensive, and on the other hand preventing major damage to equipment and facilities from extreme events that are likely to occur over the lifetime of such infrastructures (WMO, 1983).

Extreme climate events are very unfavourable (fierce), rare and intense events that occur in a certain area in a certain period of time. These events deviate from the statistically determined schedule of climate events for a particular area. The analysis of extreme climate events is required because there are trends that have been observed in recent decades, which are expected to continue and intensify in the future. There is a general trend of decrease in the number of icing days, increase in the number of warm (tropical) nights, more frequent occurrence of warm spells, fewer days with precipitation and more intense rainfall.

In the analysis of the extreme events indices for the Republic of North Macedonia data on daily values for the main meteorological elements were used, that is, air temperature and precipitation data from meteorological stations with a continuous series of historical data 5 for the period from 1951-2019 such as: Bitola, Prilep, Shtip, Kriva Palanka, Berovo, Strumica, Demir Kapija, Gevgelija, Ohrid and Lazaropole. A total of 27 indices were included, of which 16 refer to air temperature and 11 to precipitation.

Frost Days: The highest annual number of frost days in the past 69 years, that is, 157 days were observed in Lazaropole, while the lowest number, 13 days were observed in Gevgelija. The highest annual number of frost days at almost all meteorological stations was recorded in 1953. A characteristic year with the lowest annual number of frost days was 2014

Icing Days: The highest annual number of icing days (48) was observed in Lazaropole, while in Gevgelija, Demir Kapija, Shtip, Ohrid and Strumica in a certain number of years no icing days were observed. The highest annual number of icing days at most meteorological stations was recorded in 1954 and 1963, respectively. Although this index is characterized by greater variability during the analyzed period, still the lower annual number of icing days in recent years shows a downward trend in the number of icing days.

Summer days: In the period 1951-2019, the largest annual number of summer days, 178 were observed in Gevgelija, while in Lazaropole there were years in which the air temperature did not exceed 25 degrees Celsius at all. Characteristic years with the lowest annual number of summer days are 1959 and 1976. The highest annual number of summer days at all meteorological stations was mainly observed in the last 20 years, especially in 2012, 2018 and 2019. As a result, at all stations there is a noticeable upward trend in the number of summer days.

Tropical nights: The highest annual number of tropical nights, 46 were recorded at the meteorological station Gevgelija, while at higher altitude stations, such as Berovo and Lazaropole there are no days when the minimum daily air temperature is higher than 20°C. Higher annual number of tropical nights, besides the ones registered in the last 20 years, were also observed at the beginning of the analyzed period. For example in Demir Kapija the maximum annual number of tropical nights was recorded in 1952, and in Strumica in 1959. In general, this index shows an upward trend, more or less in all the stations.

Growing season length: The shortest duration of the growing season was observed at the meteorological stations at higher altitudes, so in Lazaropole in 1965 the growing season lasted only 161 days. At most stations, the shortest growing season was observed in 1997. The maximum length of the growing season of 365 days was observed in Gevgelija in 1974 and 2006, which means that in these years the growing season lasted a whole year.

Daily maximum and minimum air temperatures: The maximum values of the daily maximum air temperature (TX) were recorded on July 24, 2007 for the meteorological stations in Berovo, Kriva Palanka, Demir Kapija, Gevgelija, Ohrid and Shtip and on July 7, 1988 for Bitola, Prilep, Strumica and Lazaropole. The highest maximum air temperature for the period 1951-2019 on the territory of the Republic of North Macedonia is 45,7°C measured on July 24, 2007 in Demir Kapija. Unlike the maximum values of the daily maximum temperature observed in only two years, the maximum values of the minimum air temperature (TN) for meteorological stations are observed in different years, and the highest minimum air temperature 26,8°C was measured on 13 August 1994 at the meteorological station Gevgelija. The minimum values of the daily maximum air temperature at most meteorological stations were recorded at the end of January 1963. The lowest maximum air temperature, -16,7°C was measured on January 9, 1979 in Bitola. The minimum values of the minimum air temperature were observed in different years, and the lowest minimum air temperature -31,5°C was measured on January 27, 1954 at the meteorological station Berovo.

Cold nights and cold days: Cold nights are days with minimum daily temperature TN< 10th percentile, while cold days are days with maximum daily temperature TX< 10th percentile. The annual number of cold nights for the period 1951-2019 ranges from 3 days recorded in Gevgelija in 2014, to 76 which were recorded in Kriva Palanka in 1997 (Table 19), while the annual number of cold days ranges from 7 days observed in Gevgelija (2000) and Kriva Palanka (2019) up to 70 days in Strumica in 1956.

Warm nights and warm days: Warm nights are days with minimum daily temperature TN> 90th percentile, while warm days are days with maximum daily temperature TX> 90th percentile. The highest annual number of warm nights (115 days) and warm days (140 days) is observed in Gevgelija. The lowest annual number of warm nights (8 days) was recorded in Strumica, and the lowest number of warm days (12 days) in Berovo and Ohrid

Precipitation: According to the multi-year data, the absolute maximum amount of daily precipitation in the country is registered in Gevgelija, on 05.06.2004, and it is 201,0 mm. The maximum daily precipitation that was measured during the entire period of observations, at ten measuring points has higher values than the maximum daily precipitation measured during the period from 1986-2005 (except for Gevgelija and Strumica). However, the simplest linear analysis of the values in the multi-year period shows that in all measuring points (except in Prilep) there is a greater or lesser trend of increase in the maximum daily precipitation. This is in line with the prepared climate scenarios, according to which in most parts of the country the daily extreme precipitation is expected to increase compared to the period 1986- 2005.

Heavy precipitation: According to the definitions of WMO, a day with heavy precipitation is a day on which the measured amount of precipitation is greater (or equal) than 10mm, and a day with very heavy precipitation is a day on which the rainfall is greater (or equal) than 20mm. Also, in this extremes index, users can define a specific precipitation threshold, which in this case is done by analyzing the number of days with precipitation over 40mm. The data show that in the country the largest number of days with heavy rainfall is registered in Lazaropole (average 36 days per year), followed by Ohrid (23 days) and Gevgelija (22 days), and the lowest number is registered in Shtip (14 days). The average number of days with heavy precipitation is similar for the period 1986-2005. The maximum number of days with heavy precipitation during a year was recorded in Lazaropole and Ohrid in 2010 (56 and 42 days). Also in 2014, a maximum number of heavy precipitation events was registered at several measuring points (in Berovo 34, in Kriva Palanka 31, in Strumica 32 and in Shtip 30). The lowest number of days with heavy precipitation was recorded in 1984 and 1993.

Very wet days: In general, these indices show what is the annual sum of precipitation with larger daily quantities (above the 95th and above the 99th percentile), so-called very wet and extremely wet days. The threshold of 95 and 99 percentile

is calculated from the daily precipitation data in the period 1961-1990, for each measuring station separately. They indicate that 95 or 99 percent of the daily precipitation values are above that threshold. The maximum annual sum of precipitation from very wet days was measured in Lazaropole in 1981 and it is 506.3mm. It can be seen that in almost all places, the highest values are recorded after 2000.

Consecutive dry days: The highest annual number of dry days in the past 69 years, is 103 days and these were observed in Demir Kapija, while the lowest number, 58 days were observed in Lazaropole. The highest annual number of dry days at almost all meteorological stations is not observed in the same year. The years with the highest annual number of dry days are 1956, 1961, 1965, 1969, 1986, 1992, 2000, 2001, 2003, 2007, 2018 and 2019, which is a result of the general upward trend in the number of dry days.

5.1.2 Climate change projections

This section is a summary of a report developed for the 4th National Communication on Climate Change[10].

The climate projections for the Fourth National Communication for North Macedonia used the regional GHG emissions scenarios RCP2.6, RCP4.5 and RCP8.5, established by the IPCC-AR5 (IPCC, 2014), and EURO-CORDEX climate models. The analysis includes annual and seasonal changes in essential climate variables: mean daily temperature, minimum daily temperature, maximum daily temperature and daily precipitation. Four seasons are defined as, December-January-February (DJF), March - April-May (MAM), June-July-August (JJA) and September-October-Novembers (SON). In addition to these results, changes in selected extreme climate indices are presented, as indicators of the possible changes in the intensity and frequency of extreme weather and climate events. All future changes are presented for the period from 2016 to 2100 (within three subperiods are selected) and with respect to the reference period 1986-2005, which was used as the reference and in the last Fifth Intergovernmental Panel on Climate Change. Focus will be placed on three future twenty-year long periods: the near-future period 2016-2035, the middle of the twenty-first century 2046-2065, and the end of the twenty-first century 2081-2100.

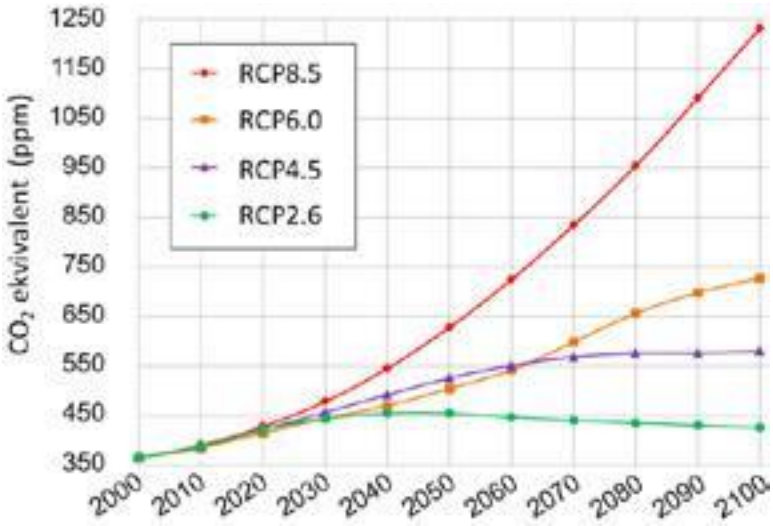
The analysis of the climate projections presented below, show that North Macedonia will have a hotter and drier climate by the end of the century, with an increase in hot temperature extremes and a decrease in cold temperature extremes. Despite projections for drier conditions, an increase in extreme precipitation events is expected, resulting in an increased risk of flash floods. In the summer period, the number of consecutive dry days is projected to increase, leading to more frequent droughts. The expected growing season is also expected to shift, resulting in a longer growing season.

5.1.2.1 Methodology

For the Fifth Report of the Intergovernmental Panel on Climate Change, four Representative Concentration Pathway (RCP) scenarios for future global concentrations of greenhouse gases (RCP8.5, RCP6.0, RCP4.5 and RCP2.6) were used as an input for climate model projections. These scenarios represent possible changes in the concentrations of greenhouse gases in the atmosphere for the period 2006-2100. Scenarios RCP2.6 and RCP4.5 assume that greenhouse gases concentrations will stabilise in the future, while under RCP8.5 and RCP6.0 scenarios, concentrations will continue to rise, or follow trends observed historically (Figure 5-23). Scenario RCP2.6 further assumes that, in the second half of this century, the concentration of greenhouse gases will decline, requiring anthropogenic emissions to be net-zero.

[10] UNDP, 2020. Report on climate change projections and changes in climate extremes in North Macedonia.

Figure 5-23. Future concentrations of greenhouse gases for RCP emissions scenarios



For different scenarios of future concentrations of greenhouse gases, with climate models that use these concentrations as input variables, appropriate climate projections can be obtained. For this report regional climate models were used. Regional Climate Models have significantly better horizontal resolution in comparison to Global Climate Models, usually of the order of 10 km. Based on their results it is possible to estimate the regional spatial changes of the selected variables.

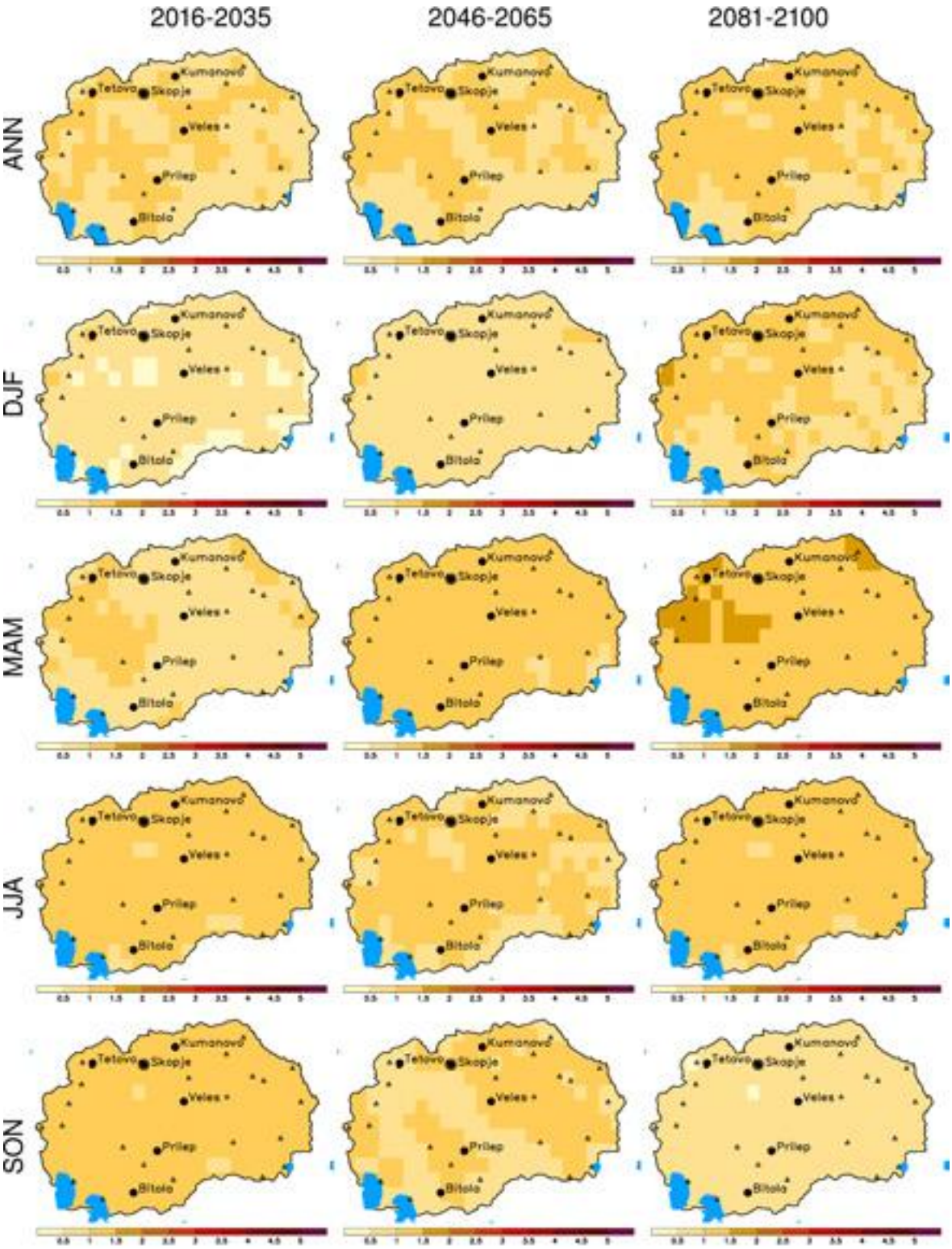
The results of regional climate models are taken from the EURO-CORDEX database, which is the reference database of climate projections for Europe, and which has been the basis of many climate studies in Europe in recent years. Also, this database forms the basis for the European Union's Copernicus Climate Change Service program. The horizontal resolution of the downloaded data is 11 km. Bias-adjusted data was also used, which removes climate projections from systematic model errors in the results, leading to more reliable future projections of selected climate indices.

In addition, regional climate models were used to estimate the regional spatial changes for Skopje, Strumica and Polog which are the three most vulnerable regions in North Macedonia. The regional analysis for these areas is shown after the national analysis.

5.1.2.2 Projections for annual and seasonal temperatures

The annual and seasonal change in the **mean daily temperature** is given in Figure 5-4, Figure 525 and Figure 52658[11] for RCP2.6, RCP4.5 and RCP8.5 scenarios, respectively. For RCP2.6 (Figure 524) the scenario mean daily temperature will continuously increase, from about 1 °C in the near future to about 1,5 °C by the end of the century. In terms of warming there are no substantial differences between different seasons.

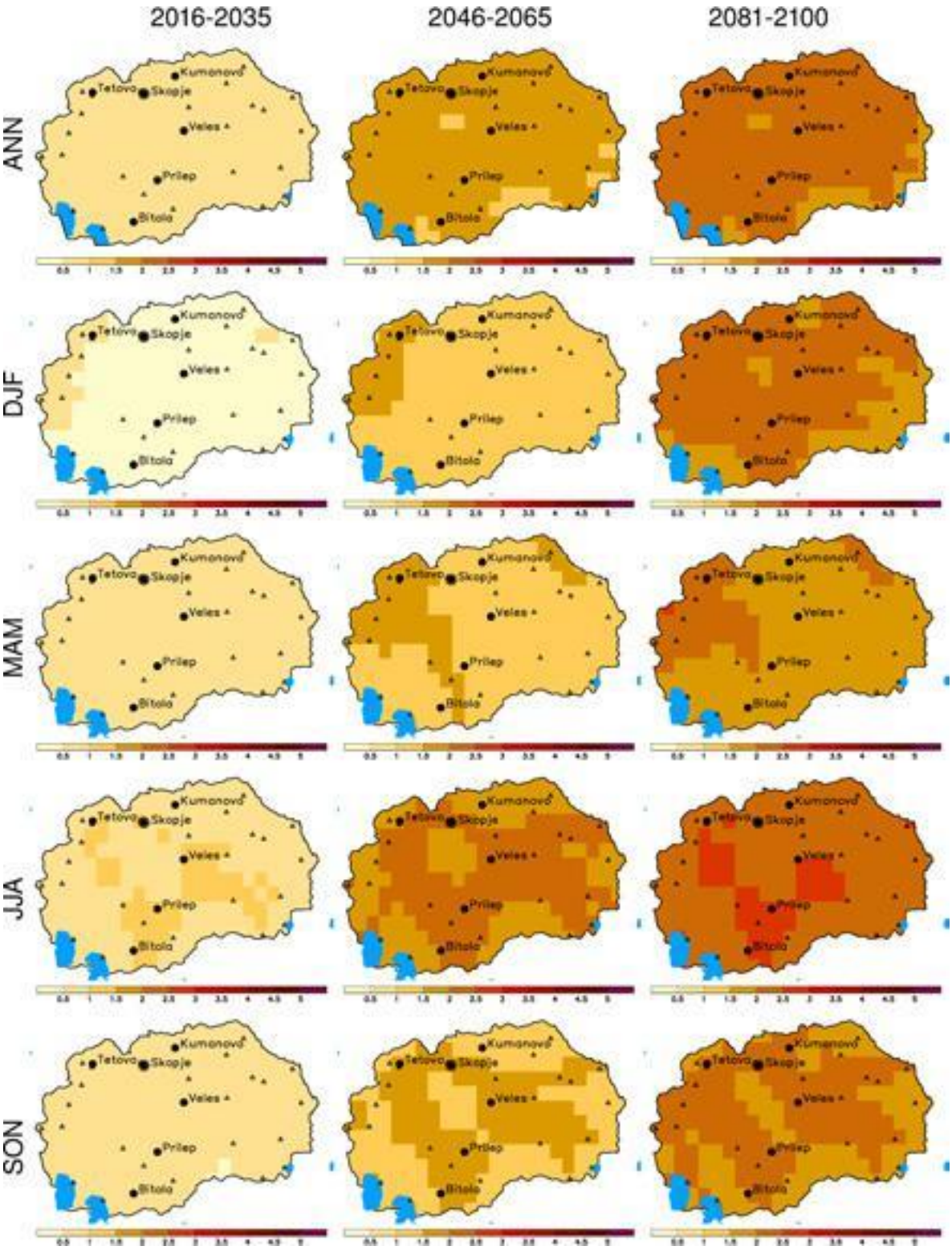
Figure 5-24. Future daily mean temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP2.6 scenario



11 On all figures, selected cities are presented with circles, and meteorological and climatological stations with small triangles.

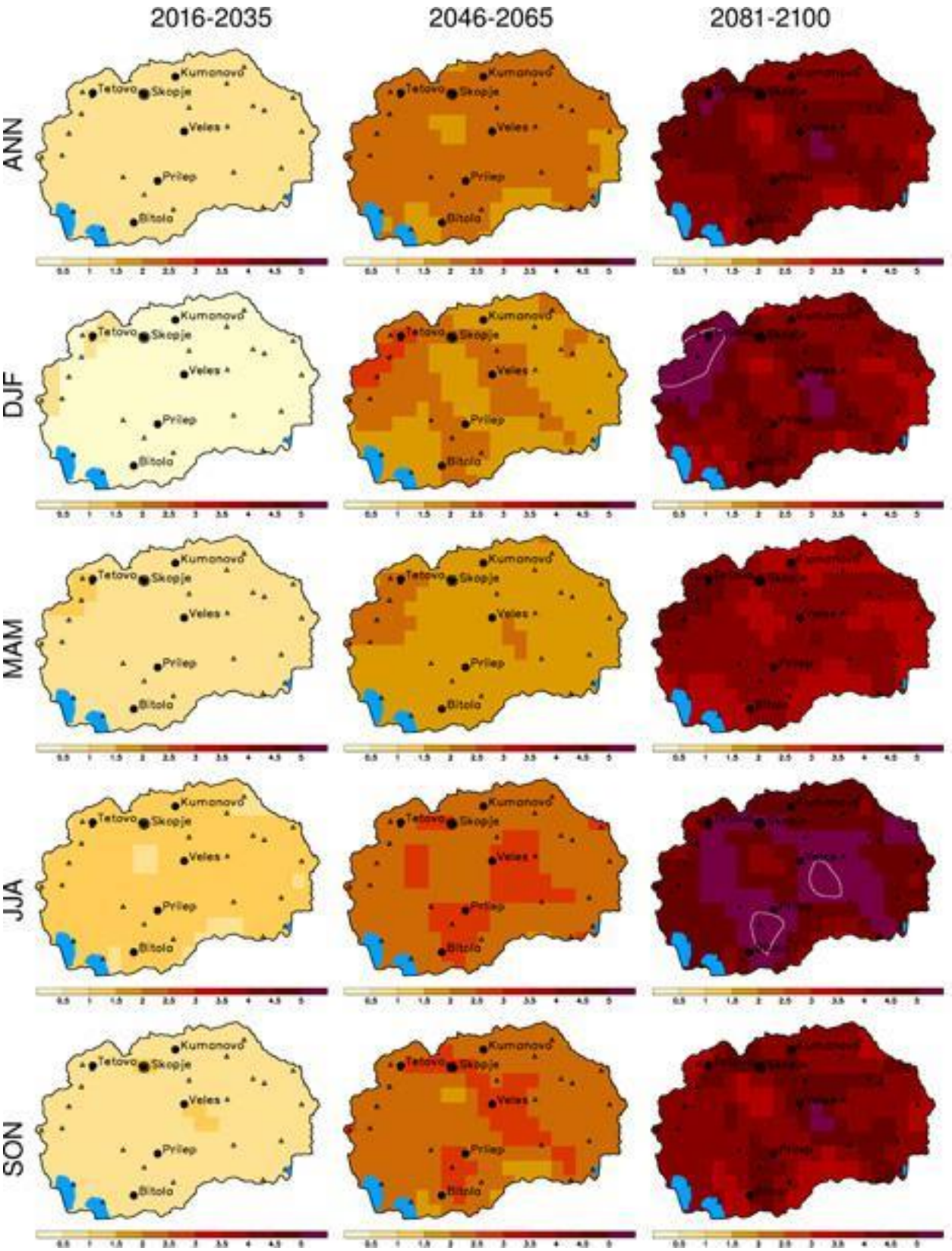
In case of RCP4.5 (Figure 5-25) scenario mean daily temperature will continuously increase, from about 1 °C in the near future to about 2,5 °C by the end of the century. In terms of warming there are no substantial differences between different seasons. The highest warming is expected for summer season for all future periods. For the middle of century, for other three seasons (winter, spring and autumn) the warming is almost of the same order, but is more pronounced for winter for the last analysed period.

Figure 5-25. Future daily mean temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP4.5 scenario



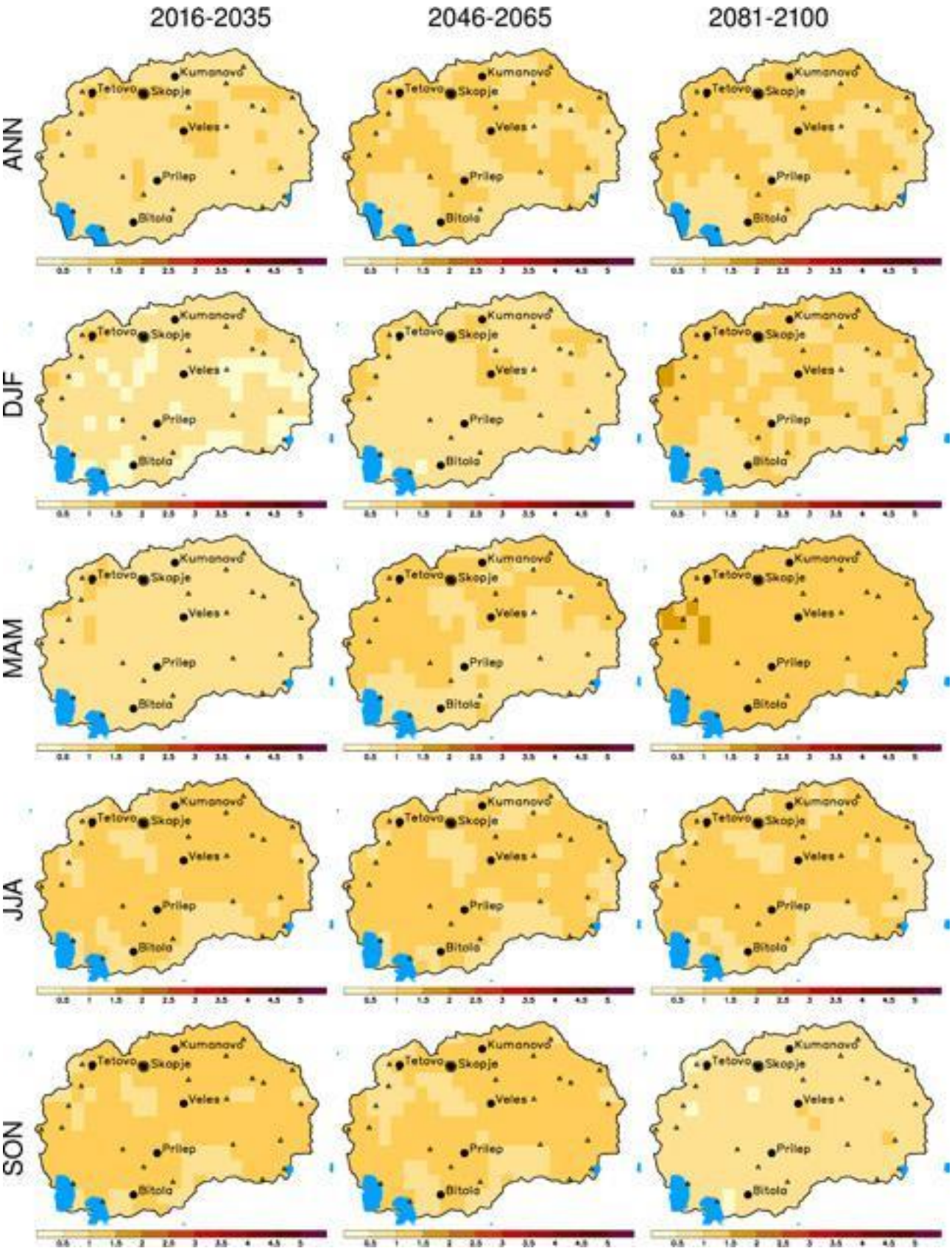
Mean daily temperature will continuously increase, form about 1 °C in the near future to more the 5 °C by the end of the century, in case of RCP8.5 (Figure 5-25). The highest warming is expected for summer season for all future periods. For the middle of century, for other three seasons (winter, spring and autumn) the warming is almost of the same order, but for the end of the century, higher warming is expected for winter in comparison to spring and autumn.

Figure 5-26. Future daily mean temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP8.5 scenario. White line represents 5.5 °C isoline



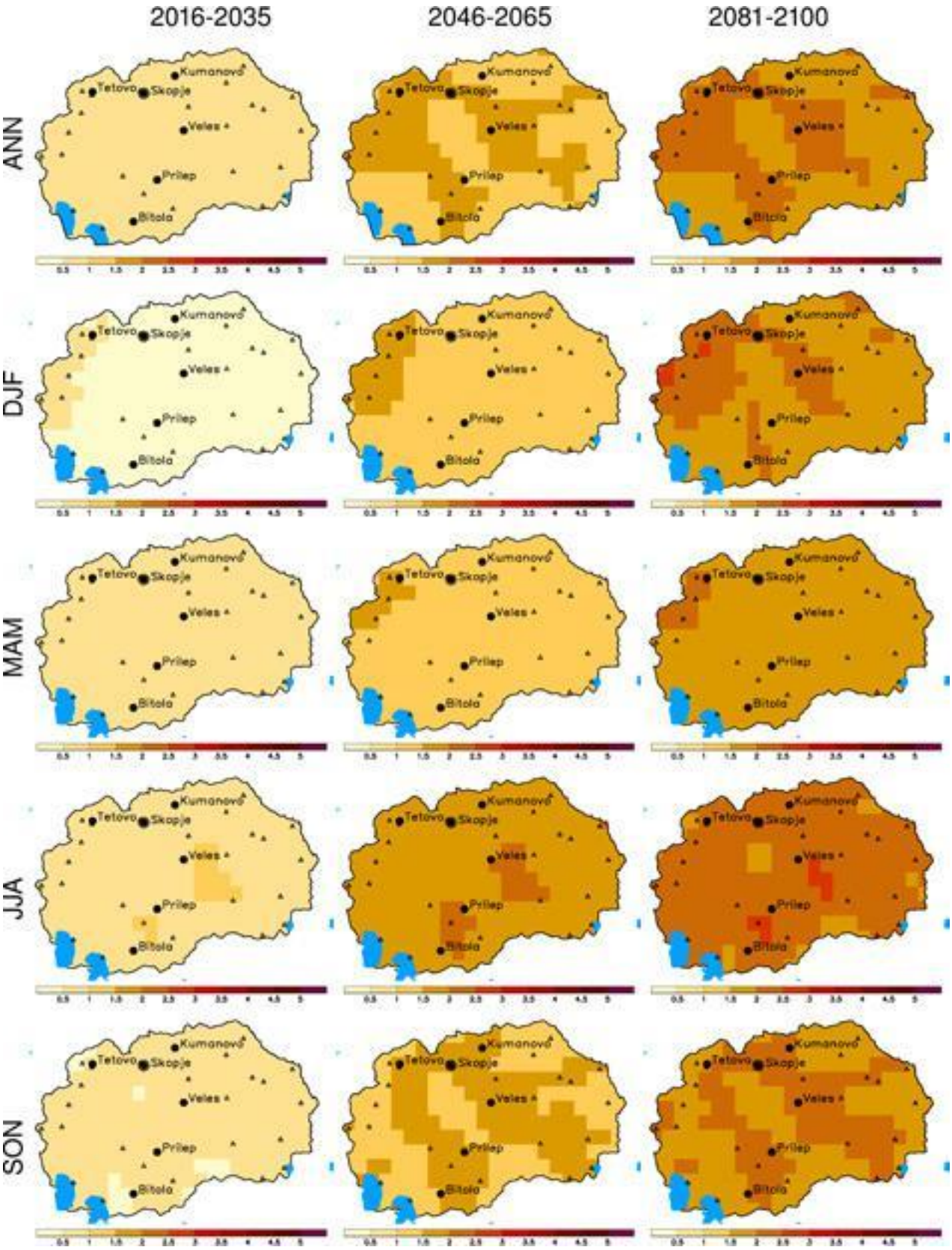
Annual and seasonal **minimum daily temperature change** is given in the figures below, and for the RCP2.6, RCP4.5 and RCP8.5 scenarios, respectively, for different periods during the 21st century. For scenario RCP2.6 (Figure 5-27) similar to daily mean, minimum daily temperature will continuously increase, from about 1 °C in the near future to more the 1.5 °C by the end of the century. Differently, spring is the seasons with the highest increase for the period at the end of the century, and changes for other three seasons, are similar to the change of mean daily temperature.

Figure 5-27. Future minimum daily temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP2.6 scenario.



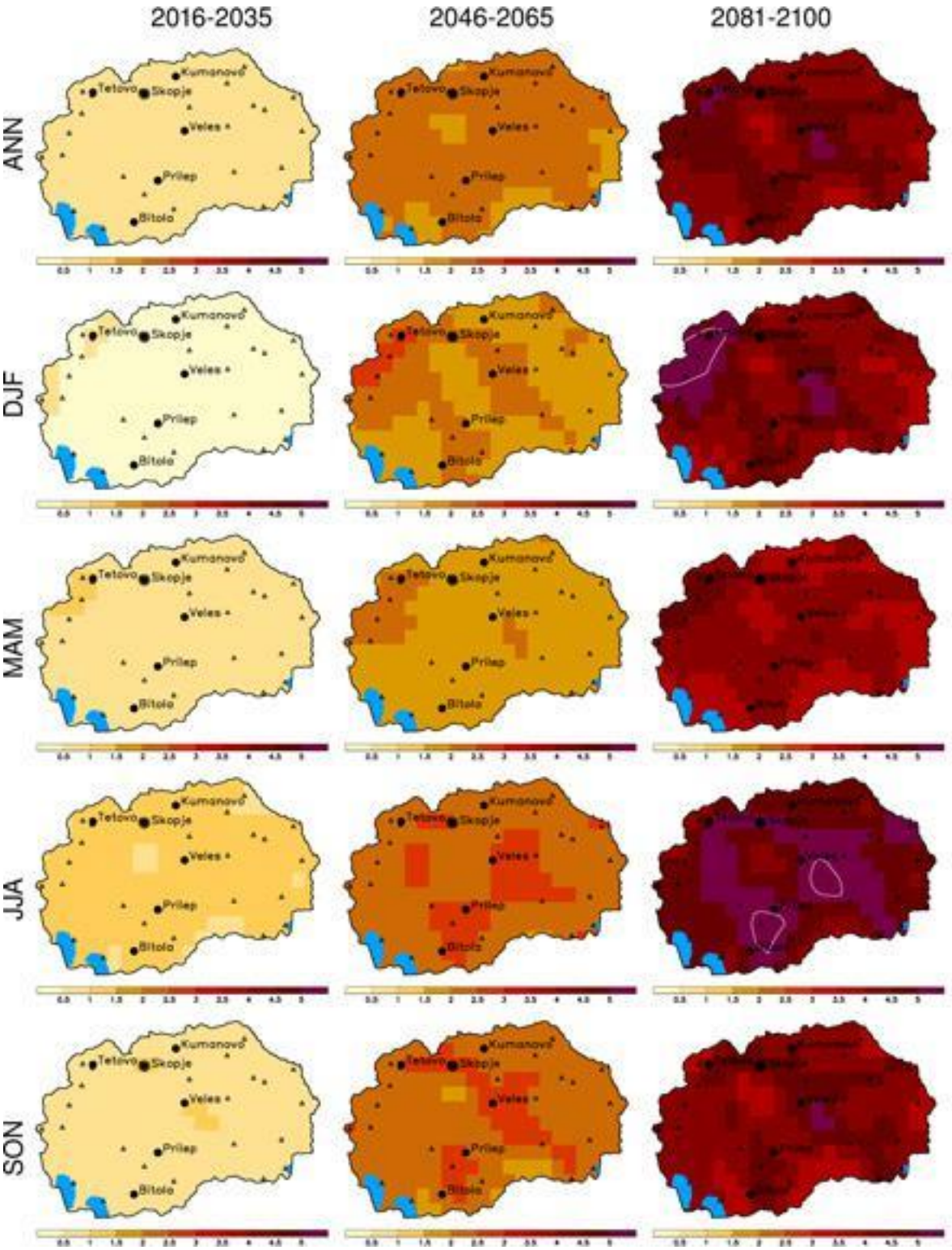
For scenario RCP4.5 (Figure 5-28) **minimum daily temperature will continuously increase, from about 1** °C in the near future to more the 2.5 °C by the end of the century. Summer is the seasons with the highest increase for the period at the end of the century, with some areas in which increase is above 2.5 °C, and changes for other three seasons, are similar to the change of mean daily temperature for same scenario.

Figure 5-28. Future minimum daily temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP4.5 scenario



For scenario RCP8.5 (Figure 5-29), minimum daily temperature will continuously increase, from about 1 °C in the near future to more the 5 °C by the end of the century. Again, summer is the seasons with the highest increase, and changes for other three seasons, are similar to the change of mean daily temperature.

Figure 5-29. Future minimum daily temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP8.5 scenario. White line represents 5.5 °C isoline



For the three future periods, annual and seasonal **maximum daily temperature change** is given in Figure 5-30, Figure 5-31 and Figure 53-2, for the RCP2.6, RCP4.5 and RCP8.5 scenarios, respectively, for the 21st century. Changes are similar to the change of mean daily and minimum daily temperature and it is form about 1 °C for the beginning of the century to 1.5 °C for the end of century for RCP2.6 (Figure 530) and form 1 °C to 5 °C by for the RCP8.5 scenario (Figure 532). On the other hand, the amplitude of change is to certain extent higher in comparison to annual and seasonal average of the mean and minimum temperature. Comparing all three temperatures it is expected that change will be highest for maximum, then for mean daily, and finally from minimum daily temperature.

Figure 5-30. Future maximum daily temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP2.6 scenario

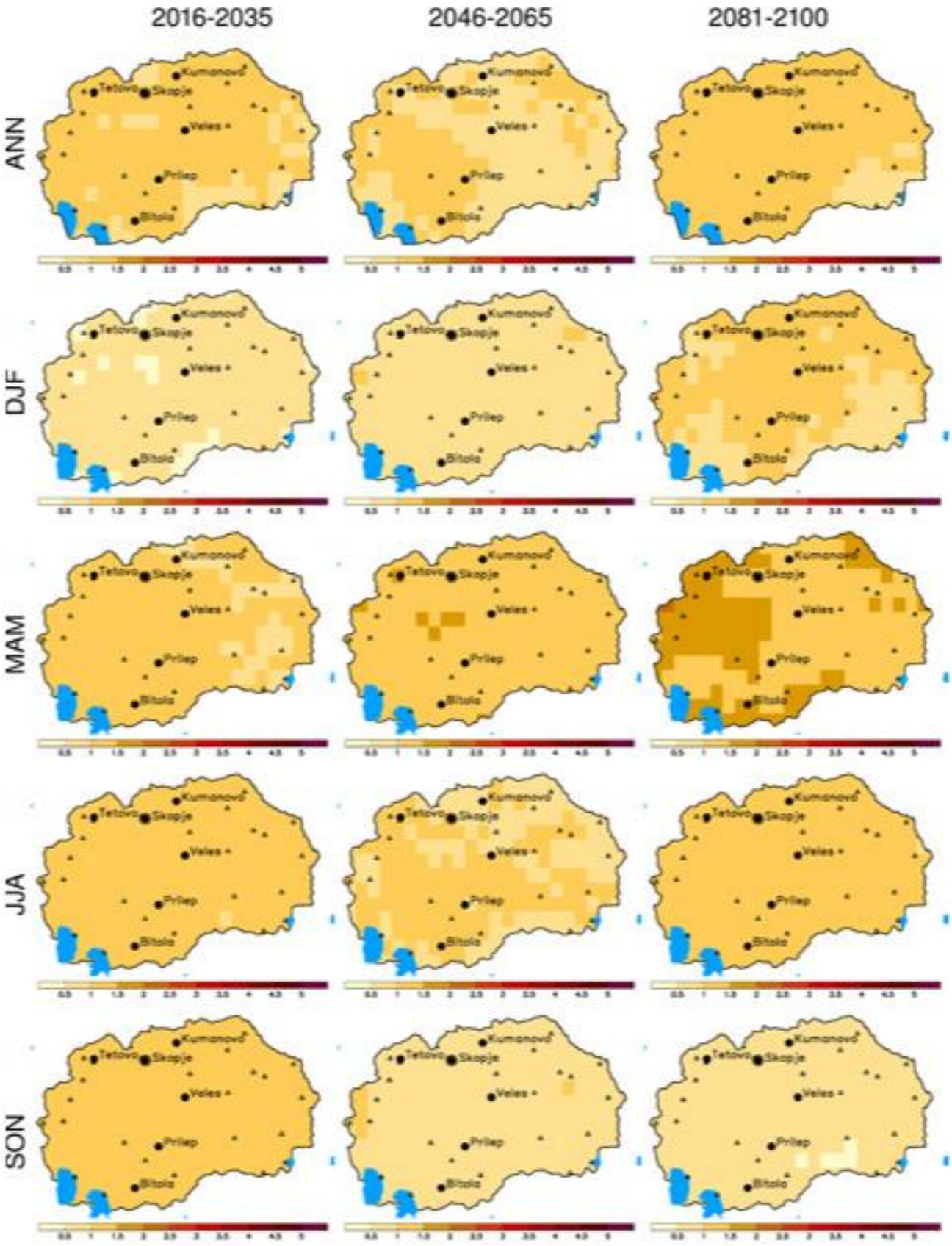


Figure 5-31. Future maximum daily temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP4.5 scenario

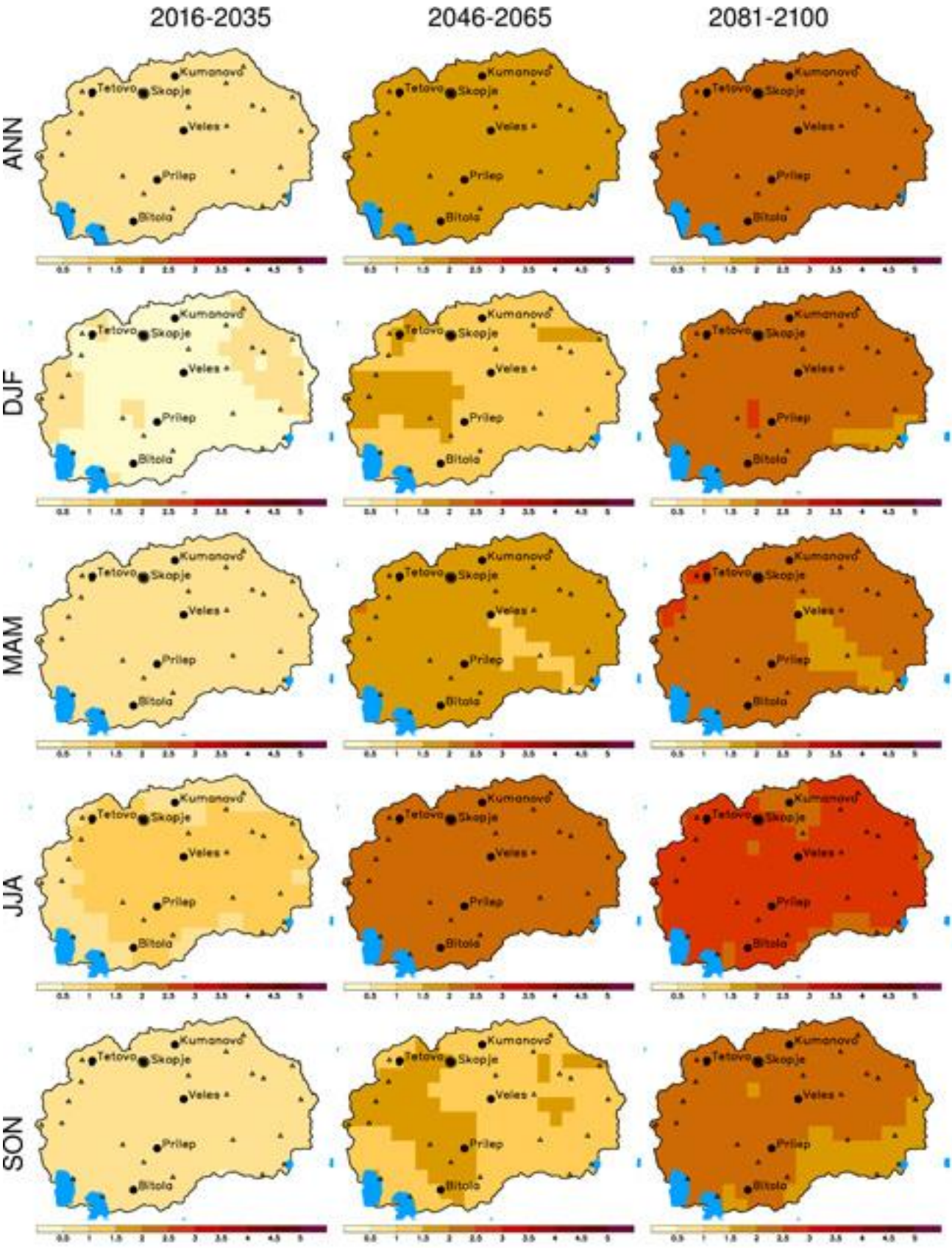
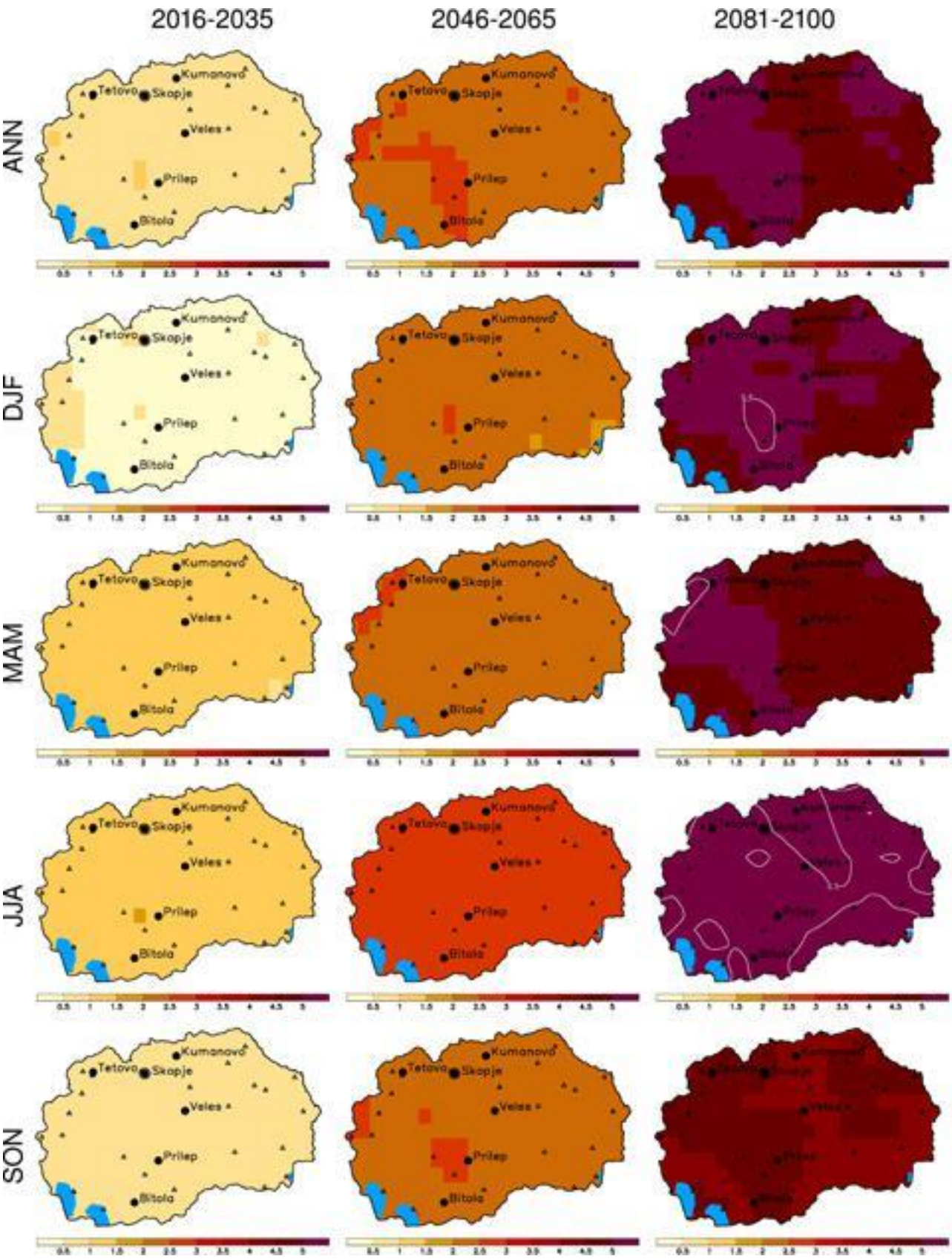


Figure 5-32. Future maximum daily temperature change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for the RCP8.5 scenario. The white line represents 5.5 °C isoline

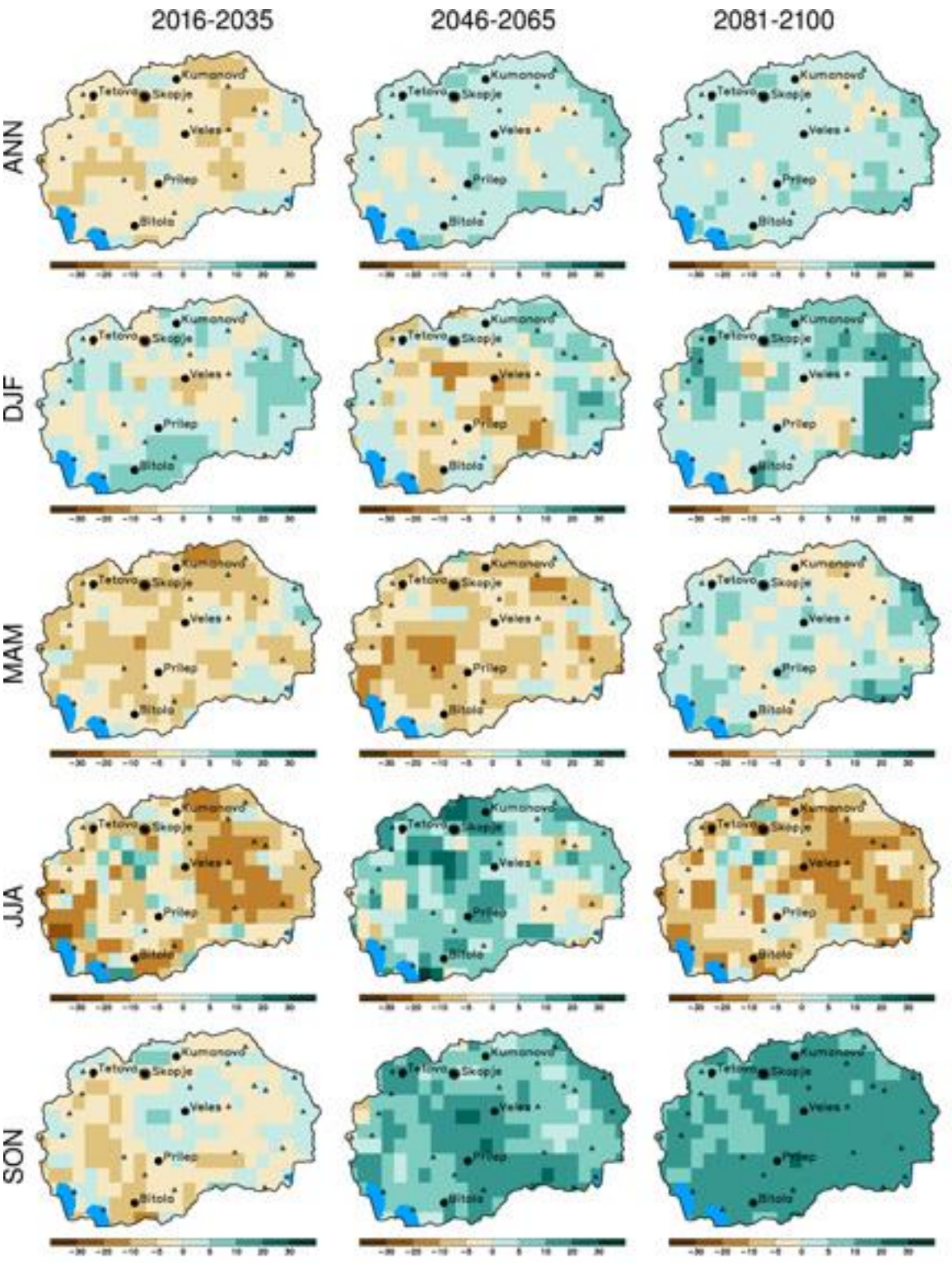


For projections of mean, minimum and maximum temperatures, it is clear that future changes in GHG concentrations play a dominant role in causing climate change in Macedonia.

5.1.2.3 Projections for precipitation

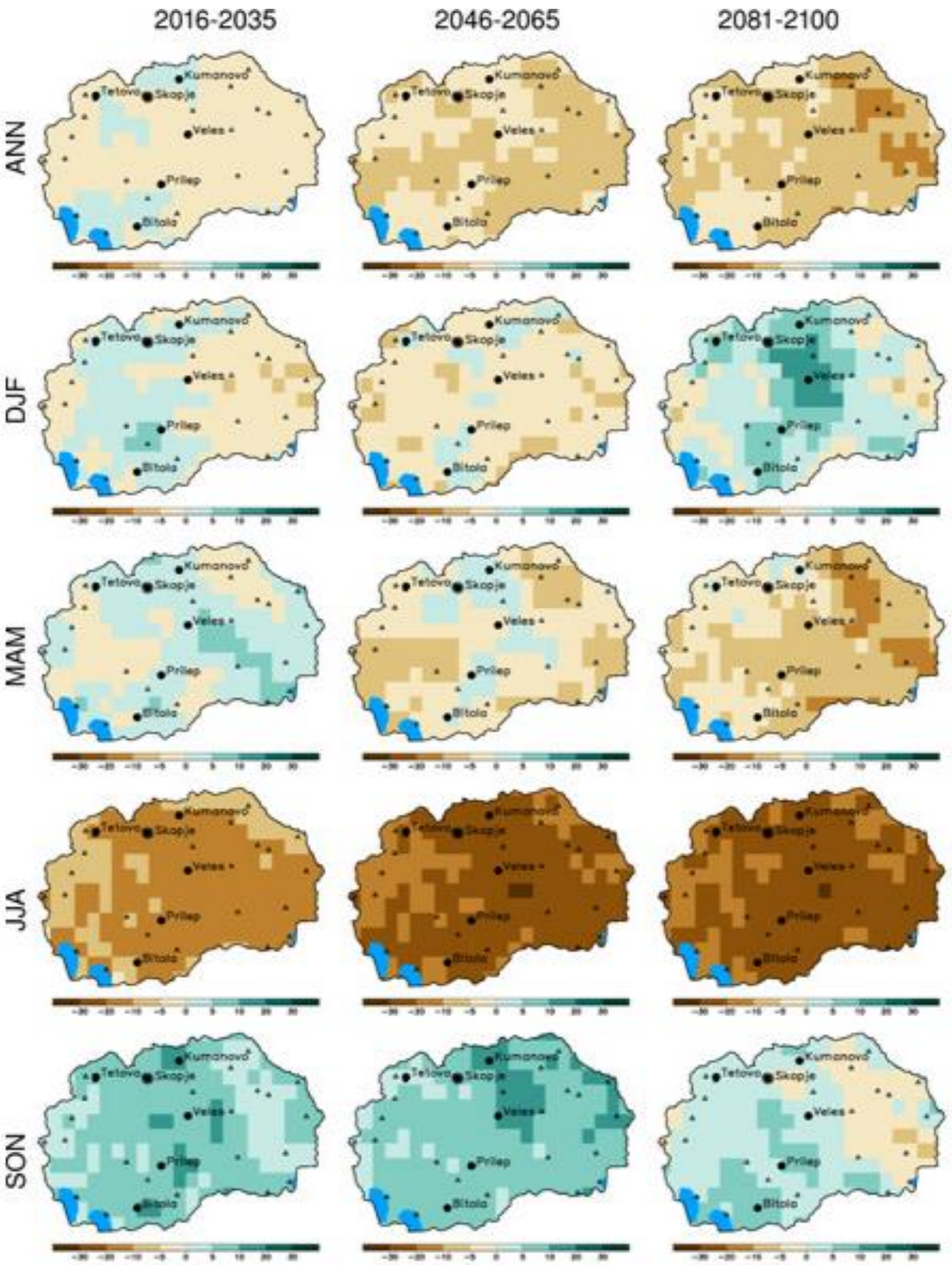
For the three future periods, annual and seasonal **precipitation change** for three future scenarios, RCP2.6, RCP4.5 and RCP8.5 are given in Figure 5-33, Figure 5-34 and Figure 53-5 respectively. For RCP2.6 (Figure 5-33) an increase of precipitation is expected for the middle and end of century, although this change is positive but not significant. Changes in winter and spring precipitation are not significant in amplitude and do not show a regular pattern. However, for summer an increase is projected by the middle of century, but a significant decrease of up to 20% is projected by the end of century. Finally for autumn a clear pattern of positive increase of +20% is projected by the end of the century.

Figure 53-3. Future precipitation change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for RCP2.6 scenario



In the RCP4.5 scenario (Figure 5-34) for all three future periods a decrease in annual, spring and summer precipitation is expected, which is clearly pronounced for the summer season which has a decrease higher then 20%. In autumn, an increase is expected for first two periods over the majority of the territory, but for the last period a decrease is projected. For winter there are no clear trends since for all three periods +/-5% of change is dominant over the majority of the territory.

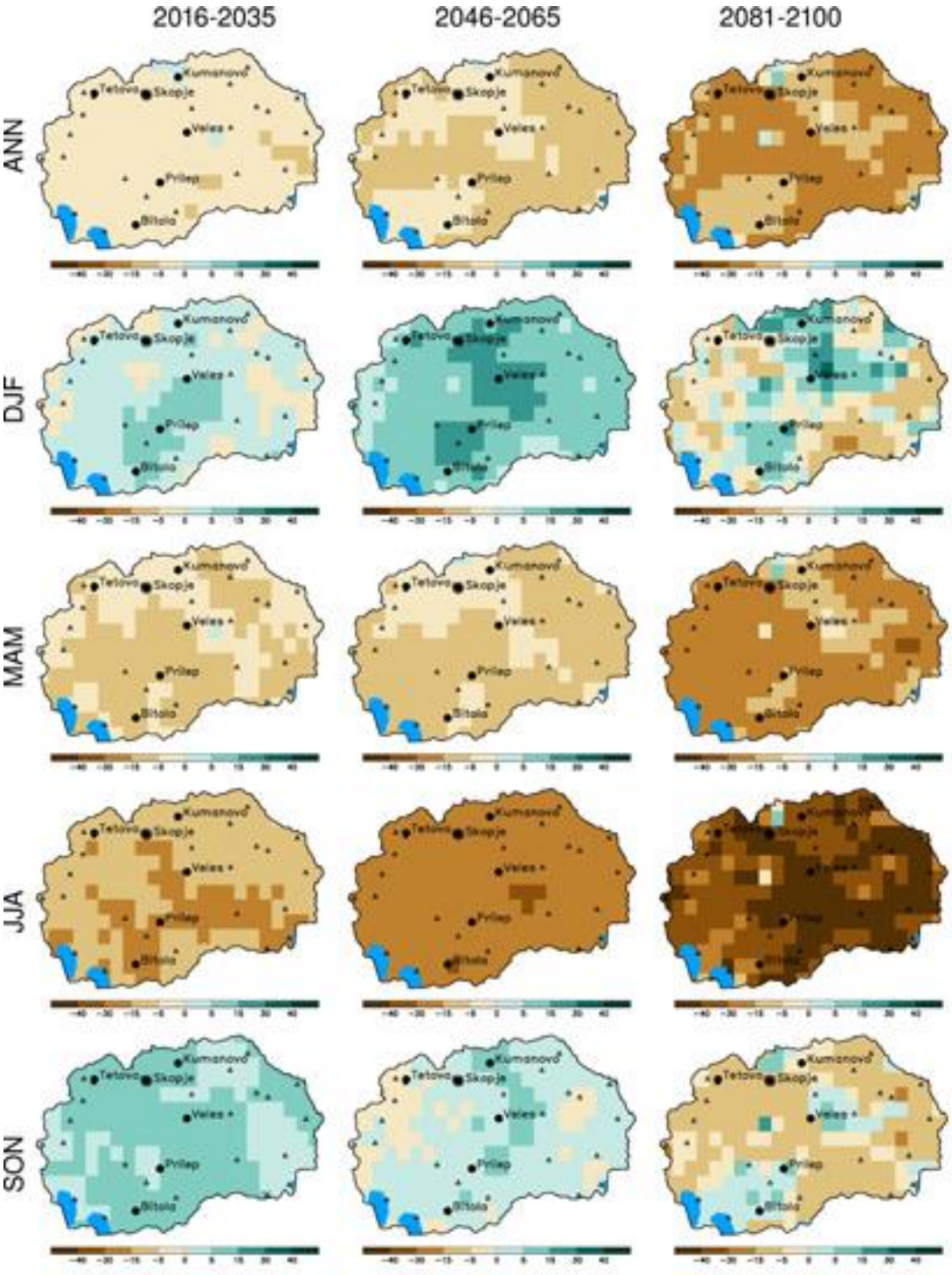
Figure 5-34. Future precipitation change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for RCP4.5 scenario



For the scenario RCP8.5 (Figure 5-35) for all three future periods a decrease in annual, spring and summer precipitation is expected, which is clearly pronounced for the summer season, with a decrease higher than 40% in some regions. For winter and autumn, for the first two periods an increase is expected over the majority of territory, but for the last period for the winter season, about half of country has an increase and half a decrease, and for autumn a decrease of up to 15% is projected.

It is interesting that RCP8.5 and RCP4.5 scenarios have more similarities in terms of precipitation change in comparison with RCP2.6, which lead us to the conclusion that again, future concentrations of GHGs (stabilization scenario or non/stabilization), will play a major role in future precipitation changes in North Macedonia.

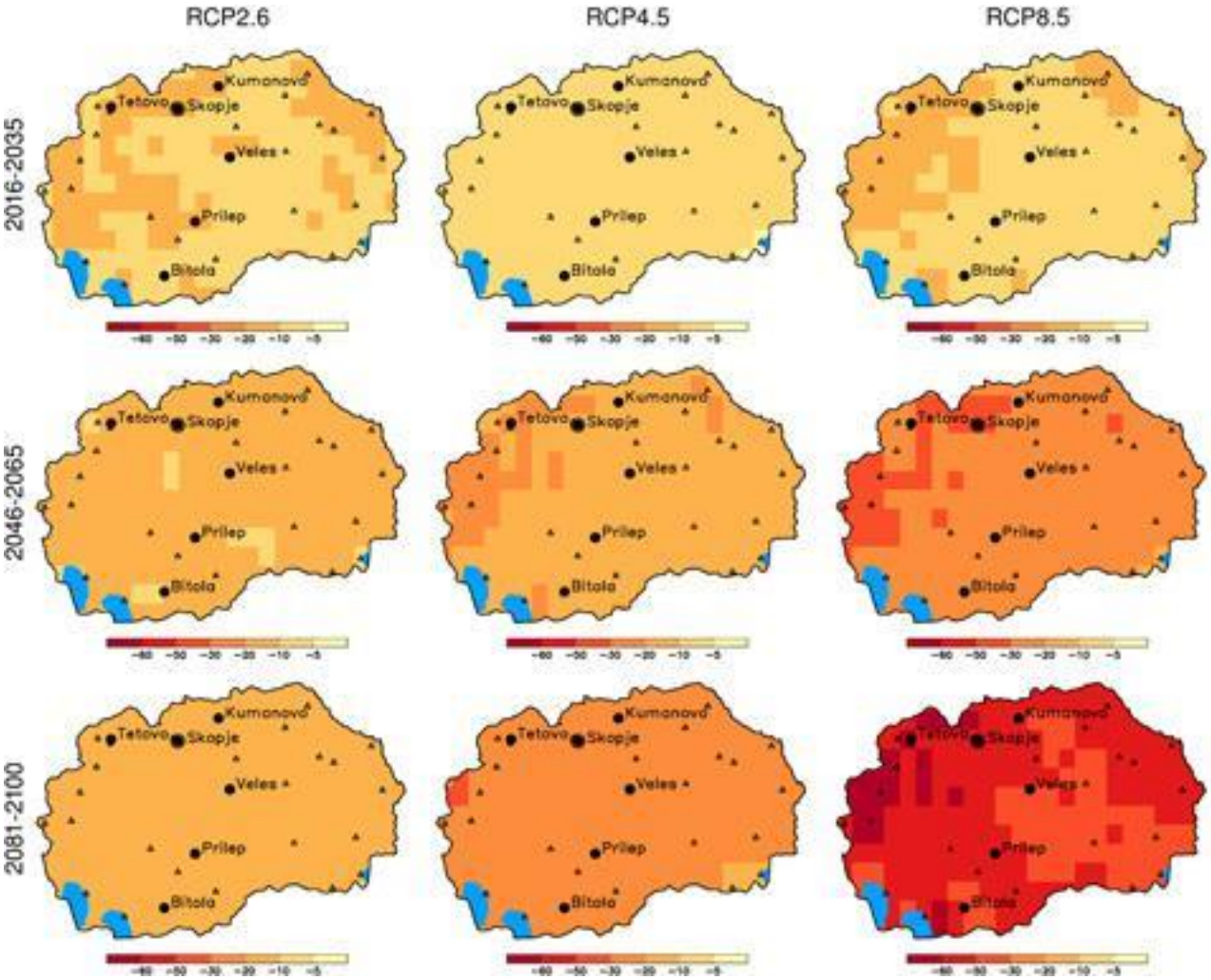
Figure 5-35. Future precipitation change, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005, on annual level and for winter (DJF), spring (MAM), summer (JJA) and autumn (SON), for RCP8.5 scenario



5.1.2.4 Extreme climate indices

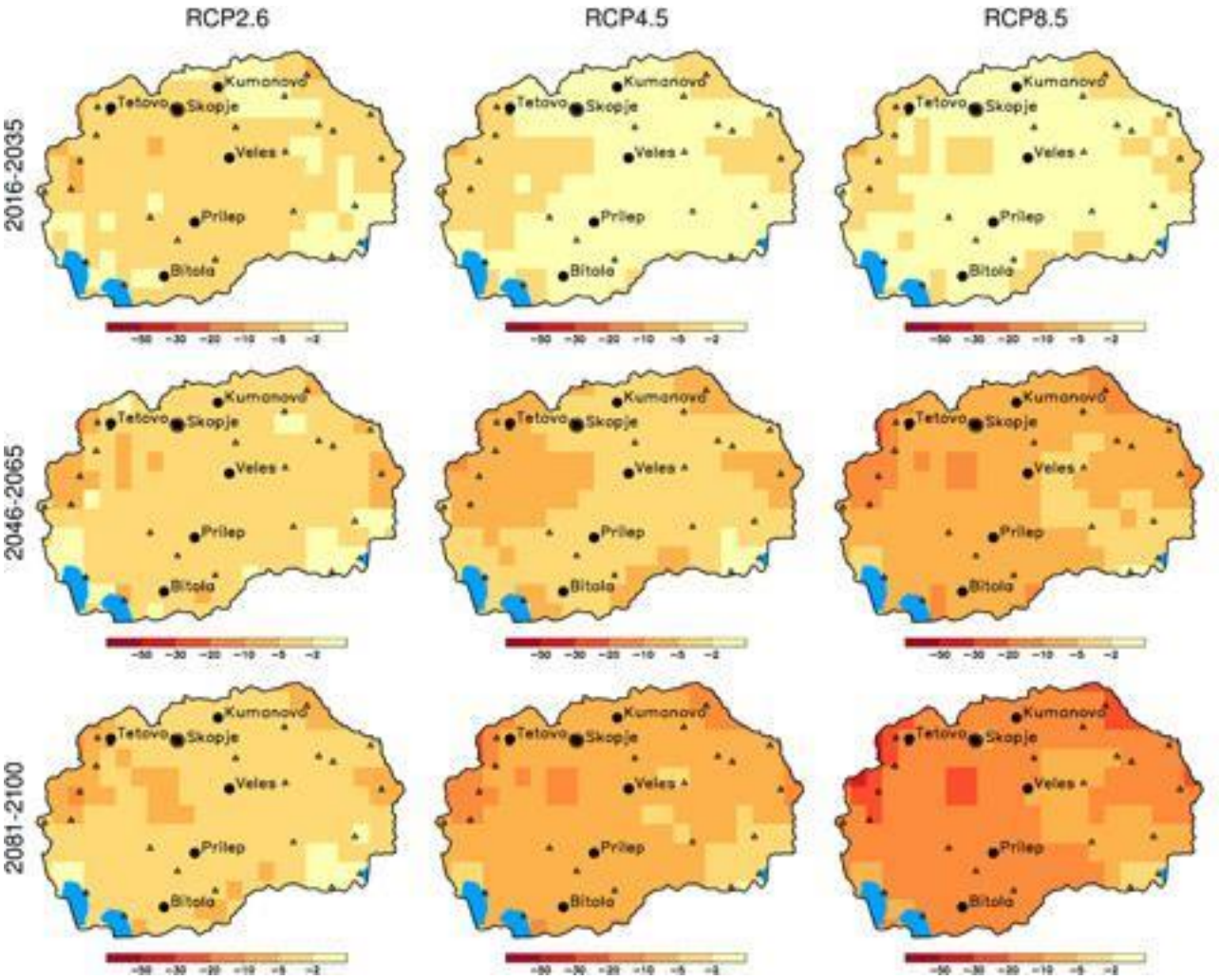
Frost days: In Figure 536, the annual change in the number of frost days (FD) is presented for three future periods, for RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios. In the near future, a decrease of between 10-20 days is expected for all scenarios. For the *low* scenario, this decrease in frost days will be constant up to 2100. However, for mid and high emission scenarios, there will be a greater number of frost days of approximately 20-30 days. More pronounced and widespread decreases of > 50 days are expected under a *high* scenario during the 2081-2100 period compared to the 1986-2005 period. The biggest decreases are simulated over higher altitude areas, which is partly due to the higher frost days experienced in these areas under the present (1986-2005) period and partly due to the increases in minimum temperatures experienced during DJF under this scenario (see Figure 5-29).

Figure 5-36. Future annual change in frost days, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



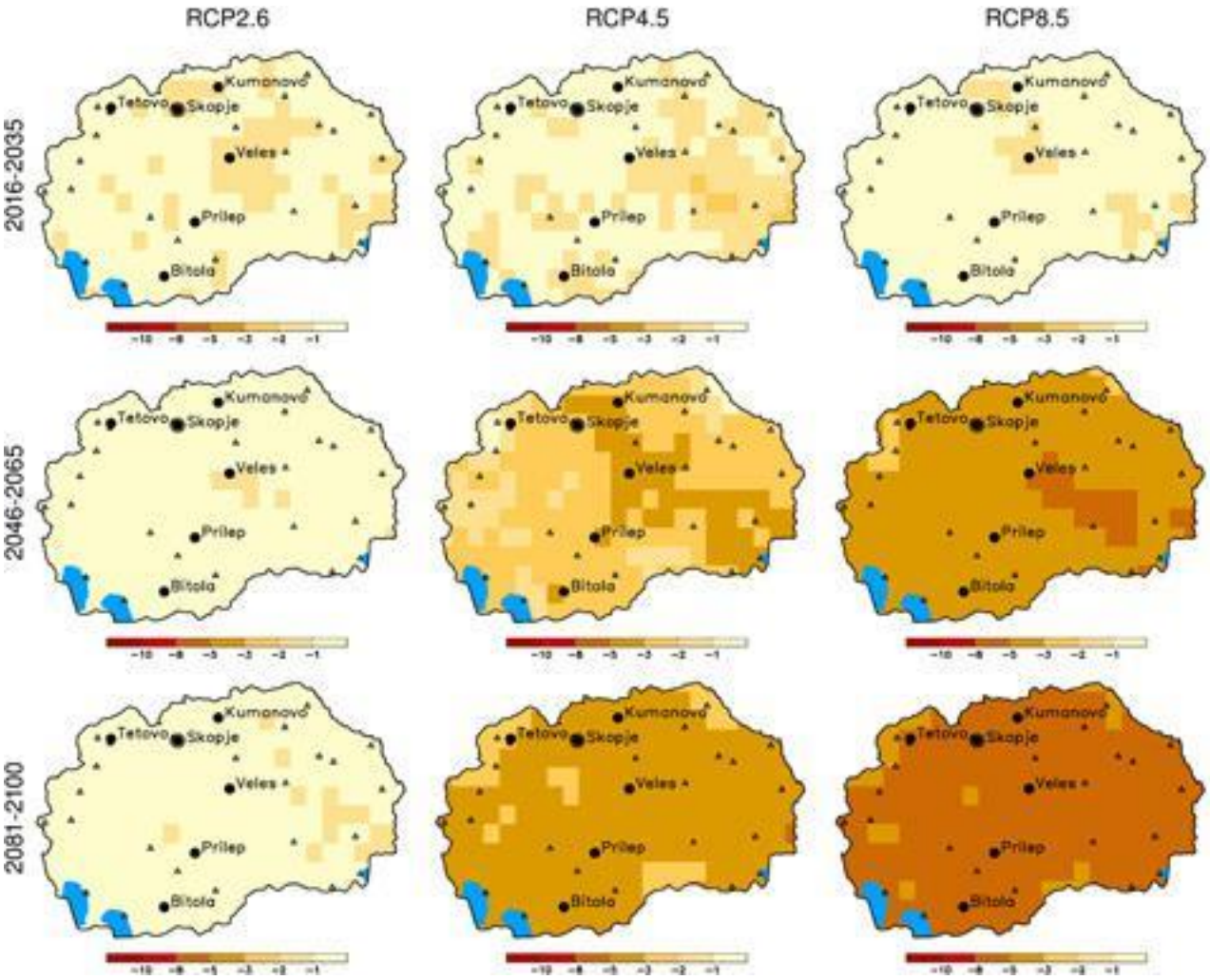
Ice days: In Figure 5-37, the annual change in ice days (ID) is presented for three future periods for the RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios. The number of the ice days is expected to the decrease, for all scenarios and future periods. The change is very similarly to decrease in frost days (Figure 5-36), but the change is lower since the number of ice days is generally smaller in both the current and future periods when compared to the number of frost days.

Figure 5-37. Future annual change in ice days, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



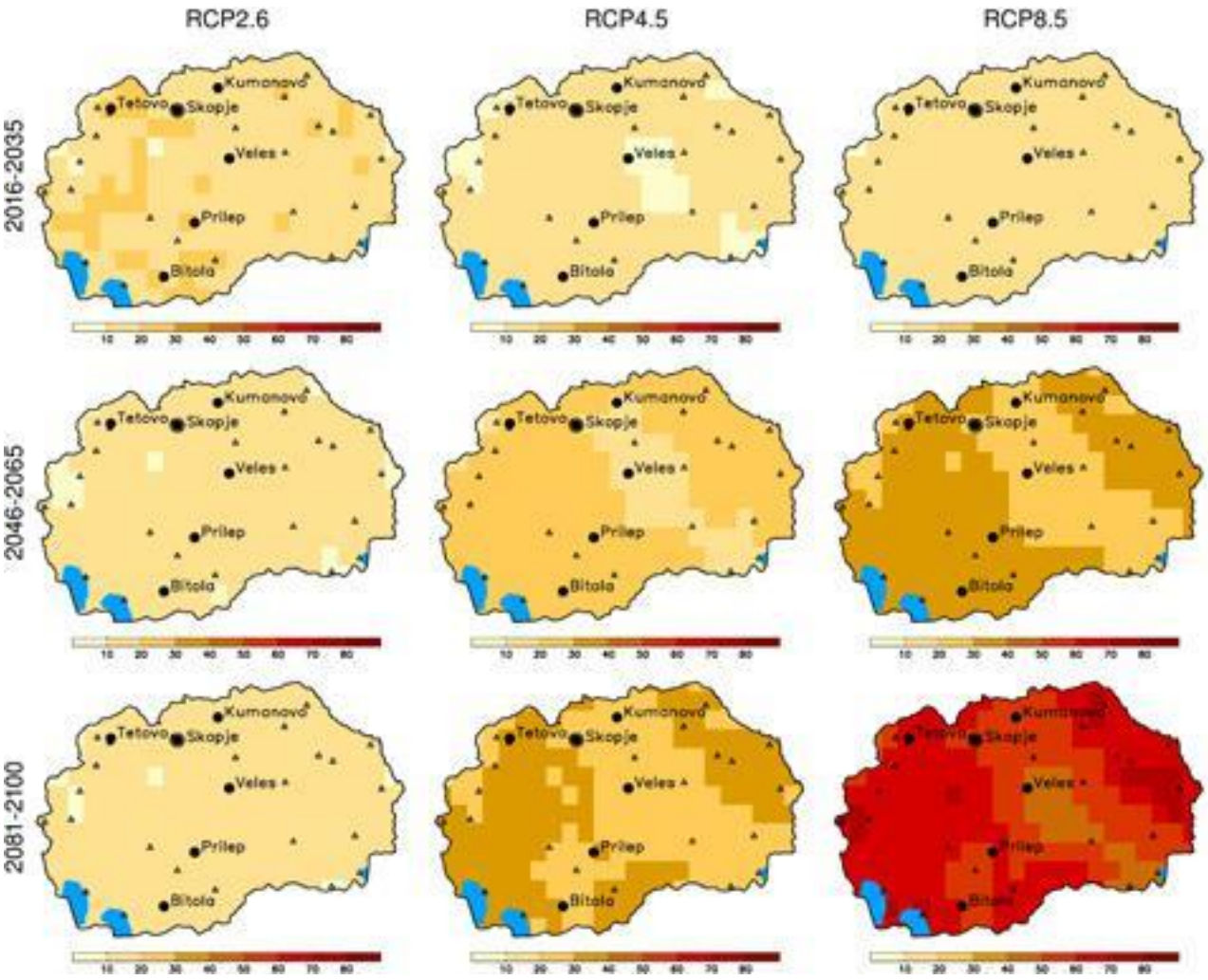
Cold waves: In Figure 5-38, annual changes of cold waves are presented for three future periods, for the RCP2.6 (*low),* RCP4.5 *(mid)* and RCP8.5 *(high)* scenarios. Trends are very similar to the changes in frost days and ice days. For the near future the expected decrease is same for all scenarios and is approximately one day shorter (with maximum change of -3 days). By 2100, the biggest change is under the *high* scenarios, where cold waves are up to 8 days shorter on average over 20 years, which means that cold waves will be almost non-existent under RCP8.5.

Figure 5-38: Future annual change in cold waves (CSDI), for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



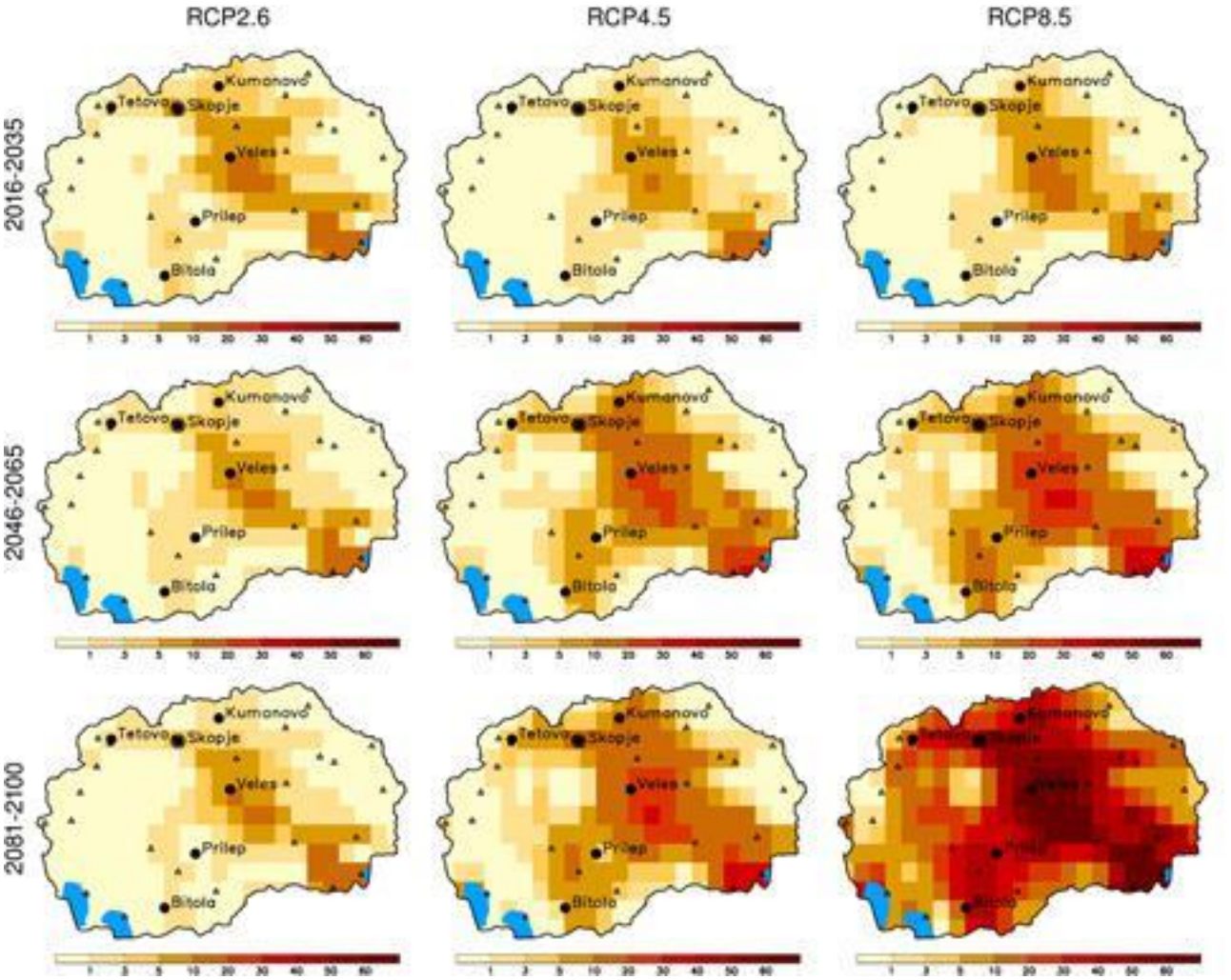
Summer days: In Figure 5-39, the annual change in summer days (SU) is presented for three future periods, for the RCP2.6 (*low)*, RCP4.5 *(mid)* and RCP8.5 (*high)* scenarios. The number of the summer days is expected to increase up to 20 days for the *low* scenario in all three periods. For all three scenarios changes are the same for near future. For the *mid* scenario further increases are expected up to 30 days by the middle of the century, and up to 40 days by the end of the century. For *high* scenario the changes for the middle of the century are very similar to changes of *mid* scenario for the end of the century, but for the last period the changes are larger, and for the majority of the territory, expected increases are about 60 to 70 days, in comparison to the 1986-2005 period.

Figure 5-39: Future annual change in summer days, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



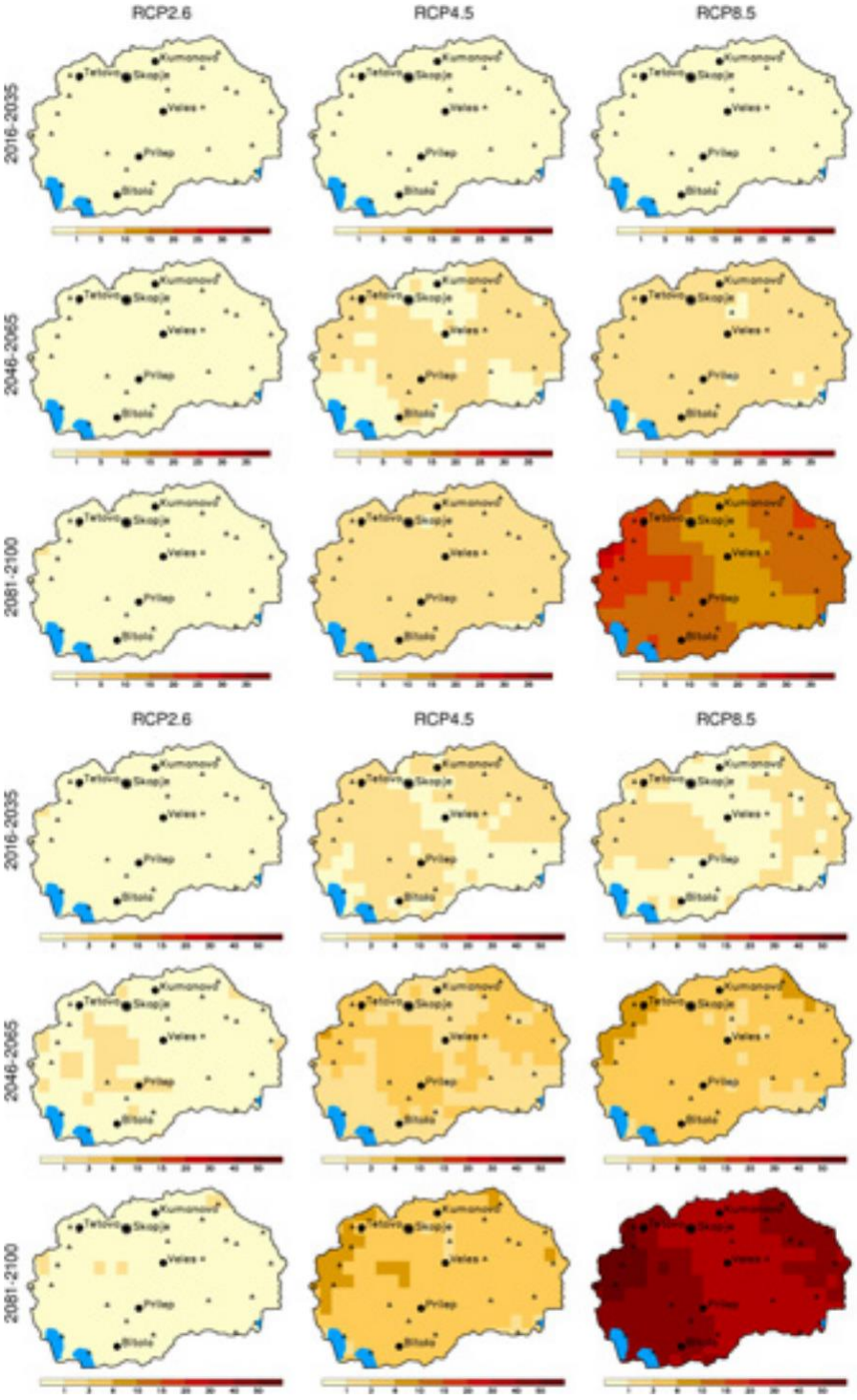
Tropical nights: In Figure 5-40, annual changes in tropical nights (TR) are presented for three future periods for the RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios. Projections clearly show an increasing trend of tropical nights, with a higher number in lower altitudes. For the near future, changes are the same for all scenarios with approximately 5 more days of tropical nights, with a maximum of 10 days. In the other two periods, the changes are the same under the *low* scenario, but for *mid* and *high* scenarios the maximum reaches an increase of 30 days of tropical nights for the period 2046-2065. Finally, for the end of the century and high scenario the maximum increases in low altitude areas are +60 days, and in the mountains approximately +10 days.

Figure 5-40. Future annual change in tropical nights, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



Heat waves: In Figure 5-41, the annual change in extreme heat waves (WSDI index) is presented for three future periods, under RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios. The duration of the heat waves (upper panel) is expected to be the same in the future for the RCP2.6 but is expected to increase for the other two scenarios. For the *high* scenario and for the last period over the majority of the territory, heat wave durations are projected to increase by approximately 20 days, in comparison to 1986-2005 period. The number of heat waves (lower panel) is expected to also increase; on average one more event for RCP2.6, but more events for other two scenarios. For the *mid* scenario change for the last period is the same as the change for the high scenario for the middle of century, and it is about 6 more events during 20-year period. For the last period and high scenario on majority of the territory, there is significant increase up to 40 more events in 20-year period.

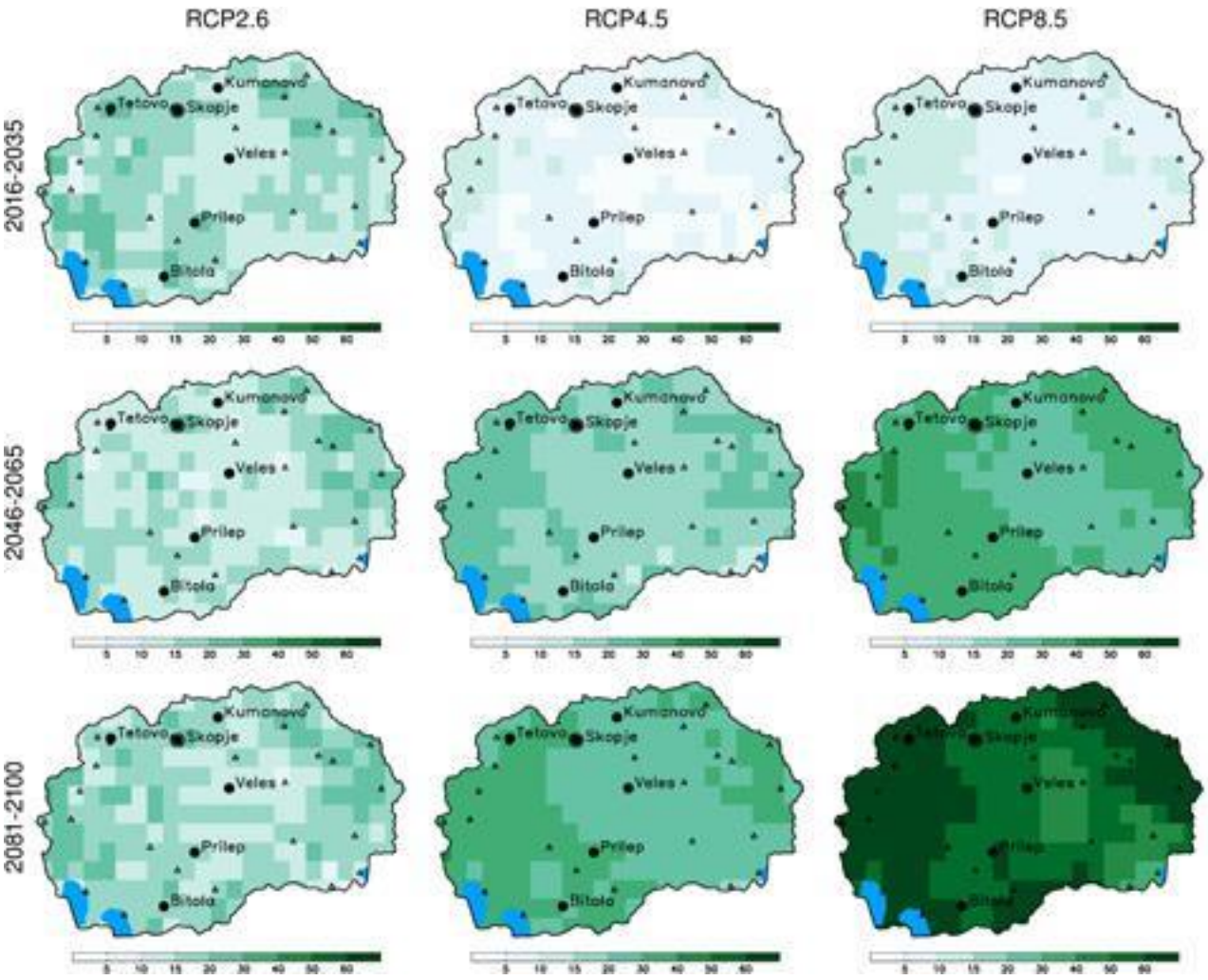
Figure 5-41. Future annual change in extreme heat waves (WSDI), for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



The upper panel shows the heat wave duration change, and the lower panel shows the frequency of the heat waves (number of events in 20 years period)

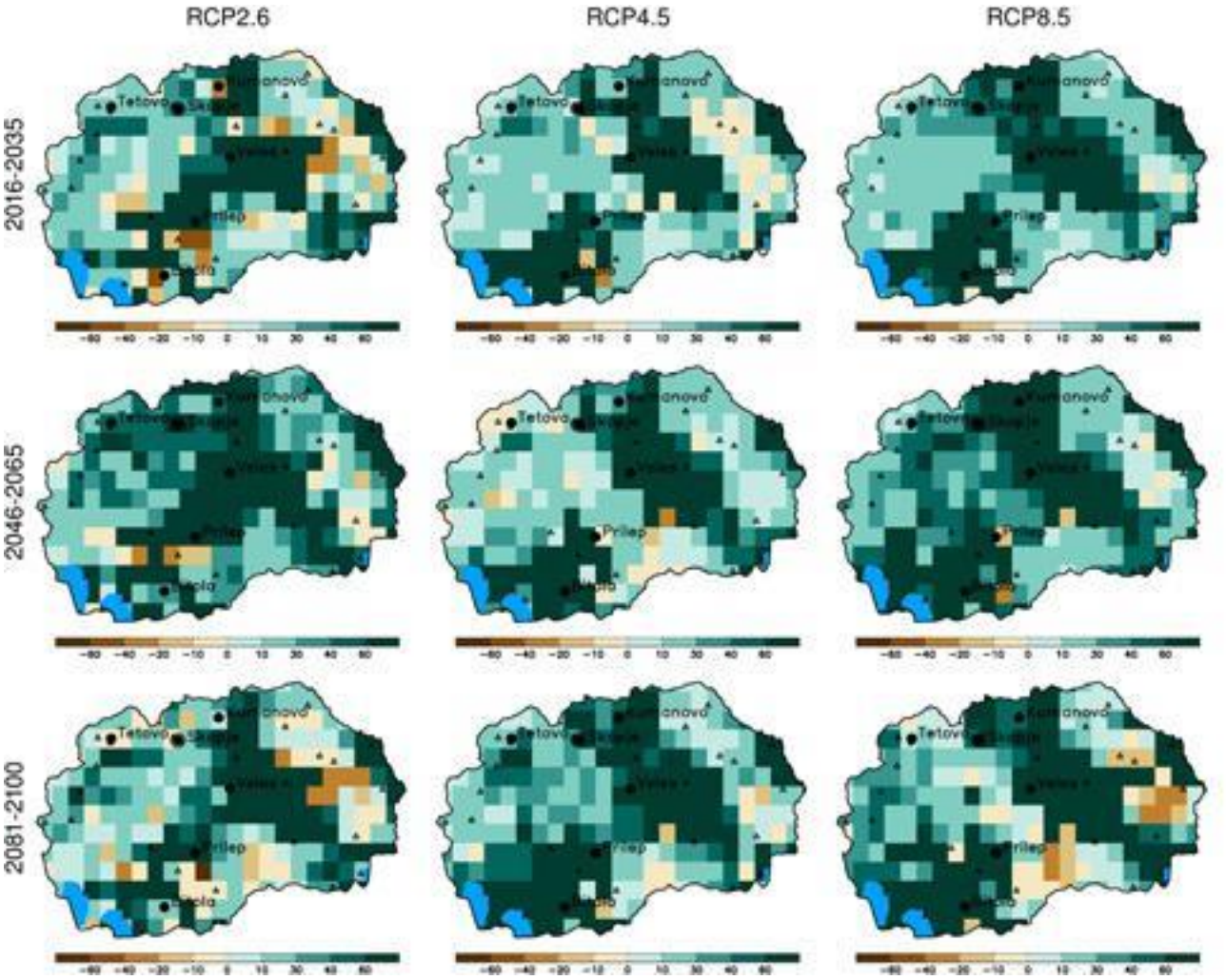
Growing season length: In Figure 5-42, for the RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios, annual change in growing season length (GSL) is presented for three future periods. The growing season is expected is expected to the increase 10-20 days for low scenario in all three periods. For all three scenarios change is similar for the near future. For the *mid* scenario further increase is expected up to 30 days, for middle of the century, and up to 40 days for the end of the century. For *high* scenario the change for the middle of the century is very similar to change of *mid* scenario for the end of the century, but for the last period increases are on average highest and cover the majority of the territory; expected increases are from 40 to 60 days, in comparison to 1986-2005 period.

Figure 5-42. Future annual change growing season length, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



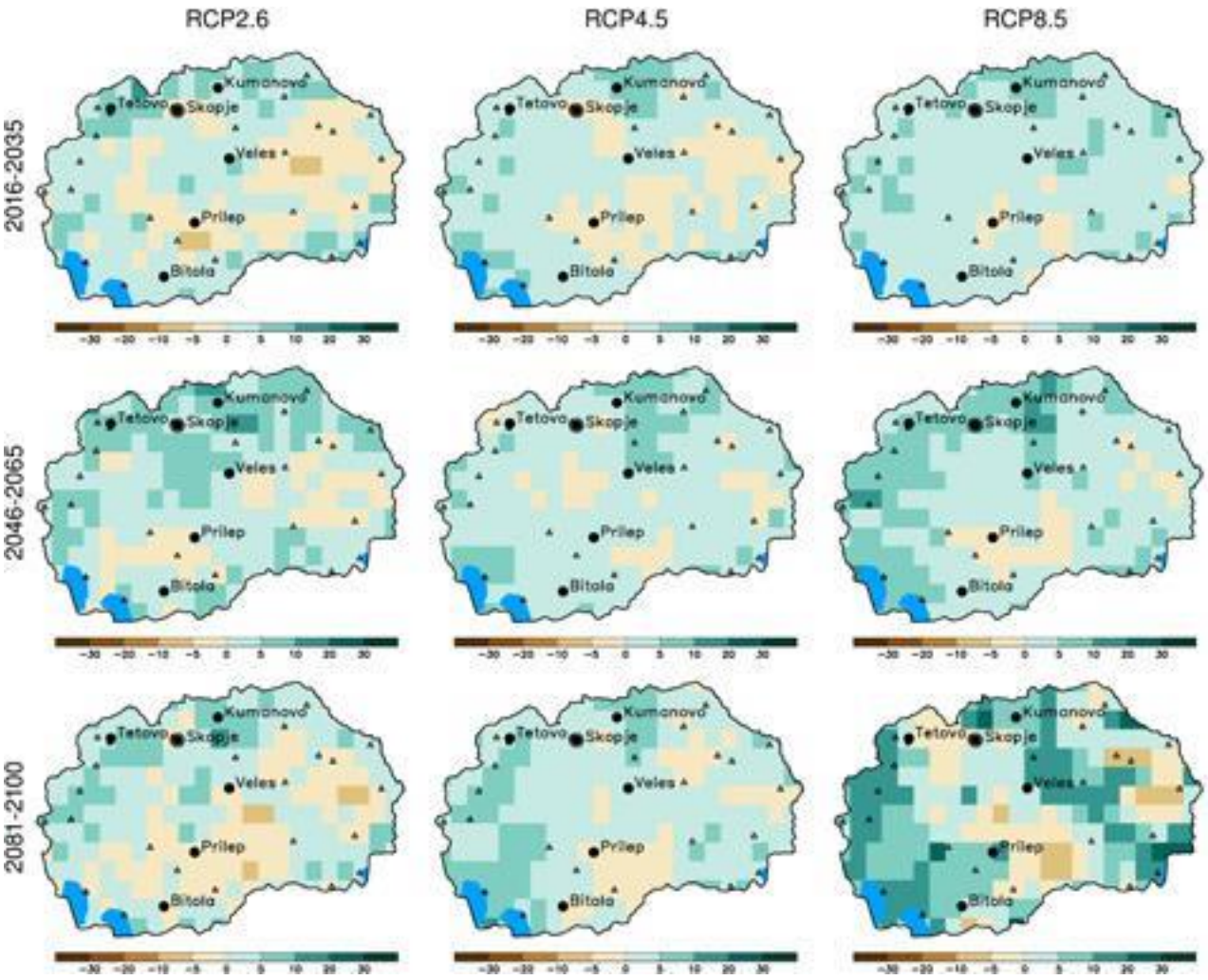
Extreme precipitation: In Figure 5-43, for the RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios, annual change in number of days with extreme precipitation (days with daily precipitation above 40 mm) is presented for three future periods. The number of extreme events is expected to the increase in comparison to 1986-2005 period for all periods and all scenarios. Due to the warmer atmosphere that can holds more water vapor, the increase in many parts of the country is higher than 60% more of these days in all three future periods. It is indicative that maximum change is present in same areas predominantly in low altitude part of the country and in the south-west.

Figure 5-43. Future annual change in number of extreme precipitation events (RR40), for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



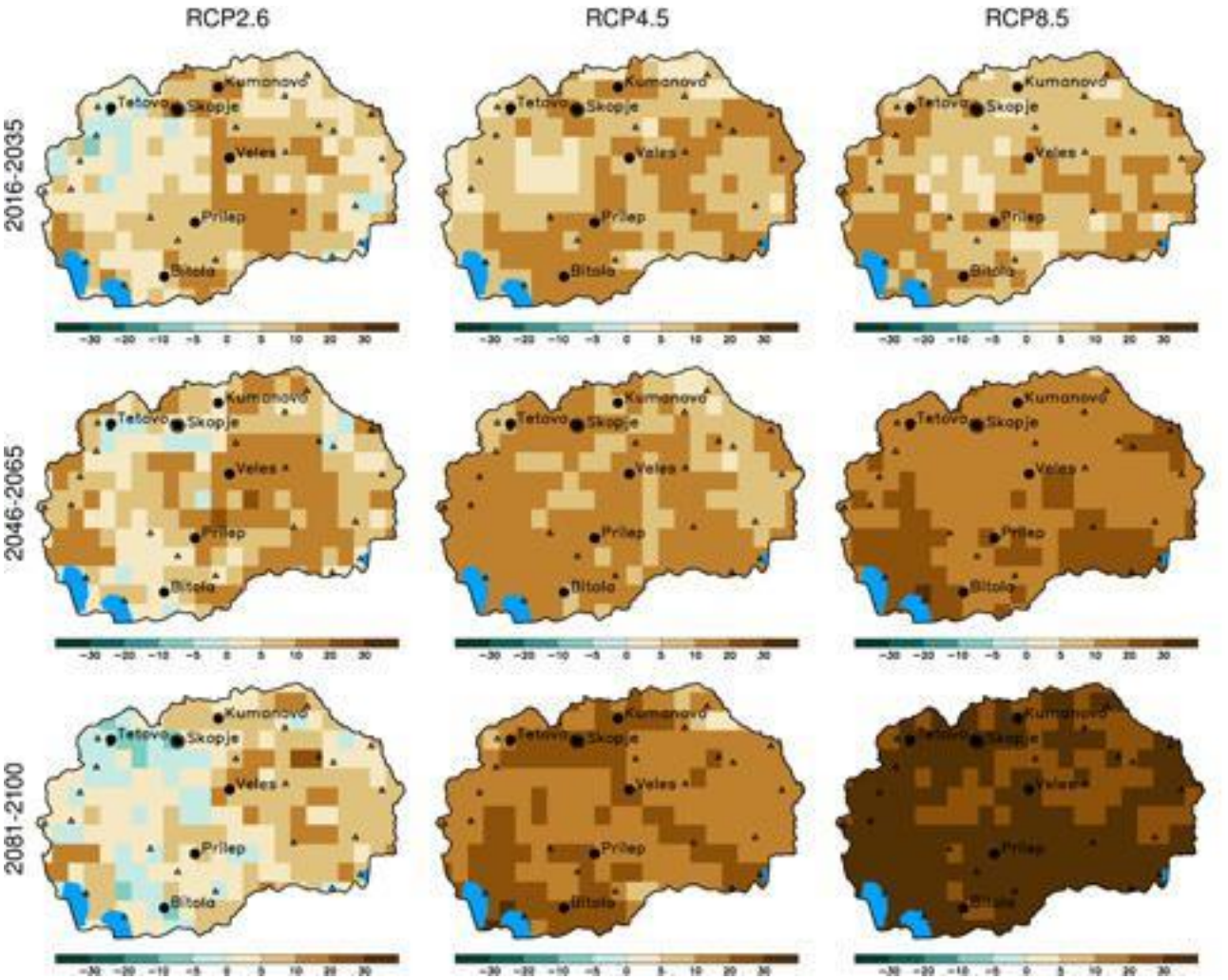
In Figure 5-44, for the RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios, annual change in daily maximum precipitation accumulation (RX1D) is presented for three future periods. The daily extreme precipitation is expected to the increase in comparison to 1986-2005 period, over majority of the territory. The change is similar for all scenarios and all future periods. For the near future increase is about 0-10% (with some areas expected to experience reductions in magnitude), and for the middle of the century increases are expected in northern and western parts to be above 10%. Similar changes are expected for the end of the century for *low* and *mid* scenario. For the high scenario for the end of the century increases in some places are expected to be higher, reaching approximately 20% greater precipitation amounts.

Figure 5-44. Future change in annual daily extreme precipitation change (RX1D), for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



Consecutive dry days: In Figure 5-45, for the RCP2.6 (*low*), RCP4.5 (*mid*) and RCP8.5 (*high*) scenarios, the annual change in consecutive dry days index is presented for three future periods. The number of consecutive dry days is expected to the increase in comparison to 1986-2005 period, and for the last period in majority of the territory, and for the *high* scenario, the length will increase for more than 30 days indicating a higher risk of drought. For the *mid* scenario in the last period, the length will increase by up to 30 days, and for the low scenario in the last period, the length will increase up to 20 days.

Figure 5-45: Future annual change in consecutive dry days, for three future periods, 2016-2035, 2046-2065 and 2081-2100 with respect to the period 1986-2005 for the RCP2.6, RCP4.5 and RCP8.5 scenarios



In summary, the following climate change projections are expected:

A. Temperature
- Temperature Increase (average, minimum and maximum)
- Increase of hot extremes
- Decrease of cold extremes

B. Precipitation
- Annual Decrease (for RCP8.5 scenario)
- Redistribution in annual cycle
- Less summer precipitation (risk of drought)
- Increase in number and intensity of extremes (risk of floods)

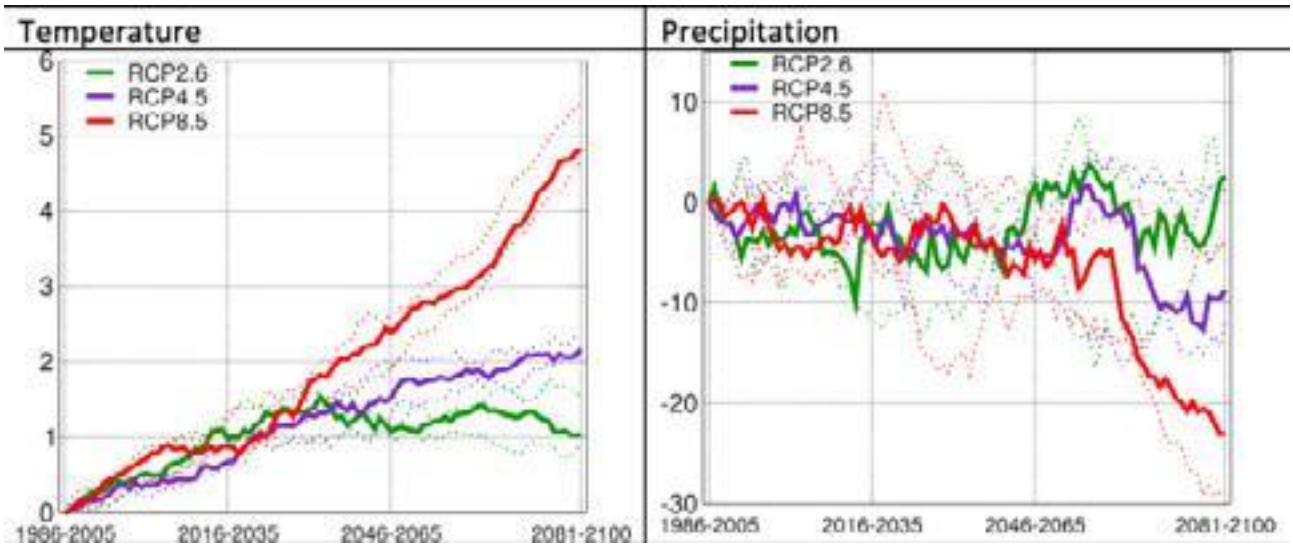
5.1.3 Climate projections and extremes in Skopje region

Mean annual temperature and precipitation temporal change for Skopje region are given in Figure 5-46 for scenarios RCP2.6 (low), RCP4.5 (mid) and RCP8.5 (high).

Temperature: For all scenarios increase in future temperature is expected. In the first half of the century there is no significant difference for different scenarios and expected temperature increase is between 1 and 1,5 °C, on the other hand for the end of the century increase in temperature is 1 °C, 2 °C and 5 °C, for low, mid and high scenarios, respectively, clearly indicating that future evolution in temperature is determined by future concentration of GHGs

Precipitation: For precipitation change, again in the first half of the century, results are similar for all scenarios giving annual precipitation change between 0 and -5 %. Full ensemble range is from +5% to -10% indicating higher chances for drier condition. For the second half precipitation change is clearly negative for high scenario up to -20%, and mid scenario -10%, but for low scenario precipitation change about zero.

Figure 5-46: Change in temperature (in °C) and precipitation (in %) for consecutive 20-year periods starting from 1986-2005 to 2081-2100, with respect to period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5



Tick lines are mean value of selected multi model ensemble, and doter lines are ensemble range from 25th to 75th percentile.

Frost and ice days: For all scenarios decrease in future frost and ice days is expected, which is not surprising since that increase in mean annual temperature is expected. In the first half of the century there is no significant difference for different scenarios and expected decrease in frost days is about -20 days, on the other hand for the end of the century decrease in frost days for high scenario is about -60 days. Expected decrease in ice days is about -3 days for all scenarios for the middle of century, and for the end of the century change is about -10 days for high scenario, -6 days for mid scenario and -3 and days for low scenario.

Cold waves: For all scenarios decrease in future cold waves duration is expected. In the first half of the century there is no significant difference for different scenarios and expected decrease cold wave duration is about -3 days on average. For the end of the century decrease in cold wave duration is 3, 3 and 6 days for high, mid and high scenarios respectively.

Summer and tropical nights: For all scenarios increase in future summer days and tropical nights is expected. In the first half of the century there is no significant difference for different scenarios and expected increase in summer days is from 20 to 30 days, on the other hand for the end of the century increase in summer days for high scenario is about 55 days. For low scenario increase is expected to stay the same, and for mid scenario for the end of the century increase is 30 days. Expected increase in tropical nights is 5 to 10 days for all scenarios for the middle of century, and for the end of the century change is 40 days for high scenario 2 days for low and 10 days for mid scenarios.

Heatwave duration: The change is very similar up to period 2046-2065, with increased duration of heat waves od about 1 day. After this period there is significant increase in heat waves duration for high scenario, and for the end of the century increase in duration is between 9 and 12 days, for mid scenario the increase is about 1 days and for the low scenario no change is present.

Consecutive wet days: For number of days with precipitation above 40 mm, overall positive change is present for all scenarios, for majority of future periods. For high scenario, upper limit of ensemble spread above 100%, which means that doubling of these days is potentially possible in the future. Similar conclusion can be applied for maximum daily accumulation, for mid and high scenario ensemble spared is predominantly positive, and for the low scenario, spread is evenly distributed on positive and negative change. Maximum of change in terms of upper limit of ensemble spread is between +5% and +10%, for the end of the century, for mid and high scenario.

Consecutive dry days: For low and mid scenario, the increase is between 0 and 3 days, for the first half of the century. For the end of the century for mid scenario change is 6 days, and for low scenario decrease is -3 days. For mid scenario upper limit of the spread is more pronounced for the end of the century with values above 9 days. For the high scenario significant increase is present for the end of the century with change between 9 and 12 days, indicating higher risk for drought in case of this scenario.

Growing season length: For all scenarios increase ins growing season length is expected. In the middle of the century the expected increase is 20 days, and for the end of the century, for low and mid scenarios, will stay on this level, but for high scenario increase is between 50 and 60 days.

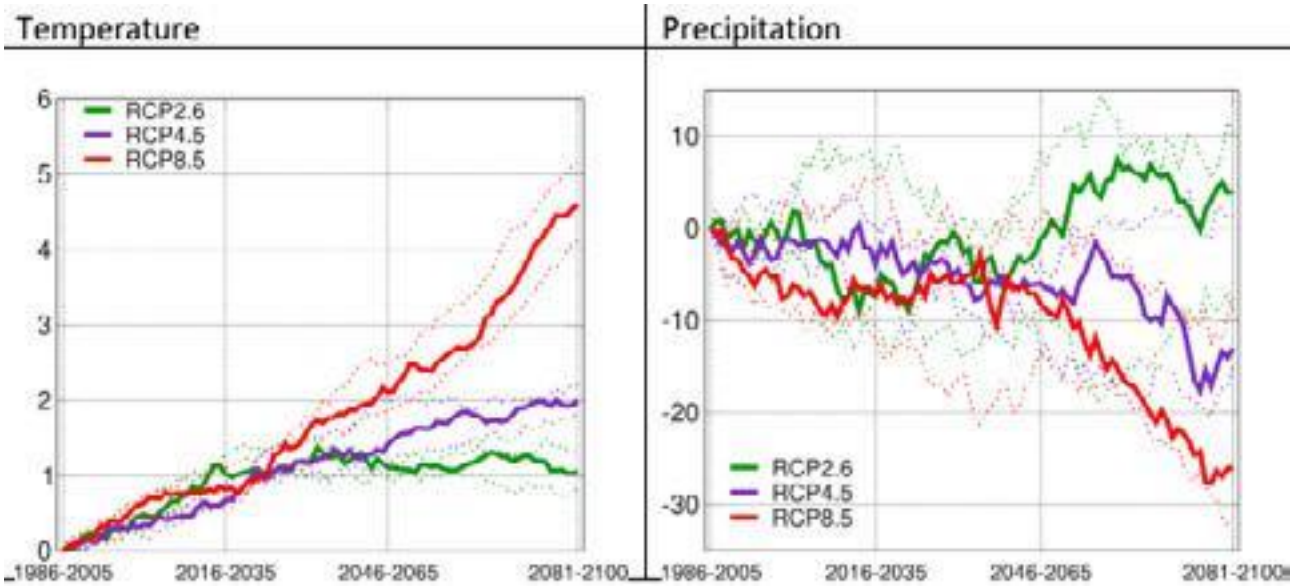
5.1.4 Climate projections and extremes in Strumica region

Mean annual temperature and precipitation temporal change for Strumica region are given in Figure 5-47 for scenarios RCP2.6 (low), RCP4.5 (mid) and RCP8.5 (high).

Temperature: For all scenarios increase in future temperature is expected. In the first half of the century there is no significant difference for different scenarios and expected temperature increase is between 1 and 1,5 °C, on the other hand for the end of the century increase in temperature is 1 °C, 2 °C and 4.5 °C, for low, mid and high scenarios, respectively, clearly indicating that future evolution in temperature is determined by future concentration of GHGs.

Precipitation: For precipitation change, again in the first half of the century, results are similar for all scenarios giving annual precipitation change between 0 and -10 %, with some chances that anomaly can be even positive. For the second half precipitation change is clearly negative for high scenario up to -30%, and mid scenario -15%, but for low scenario precipitation change is positive, about +5%.

Figure 5-47: Change in temperature (in °C) and precipitation (in %) for consecutive 20-year periods starting from 1986-2005 to 2081-2100, with respect to period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5



Tick lines are mean value of selected multi model ensemble, and doted lines are ensemble range from 25th to 75th percentile.

Frost days: For all scenarios decrease in future frost and ice days is expected, which is not surprising since that increase in mean annual temperature is expected. In the first half of the century there is no significant difference for different scenarios and expected decrease in frost days is about -10 days, on the other hand for the end of the century decrease in frost days

for high scenario is about -45 days. Expected decrease in ice days is about -3 days for all scenarios for the middle of century, and for the end of the century change is about -6 days for high scenario and -3 days for low and mid scenarios.

Cold waves: For all scenarios decrease in future cold waves duration is expected. In the first half of the century there is no significant difference for different scenarios and expected decrease cold wave duration is about -3 days on average. For the end of the century decrease in cold wave duration is 2, 4 and 6 days for high, mid and high scenarios respectively.

Summer and tropical nights: For all scenarios increase in future summer days and tropical nights is expected. In the first half of the century there is no significant difference for different scenarios and expected increase in summer days is from 15 to 20 days, on the other hand for the end of the century increase in summer days for high scenario is about 50 days. For low scenario increase is expected to stay the same, and for mid scenario for the end of the century increase is +25 days. Expected increase in tropical nights is 10 to 15 days for all scenarios for the middle of century, and for the end of the century change is 50 days for high scenario 8 days for low and 15 days for mid scenarios.

Heat wave: The change is very similar up to period 2046-2065, with increased duration of heat waves od about 1 day. After this period there is significant increase in heat waves duration for high scenario, and for the end of the century increase in duration is between 12 and 15 days, for mid scenario the increase is between 1 and 2 days and for the low scenario change no change is present.

Consecutive wet days: For number of days with precipitation above 40 mm, overall positive change is present for all scenarios, for majority of future periods. For high scenario, upper limit of ensemble spread above 100%, which means that doubling of these days is potentially possible in the future. Similar conclusion can be applied for maximum daily accumulation, for mid and high scenario ensemble spared is predominantly positive, and for the low scenario, spread is evenly distributed on positive and negative change. Maximum of change in terms of upper limit of ensemble spread is between +10% and +15%, for the end of the century, for mid and high scenario.

Consecutive dry days: For low and mid scenarios, the increase is between 0 and 3 days, for most of the analyzed future period. For mid scenario upper limit of the spread is more pronounced for the end of the century with values above 9 days. For the high scenario significant increase is present for the end of the century with change between 9 and 12 days, indicating higher risk for drought in case of this scenario.

Growing season length: For all scenarios increase ins growing season length is present. In the middle of the century the expected increase is 20 days, and for the end of the century, for low and mid scenarios, will stay on this level, but for high scenario increase is between 40 and 50 days.

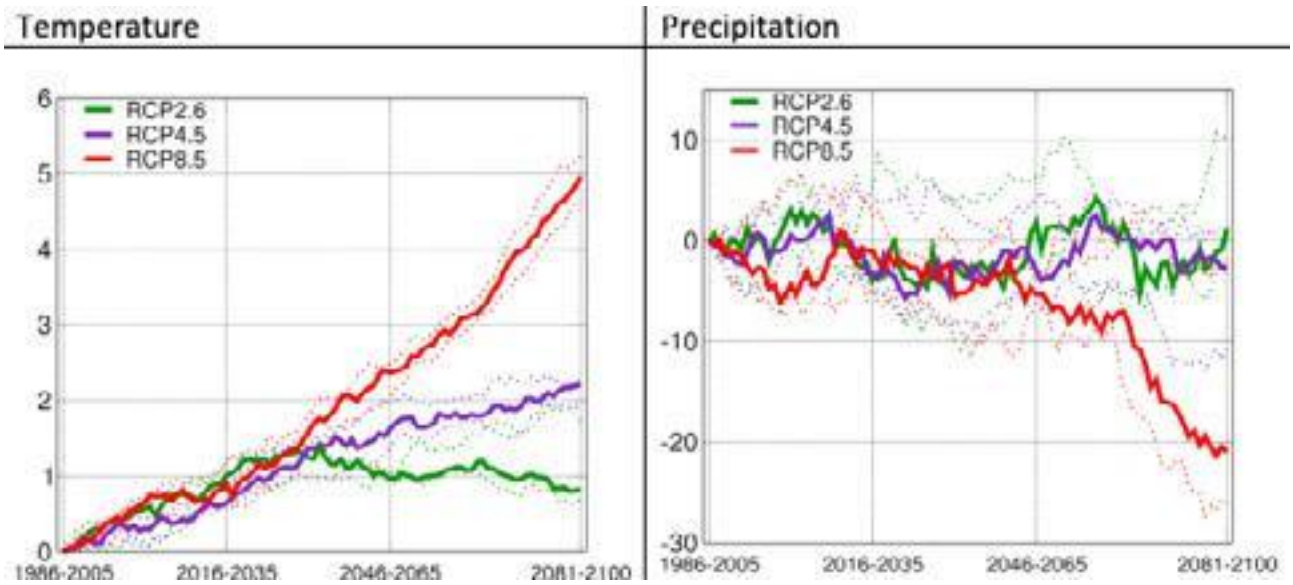
5.1.5 Climate projections and extremes in Polog region

Mean annual temperature and precipitation temporal change for Polog region are given in Figure 2 for scenarios RCP2.6 (low), RCP4.5 (mid) and RCP8.5 (high).

Temperature: For all scenarios increase in future temperature is expected. In the first half of the century there is no significant difference for different scenarios and expected temperature increase is between 1 and 1,5 °C, on the other hand for the end of the century increase in temperature is 1 °C, 2,2 °C and 5 °C, for low, mid and high scenarios, respectively, clearly indicating that future evolution in temperature is determined by future concentration of GHGs.

Precipitation: For precipitation change, again in the first half of the century, results are similar for all scenarios giving annual precipitation change about -5 %, and according ensemble spread (doted lines) there are some chances that anomaly can be even positive. For the second half precipitation change is clearly negative for high scenario up to -20%, and about zero for mid and low scenario. Ensemble spread indicates that there is a higher chance for mid scenario that change will be negative up to -10%.

Figure 5-48: Change in temperature (in °C) and precipitation (in %) for consecutive 20-year periods starting from 1986-2005 to 2081-2100, with respect to period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5.



Tick lines are mean value of selected multi model ensemble, and doted lines are ensemble range from 25th to 75th percentile.

Frost and ice days: For all scenarios decrease in future frost and ice days is expected, which is not surprising since that increase in mean annual temperature is expected. In the first half of the century there is no significant difference for different scenarios and expected decrease in frost days is between -10 and -20 days, on the other hand for the end of the century decrease in frost days for high scenario is about -55 days. Expected decrease in ice days is about -6 days for all scenarios for the middle of century, and for the end of the century change is about -13 days for high scenario and -6 days for low and mid scenarios.

Cold waves: For mid and high scenarios decrease in future cold waves duration is expected. For the low scenario and whole period change in cold wave index oscillates between +3 and -3 days. In the first half of the century there is no significant difference for different scenarios and expected decrease cold wave duration is about -3 days on average. For the end of the century decrease in cold wave duration is 3 and 6 days for mid and high scenarios respectively.

Summer and tropical nights: For all scenarios increase in future summer days and tropical nights is expected. In the first half of the century there is no significant difference for different scenarios and expected increase in summer days is from 20 to 30 days, on the other hand for the end of the century increase in summer days for high scenario is about 65 days. For low scenario increase is expected to stay the same, and for mid scenario for the end of the century increase is 35 days. Expected increase in tropical nights is 1 to 2 days for all scenarios for the middle of century, and for the end of the century change is 15 days for high scenario 3 days for mid and no change for low scenario.

Heatwave duration: The change is very similar up to period 2046-2065, with increased duration of heat waves od about 1 to 2 days. After this period there is significant increase in heat waves duration for high scenario, and for the end of the century increase in duration is between 15 and 18 days, for mid scenario the increase is about 3 days and for the low scenario no change is present.

Consecutive wet days: For number of days with precipitation above 40 mm, overall positive change is present for all scenarios, for majority of future periods. For high scenario, upper limit of ensemble spread above 100%, which means that doubling of these days is potentially possible in the future. Similar conclusion can be applied for maximum daily accumulation, for mid and high scenario ensemble spared is predominantly positive, and for the low scenario, spread is evenly distributed on positive and negative change. Maximum of change in terms of upper limit of ensemble spread is between +10% and +15%, for the end of the century, for mid and high scenario.

Consecutive dry days: For low and mid scenario, the increase is between -3 and 3 days, for most of the analyzed future period. For the high scenario significant increase is present for the end of the century with change of 9 days, indicating higher risk for drought in case of this scenario.

Growing season length: For all scenarios increase in growing season length is present. In the middle of the century the expected increase is 20 days. For the end of the century, for low and mid scenarios, change is 20 and 30 days respectively, but for high scenario increase is about 70 days.

5.1.6 Microclimate in urban environments – Skopje Valley

Urban areas affect the environmental microclimate by increasing air temperature, reducing the intensity of solar radiation, reducing wind speed, increasing the occurrence of foggy days and their intensity and duration and so on. In summer, urban areas are a „source of heat“ compared to green grassy areas. On the other hand, due to air pollution in the cities, the effective radiation is reduced, which diminishes cooling of the ground air layers. This is very important because urban areas have a higher heat capacity compared to green areas.

Several factors affect the thermal regime of cities. One of them is the change of meteorological elements and phenomena (for example, the processes of fog formation, etc.). The occurrence of fog in the cities is 10 - 20% more common than in the surrounding areas. This is due to the appearance of city impurities of hygroscopic particles that absorb water vapor, as well as the condensation and sublimation processes and the appearance of so-called smog. Aerosols absorb long-wave ground radiation which reduces night cooling. Due to that, the ground air layer temperature in the cities is higher.

Besides this, solid and gaseous impurities in the city air affect the direct solar radiation, especially in the winter months. Under those conditions, in the polluted atmosphere the ultraviolet radiation is weakened. Visibility in cities is reduced by up to two times. Transparency coefficients in cities are 2-5% lower than in surrounding areas. The albedo in the cities is reduced compared to the rural areas due to the impact of the urban environment.

Many scientific papers conclude that the urban areas impact local climate, which is the situation in the city of Skopje and the Skopje Valley as well, by increasing air temperature, decreasing wind speed, increasing fog frequency, reducing visibility, reducing intensity of solar radiation and reducing effective radiation.

The current climate change and their manifestations have shown that there is a need to reactivate mesometeorological measurements in the Skopje Valley, thus starting from 2011 every year several series of 2-day mesometeorological measurements are performed. In the past period, in addition to the regular meteorological and occasional mesometeorological measurements and observations with classical instruments and equipment, a modern automated meteorological-climate monitoring system was established in the Skopje Valley (in accordance with the standards of the World Meteorological Organization).

As part of this activity, four automatic meteorological stations have been set up in the Skopje Valley. The process of establishment of an automated meteorological monitoring system in the Skopje Valley started in 2012 with the installation of an automatic meteorological station in Creshovo as a result of the participation of the HMO in the Twinning project of the Ministry of Environment and Physical Planning and the Finnish Meteorological Institute, „Strengthening the Capacities at Central and Local Level in Environmental Management in the Area of Air Quality”. Within the Agreement of HMO, the Skopje Planning Region and the City of Skopje for realization of the „Program for Mesometeorological Measurements in the Skopje Valley and its Implementation“, three automatic meteorological stations were installed, in 2013 in the Municipality of Karposh (in the primary school Petar Pop Arsov), in 2015 at Zajchev Rid and in 2016 in the Municipality of Gazi Baba.

According to the data from the measurements performed every full hour from 07:00 to 20:00, during all series in the period 2011-2020, the air temperatures ranged in absolute limits from the lowest measured value -4,0°C (at 07:00), measured at the measuring point Gazi Baba AMS on 16.2.2017, up to the highest measured value of 38.4°C which was registered at the measuring point Zajchev Rid (at 15:00) on 12.07.2012. During the measurements the lowest values of temperature were measured in the early morning hours (at 07:00), with small exceptions when the lowest temperature was also measured at 20:00, while the maximum values were reached in the period from 14:00 to 16:00.

The highest mean daily air temperatures are measured in the downtown area, while the lowest values are measured at peripheral measuring points such as Gjorche Petrov and Butel 1 and in the places with higher altitude such as Zhdanec, Hotel Panorama and Sredno Vodno.

The introduction of an automated meteorological and climate monitoring system in the Skopje Valley in recent years has enabled the collection of meteorological data in a database which serves as a basis for more detailed analysis of the impacts of the city on the climate conditions on a meso-scale. The highest values of mean annual and monthly air temperature for most of the months were recorded at AMS Karposh. The highest absolute and mean annual maximum air temperature was recorded at AMS Gazi Baba. Also the lowest absolute and mean annual minimum temperature was recorded also at AMS Gazi Baba.

The results of the occasional mesometeorological measurements performed so far as well as the data from the established automated meteorological observation system in the Skopje Valley feed into a meteorological database that serves as a basis for more detailed research of local impacts of the city on the climate. The website of the HMO https://uhmr.gov.mk/

aktuelnipodatoci/ contains current data taken from the automatic meteorological stations in the Skopje Valley which are part of the established national automated observation system.

As stipulated in the Strategy for Establishment of an Automated Meteorological Monitoring System in the Skopje Valley, the installation of an automatic meteorological station in the downtown area is a priority. For complete and continuous future monitoring of the components of the meso-scale climate system in the Skopje Valley it is necessary to continue the activity by setting up automatic meteorological stations of different types at several points in the Skopje Valley, which will be permanent measuring points for carrying out continuous meteorological measurements.

5.2 Sectoral vulnerability and adaptation analyses

Climate change is predicted to impact different geographic regions of North Macedonia slightly differently in term of; intensity, frequency and duration of rainfall; temperature changes/variables in terms of duration, intensity[12]. The various impacts from climate change for North Macedonia include the following:

1. Drought can result in loss of cultivable lands and changes in cultivation periods/seasons
2. Drought can cause changes in sub-surface water levels especially water table. It can also affect ground water resources both un-confined and confined aquifers
3. Changes in soil salinity, moisture and drainage capacity caused by drought
4. Drought can also cause changes in shoreline of lakes and water-bodies. Perennial water bodies can see drying caused by lowering water tables. Non-perennial water bodies which are dependent on rainfall can also dry up due to extended dry spells, but at the same time cause flash floods when there are extreme rainfall events (The risk of such flash floods are higher in urban landscapes with non-permeable surfaces as this will result in increased run-off and reduced time of concentration).
5. Flooding of rivers and in long run change in river morphology in areas with predicted increase in rainfall.
6. Catchment capacity changes caused by increased run-off which can mean additional storage needs for Dams, possible risks of dam breach due to extreme precipitation events
7. Flash floods and depending on where these flash floods happen there is additional erosion and landslide risks
8. Water resource variabilities (changes in incident rainfall, seasonal changes in rainfall, extreme rainfall events leading to flash floods)
9. Glacial melting and snow destabilisation that may increase risks of avalanches in new areas
10. Heat Waves can increase the risks of heat exhaustion especially for people in urban landscapes with added heat island effects, it can also affect the flora landscapes, plant health and cultivation.
11. Health risks and human fatality are some direct impacts. There is also greater risks of emergence of new diseases.
12. Reduced Frost days would mean arrival of early spring. This means plant blooms and other ecosystem life-cycle changes
13. Changed cultivation periods and productivity due to drought (pH changes, nutrient losses/salinity) and redistribution of annual cycles of precipitation
14. Increase in cases of pests and diseases (risks to humans and for agriculture)
15. Species migration changes in terms of both spatial and temporal shifts
16. Habitat regions can change with altering weather and shift in flora spread (new regions may become preferred habitats for different species, some other hot-spots and habitats may no longer be preferred habitats for species)

[12] UNDP (2020) Methodology for mainstreaming Climate Change consideration into spatial planning, with a focus on National Spatial Plan

17. Disasters triggered by extreme events of floods, dam breach, landslides, glacier melts. Eg; Leaching from mining lands caused by flash floods or altered river inundation. This can pollute productive lands, ground water etc.

18. New vulnerable zones may emerge with the changes in climate variables. Disasters related to leaks and failures of chemical and other high risk industries which are located in landslide risk zones, seismic zones, dam breach zones etc. This can result in loss of life, loss of habitats, cause health hazards etc.

The following section provides information and analysis of impacts, vulnerability and adaptive capacity and measures in the following sectors: water resources, agriculture (crop production, soil and livestock), forestry, biodiversity, and livelihoods. The sections are a summary of a report prepared by the UNDP unless otherwise referenced[13].

5.2.1 Water resources

5.2.1.1 Overview

North Macedonia has about 8 billion m^3 of freshwater sources. In the years of intensive water use, the WEI (water use index) was about 20%, and at peak times, as in 2012, up to 35%. Water is used for human consumption (drinking water), irrigation, industrial, economic and other purposes. In the last few years, it has been observed that the demand for water is becoming quite variable, both in terms of the total demand for water from all sectors, but also in terms of demand from individual sectors.

In 2015, about 80% of the country's 2.07 million inhabitants were supplied with water from centralized drinking water systems operated by public utility companies. About 10% of the population is supplied to local rural water supply systems, and 10% have their own, individual water supply. Water losses in water supply companies remain high, ranging from 40 to 65%. North Macedonia has faced a seasonal shortage of drinking water in urban and rural areas. In addition, a high incidence of water-borne diseases may indicate that water resources are contaminated with untreated municipal wastewater.

5.2.1.2 Sewerage

The current state of sewage systems differs in urban and rural areas. Overall, existing systems are quite old, the collection network is composed of different materials, the pipes are cracked and there are leakages of wastewater. Urban wastewater and stormwater systems are not separated, and during floods the pipes are overloaded and subject to increased pressure, causing flooding of streets during heavy rainfall. By now, 12 cities and towns have built separate sewerage systems. Skopje has separate systems for wastewater (56% of the entire network) and for rainwater (18% of the network).

5.2.1.3 Irrigation

Most irrigation systems in North Macedonia were built before the 1990s. For this purpose, more than 27 large dams, more than 120 small dams, about 1,400 km of main canals / pipelines and about 6800 km of detailed irrigation networks were built. Namely, the existing network is old, destroyed or not functioning and needs to be repaired. Therefore, it was up to the farmers to find solutions on their own, by digging wells, securing pipes and installing pumps.

With irrigation of less than 10% of agricultural land and climate change causing more frequent and intense heat waves and droughts, losses in agricultural production can be expected.

5.2.1.4 Climate impacts in the water sector

Water management infrastructures can be used for agricultural purposes or for urban and industrial use. Water infrastructures for agricultural use include storage reservoirs and derivation works, adduction and distribution networks (pressurised, free-flowing and mixed) and, finally, irrigation systems, understood as the final part of the water network that connects the distribution network to the irrigated crops. The water infrastructures for urban and industrial use considered include the collection, purification and depuration works, adduction and distribution to the final users (mainly industrial users and, in urban areas, residential, commercial and service users) and, finally, the drainage and collection systems of rainwater and wastewater. The climate impacts on water management infrastructures are described below.

[13] Cyril and Methodius University, 2021. Climate change vulnerability and adaptation agriculture, forestry and land use.

Heat waves: Heat waves have a generally limited impact on storage, diversion, supply and distribution works. Some impacts may occur on drinking water and sewage infrastructure, resulting in increased operating costs, due to potential changes in concentrations of toxic algae and organic material in water at source.[14]

Cold waves: As with heat waves, extreme minimum temperatures associated with cold waves do not generally induce significant damage to open water storage and distribution infrastructure, while frost damage to pressurised systems and irrigation systems is possible. Similarly, also for urban and industrial water infrastructures, impacts can occur on water collection works, where frost can limit accessibility and withdrawal (e.g. from mountain springs), or on supply and distribution networks, where frost can cause breakage of pipes and meters (Rajani & Kleiner, 2001). Such events can therefore generate necessary costs for restoration/ replacement/reconstruction of affected infrastructure components.

Drought: Droughts have an indirect impact on irrigation infrastructures, producing a significant increase in irrigation demand in the served territories. Droughts generate high impacts on catchment works directly dependent on water availability. An increase in temperature accompanied by a slower recharge of the aquifers can cause both a reduction in water availability and alterations in its quality, thus requiring changes in the operations of the water collection and, subsequently, purification and transport infrastructures, with possible increased management costs. Increased water demand in different sectors may be a source of increasing conflict and competition between different water uses.[15] Finally, prolonged drought situations may have direct impacts on water supply and distribution works (e.g. increased failure of water mains in hot and dry periods due also to changes in the soil stress state with reduced moisture content) and on wastewater drainage systems (with reduced dilution capacity and increased solids concentration, which may cause blockages, clogging and blockage/breakage of pumping systems).[16] These issues may cause an increase in costs related to ordinary and extraordinary maintenance of the physical components, as well as operating costs related to interruptions and anomalies in the regular operation of the mentioned infrastructure components. Impacts may occur on supply and distribution works if continuous supply is jeopardised, especially in regions exposed to prolonged drought conditions, with consequent costs related to the use of alternative sources of drinking water supply (e.g. tankers).

Table 5-1. Climate impacts in the water sector.

Climate hazard	Impacts for the water infrastructure
Heat waves Increase in average temperature	y Loss of efficiency of fossil fuel plants y Reduction in electricity transmission capacity y Reduction in power generation capacity due to reduced discharge capacities in reservoirs y Reduction in wind power generation capacity due to weakening of high pressure winds y Increased energy demand in the summer period and consequent increased vulnerability of the system when exposed to extreme events
Drought	y Structural damage to oil and gas pipelines due to subsidence y Decreased water availability for cooling of production facilities
Cold waves Snowfall	y Formation of snow/ice sleeves on transmission and distribution lines Yield loss in solar installations
Wildfires	y Structural damage caused by exposure to fire and high temperatures
River flooding	y Structural damage to process plants, storage systems and fuel transport systems due to direct impact with the waves
Wind storms	y Structural damage as a result of wind pressure or debris impact y Reduction in operation of wind turbines due to decoupling of turbines from generators to avoid damage to them y Disruption caused by the action of wind on foreign bodies on the infrastructure: falling trees and their impact on transmission and distribution lines

Source: Li et al., 2014, de Oliveira et al., 2015, Hughes et al., 2021

14 Li, Z., Clark, R. M., Buchberger, S. G. e Jeffrey Yang, Y. (2014). Evaluation of Climate Change Impact on Drinking Water Treatment Plant Operation. J. Environ. Eng. 140, A4014005.

15 de Oliveira, R. P., Matos, J. S. e Monteiro, A. J. (2015). Managing the urban water cycle in a changing environment. Water Util. J. 9, 3-12.

16 Hughes, J., Cowper-Heays, K., Olesson, E., Bell, R. e Stroombergen, A. Impacts and implications of climate change on wastewater systems: A New Zealand perspective. Clim. Risk Manag. 31, 100262 (2021).

5.2.2 Agriculture

Agriculture is one of the key economic sectors in North Macedonia and plays a critical role in the social and economic stability of North Macedonia. Changes in temperature and precipitation as well as extreme events are already influencing crop yields and livestock productivity in North Macedonia. Climate change is projected to reduce crop and livestock productivity in the country, leading to significant socio-economic impacts for the country's economy and farmers in particular.

Current conventional agricultural practices and food systems applied in North Macedonia are inadequate to address the ever-growing climate impacts. Measures to improve resilience against climate impacts are therefore imperative to protect the agricultural sector in the country and ensure a climate resilient and low-carbon economic development and accession to the European Union.

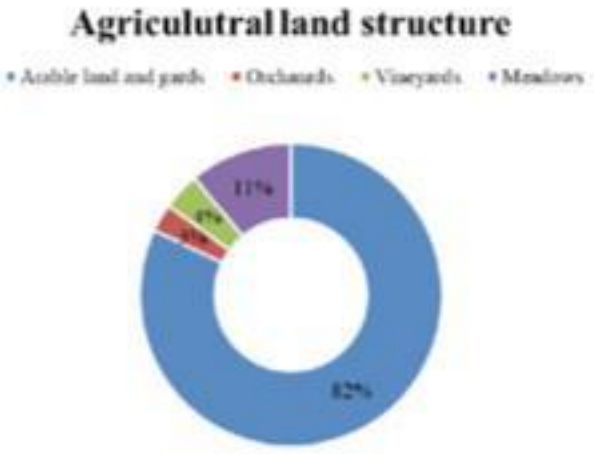
5.2.2.1 Overview

Agriculture is one of the key economy sectors and plays a critical role in the social and economic stability of North Macedonia. Agriculture's contribution to the nation's GDP has slightly declined in the past decade due to a shift of economic structure. At present agriculture contributes 10 percent to GDP (2017) and accounts for 18 percent of total employment (State Statistical Office, 2019). About 42% of country's population live in rural areas where off-farm employment opportunities are limited. Therefore, official figures are considered to underestimate the importance of the agriculture sector, because they include only a fraction of the value of smallholders' outputs and do not measure all family labour inputs (which are the dominant type of informal employment arrangements on family farms).

Agriculture suffers from low productivity and does not reach to its potential due to several structural constraints. The average farm size is less than two hectares, more than 60% (106,875 farmers) of all farmers use up to 1 ha of agricultural area (State Statistical Office, 2017). Half of the agricultural producers are semi-subsistent with limited opportunities to produce at scale and higher quality and introduce innovation. In addition, smaller agricultural producers and agri-businesses lack access to new technologies and market opportunities, as well as agricultural knowledge and skills in climate resilient technologies. In addition, farmers also have limited capacities in business management, logistics, financial literacy, and domestic and international marketing.

Agricultural land is fragmented and unproductive. More than 40% of the total area of arable land (approximately 240,000 hectares) and 80% of the pastureland (approximately 570,000 hectares) in North Macedonia is owned by the State. Nearly one third of the total arable land is either abandoned or not utilized for agricultural production. Out of the total territory of the country, 50.1% (1,261,000 ha) is agricultural land (cultivated land, permanent pasture and meadow, land used for permanent crops and kitchen gardens), 44.3% are under forests and the rest are water and other land use. The cultivated land covers about 40% (509,000 ha) of total agricultural land (State Statistical Office, 2017). From the total cultivated land 81% are under arable land and gardens, 3% are under orchards, 4% under vineyards, while the meadows represent 11 % from total cultivated land (State Statistical Office, 2017). Pastures are represented on 751,187 ha or 60% of total agricultural land.

Figure 5-49: Agricultural land use for North Macedonia



In North Macedonia, irrigation is a significant factor for stable and competitive agricultural production. Some crops cannot be commercially grown without irrigation. Water demand for irrigation is estimated to 62.6% of the total water demand in the country. The existing irrigation systems (area equipped for irrigation) cover about 120,000 ha of arable land. However, in reality, irrigated area is about 30,000 ha or only 10% of the arable land (Government of North Macedonia, 2014). With the exception of the western parts of the country, water deficiencies occur in summer, resulting in significant moisture stress for summer and annual crops.

5.2.2.2 Crop production

Overview

Cereals are the major crops in the country, usually not irrigated because their growing period is during the humid season. However, their yield is only about 3 t/ha. Cereal crops were sown on about 41% of the arable land area or in total 166,664 ha for 2018.

Fodder crops covered about 40,749 ha in year 2018. The most important fodder crop is alfalfa planted on more than a half of fodder crops area.

Industrial crops in 2018 were planted on about 19,878 ha. Tobacco is the major industrial crop produced exclusively by small farmers and planted on about 80% of industrial crops area.

In 2018 vegetables were produced on a total area of 51,617 ha. The most important vegetable crops are:

- Potato, which is grown on 12,000 ha;
- Pepper – 9,200 ha;
- Tomatoes - 5,600 ha, and
- Cabbage - 4,500 ha.

The total area for fruit production is about 17,000 ha (apples, plums, sour cherries, pears, and peaches). The most important fruit is apple – 4.8 million fruit trees in 2018. Furthermore, melon and watermelon were grown on 5,300 ha.

Grapes and viticulture are one of the most important sectors with wine being a significant export commodity, grown on approximately 24,000 ha with more than 2/3 being for wine production. Viticulture and wine production comprise 17-20% of agricultural GDP. Wine (after tobacco) is the second most important product related to the export value of agricultural commodities in the country. Most vineyards are situated in Povardarski and South East region. The cultivated varieties and the overall wine style that a region produces is a direct result of the average climatic conditions, while climate variability determines vintage quality differences.

Vulnerability and climate impacts on crop production

A large proportion of crop production is exposed to open spaces and the impacts of weather and extreme weather events. Higher temperatures will more put more health stress on crops and higher maximum temperatures will be above optimal for photosynthetic activities, reducing the synthesis of organic matter. Prolonged periods of higher temperatures and heat waves will lead to greater yield losses, sun burns and discolouration of fruits, particularly on the west side of fields.

Agricultural drought is occurring almost every season in most of the agricultural areas in North Macedonia and is projected to be more severe with climate change, further reducing crop yield. Extreme low temperatures and extreme precipitation events are also impacting crop production. The last frost in Spring is occurring later in the season, close to the end of April, damaging early flowering fruits and impacting the fruit growing sector.

Extreme precipitation events are causing low permeable soils to become water logged, destroying sensitive crops such as green peppers after several consecutive days of water logging. Several of these events occurred during critical soil cultivation and sowing windows, causing extensive damage, particularly in the Bitola area. In addition, agricultural soils in the surrounding areas were severely polluted by deposited materials transported by flooding water to the extent that agricultural production was not possible without land reclamation measures. Intensive rainfall is also leading to further soil erosion and increasing crop vulnerability.

Impacts on wheat, maize and grapevine production

Increasing mean temperatures and decreasing mean precipitation levels will, combined, result in increased aridity in the region. Projections display the spatial variability of yield impacts across the country and the difference between the crops. For rain-fed wheat, the major growing areas in the continental and Mediterranean agro-ecological zones are projected to experience a moderate increase in yields of up to 10% for both 2025 and 2050. For rain-fed maize, moderate (0-10%) and severe yield declines (10-25%) are projected for the majority of Macedonia by 2025 and almost all of Macedonia is projected to experience severe maize yield declines of up to 25% by 2050, with some highly vulnerable areas projecting catastrophic yield declines of greater than 25%.

The existing age and size of vineyard plantations are unfavourable. The size of the plots are very small which is due to the long-term fragmentation of the agricultural land as a result of the inheriting tradition, inexistence of land market and long period of insufficient investments in this sector. More than 60% of the vineyards are older than 15 years. This situation of small parcels and old plantations makes the viticulture sector prone to the negative impact of climate change which is especially due to the low capacity of farmers to apply effective adaptation measures and low efficiency of the adaptive measures on small sized plots.

A study was conducted for three emissions scenarios, RCP2.6, 4.5 and 8.5, using three values of the temperature as a base: n = 0 0C, n = 5 0C and n = 10 0C respectively comparing the two 30-year periods – 2030 (near-future) and 2060 (distant future) with the 2000, with predictions how these changes will affect to the potential wheat, maize and grapevine production[17]. For the analysis of the results, five grids were selected for each crop, The key findings from the analysis were as follows:

Wheat:

- The increased temperature has negative impact of photosynthesis and respiration and reduces the yield of wheat. For each 0C increase in global mean temperature, there is a reduction in global wheat grain production of about 6%.
- The last spring frost days are projected to have greater variability, occurring both earlier and later, depending on the grid location and scenario. The timing of spring frosts is critical, depending on the stage of wheat development, causing damage and affecting yields.
- Wheat production is projected to drastically reduce in the next 50 years due to increasing growing degree days (GDD). The growing season length and dry matter production critically depend on seasonal temperature conditions.

Maize:

- Rising temperatures shortened crop growth stage and reduced maize yields, hence reducing revenue from maize. Maize production is expected to decrease by 23% by 2100 based on simulations from climate scenarios.
- Maize is a spring crop and is impacted by the changing occurrence of the last spring frost. The last spring frost is projected to occur between 1 and 8 days later for certain grid locations (for RCP4.5 and RCP8.5), and by more than 10 days earlier for other grid locations. Early sowing as a measure of adaptation from increasing temperatures may result in an increased risk of spring frost.
- In selected grids, the sum of effective temperatures (growing degree days) under RCP 2.6 rises from 4294OC to 4591OC by 2030 and to 4600OC by 2060. Such high effective temperatures will have an impact on maize production. Higher effective temperature sums will result in earlier and advancing maturity and a shorter time for grain filling which will have a direct negative effect in yield quality and quantity.

Grapevine:

- Increasing mean daily temperatures will influence grapevine yield, as well as berry and wine quality. Grapevine development and bud burst only occurs at temperatures between 7 OC and 11 OC and is dependent on latitude, grape variety, and the year. Temperatures above the optimal range causes growth to decline and eventually stop.
- Mean annual temperatures are projected to rise by 0.4 OC and 0.9 OC under RCP4.5 by 2030 and 2060 respectively. Higher temperatures, earlier phenological timings and a shortening growing season cause a decrease in acidity content, increase in sugar content or alcohol, and ripening during excessively warm conditions.

[17] Cyril and Methodius University, 2021. Climate change vulnerability and adaptation agriculture, forestry and land use.

- The minimum number of frost-free days, known as the growing season, between winter/spring and autumn is 180 days for viticulture. Low temperatures below -1^{O}C cause damage and injury to plants who have a low tolerance during certain stages of development, such as bud swelling.

- Projections show that the occurrence of the last spring frost on selected grids with grapevine production occurred much earlier than compared to wheat and maize. Under RCP4.5, the last spring frost is projected to occur between 2 and 7 days earlier, resulting in an earlier occurrence of low temperatures in spring.

In conclusion:

- Temperature is expected to rise during the growing season and especially in summer months for 1.0°C in 2030 and for 1.6 °C in 2060, increasing the likelihood of drought conditions.

- More days with extreme high temperatures will negatively influence wheat, maize and grapevine physiology.

- Higher effective temperature sums (growing degree days) result in earlier maturity, shorter periods for grain filling and an advance in maturity of wheat and maize. This will negatively affect yield quality and quantity. Higher effective temperatures in grapevine production will impact plant development phases for the next 50-year period, resulting in lower quality for wine making sector.

Adaptation of the crop sector

Research conducted in the past 20 years has prioritised irrigation as one of the best adaptation options for crop production in North Macedonia. The irrigation sector has gone through several reforms that resulted in significant irrigation and drainage changes. Due to water limitations in the summer period, and water shortages for crop growth and sustainable productivity, a number of important investments for the development of irrigation were undertaken, as the most efficient available practice for reducing water shortages for normal agricultural production.

However, somewhere between 50 – 100 thousand hectares of land suitable for irrigation is not in use and could be regenerated. There is huge potential for increasing the irrigated areas in the country, and to increase resilience and productivity. Moreover, the regeneration of these areas will contribute to the one of the most important targets of the national policy in agriculture, improving the competitiveness of the agricultural sector.

Using FAO AquaCrop models for RCP2.6, RCP 4.5 and RCP 8.5 scenarios, the effect of irrigation on maize yield was studied for five grid locations. Maize is a crop that is usually irrigated in the country and is quite tolerant to water stress, particularly after the grain filling stage. An irrigation event was triggered when the soil moisture was 80% depleted. Results show that irrigation increased crop yield from 8.34t/ha to 12.02t/ha for RCP4.5 by 2030 and from 7.45 t/ha to 11.43 t/ha for RCP4.5 by 2060 (Table 523). The irrigation increases yield for about 31% in the year 2020 (base case), very similar to the increase in 2060 for the RCP2.6 scenario. Also, the same RCP resulted with smaller yield increase of about 39% in year 2030. Much higher increase in the yield is achieved when simulation was done using the weather data and Co2 concentration for RCP4.5 scenario 44% in year 2030 and 53% in year 2060. The highest yield increase is achieved in the scenario that caused the highest yield reduction RCP 8.5. The yield increase as result of irrigation is almost 41% for year 2030 and maximal 139% of yield increase were achieved in the year 2030.

Table 5-2. Simulated yield and yield increase, simulated irrigation water use and water productivity for base case (2000) and climate change periods (2030 and 2060) for RCP2.6, 4.5 and 8,5

	Simulated Yield without adaptation t/ha	Simulated Yield with adaptation t/ha	Yield increase as result of adaptation t/ha	Yield increase as result of adaptation %	Simulated Irrigation water use in mm	Irrigation water productivity in kg/m3
Base case	8.91	11.64	2.73	30.70	229.8	1.18
2030 RCP2.6	9.15	12.68	3.53	38.56	365.43	0.97
2030 RCP4.5	8.34	12.02	3.68	44.12	303.22	1.21
2030 RCP8.5	7.94	11.15	3.22	40.52	246.5	1.30
2060 RCP2.6	9.99	12.87	2.88	28.86	225.9	1.28
2060 RCP4.5	7.46	11.43	3.97	53.23	236.1	1.68
2060 RCP8.5	5.46	13.05	7.59	139.01	241.9	3.14

In conclusion, irrigation as an adaptation measure will have significant advantages. Improving and repairing existing water infrastructure should be set as a high priority in the crop production sector to improve climate resilience. There are also challenges associated with the cost of irrigation water. To keep irrigation profitable the cost for irrigation should not be higher than profit that can be achieved. Nevertheless, the benefit of the irrigation water in case of maize growing is between 1 to 3 kg of maize for 1m^3 of water. If water prices rise above cost of the 1kg of maize for m3 then irrigation will not be profitable. Competition for water resources will rise in the future, as almost all sectors will need more water and it is expected that prices will increase. Therefore, policy for maintaining the cost for irrigation in the future should be one of high priority for decision makers and for policy development in agriculture. Adaptation measures should include:

1. Rehabilitation of the existing irrigation and drainage systems, and construction of the new infrastructure in order to reduce losses in the conveyance and distribution network and to adapt irrigation distribution network to the modern irrigation techniques and farmer's needs.

2. Increasing the water use efficiency at the farm level in order to increase the productivity and production and to achieve higher water productivity (more crop per drop).

Other adaptation measures for the agriculture sector, other than irrigation, have been tested as part of the Rural Development Network (RDN) and supported by USAID. These include:

- Using anti-hail and UV protective nets increase pear, plus, apricot and peach yields by 50%, and that of vegetable plants by 0.5kg/plant.

- Use of drought tolerant apple and cherry rootstocks

- Deeper planting of apple and cherry trees has a positive influence on growth and productivity by 28%, because of their increased ability to absorb the available water

- Trees planted with water conservation materials such as hydrogel lead to better development, growth and survival of cherry orchards

- Short pruning techniques of peach and apple trees result in lower yields of 2.5% but result in fruits of better quality and of a higher grading class, which is more profitable.

- The use of sunburn protection materials such as calcium carbonate on apple and pear fruits reduces damage.

- Peat and sawdust mulch helps to reduce temperatures and conserve water, resulting in a higher yield of up to 43%

- Plastic bags filled with soil mixtures enables better water and fertiliser control, resulting in over 50% increases in yield for vegetables.

- With drip fertigation, water use efficiency is almost 25% higher in comparison with drip irrigation and traditional spreading of fertilizer and almost 50% higher in comparison with furrow irrigation and spreading of fertilizer.

Cross-cutting measures that contribute towards mitigation and adaptation in agriculture include:

- Biochar, with its high carbon concentration and negative emissions potential, shows promising and significant effects on productivity, increasing yields by 10%.

- Replacing irrigation energy sources to electricity produced from renewable photovoltaics can increase the adaptive capacity of crop production sector by converting non-irrigated land into irrigated land, whilst reducing emissions from using petrol or gas-powered electricity to pump water.

5.2.2.3 Agricultural soils

Overview

Climate change and soil degradation are among the major threats to agriculture and food security. Soil with a lowered capability to store and release water and nutrients can provide only little relief to crops coping with impacts from climate change. Vulnerability of organic carbon pools to climate change has important repercussions for land sustainability and climate mitigation actions. Soil organic matter (SOM) is crucial to terrestrial ecosystem processes and play a key role in nutrient release, maintenance of soil structure, in greenhouse gas emissions, and is a major pool in the global carbon cycle.

Soil Organic Carbon (SOC) turnover can be considered a key indicator in the evaluation of the vulnerability of soil to climate change. Forest and agriculture are key systems in the carbon cycle, as they hold and rapidly exchange large amounts of carbon and is accelerated by human activity. While climate change is expected to have an impact on soil carbon in the long term, changes in the short term will more likely be driven by changes in land use, soil management technologies in agriculture or changes in age-class structure of forests. Some examples include:

- Adoption of appropriate conservation and restoration practices can build up SOC contents, improving soil structure and aggregation, compared to intensively tilled soils.

- Conservation tillage is a complex set of measures towards preservation of agricultural soils from degradation and are focused on preservation of SOC, soil moisture, intensity of soil erosion, and the overall health of soil, like: reduced or no-tillage systems, contour ploughing, cover crops etc.

- Continuous cropping can deplete soil fertility due to inadequate replacement of nutrients harvested with produce or lost through leaching, erosion, and atmospheric emissions. Most of the processes responsible for soil degradation, including soil organic matter mineralization and erosion, are enhanced by higher temperatures and more intense precipitation.

- Nutrient balance is critical for plant growth and the application of nitrogen improves plant growth and soil carbon storage.

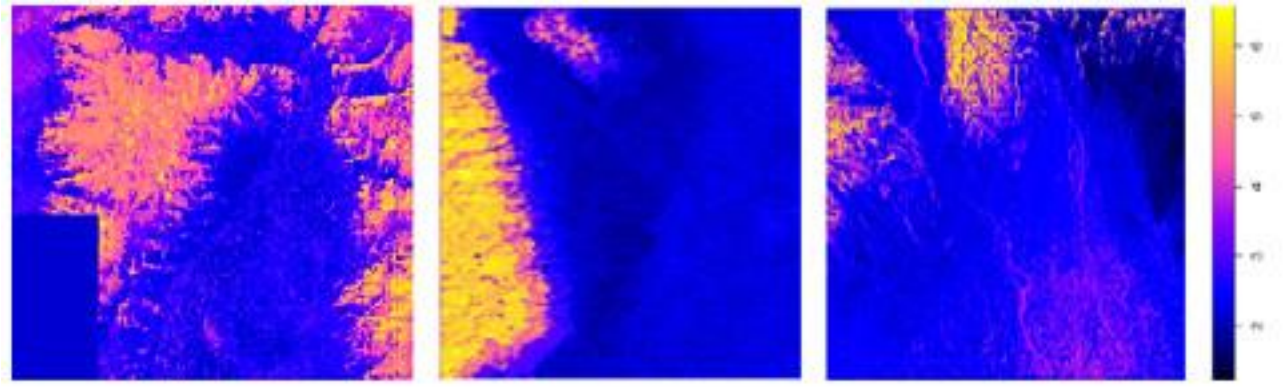
- Land use/land use change is another process which significantly affects soil carbon stocks. Carbon is lost from soils when grasslands, managed forestlands or native ecosystems are converted to croplands, a process that is slowly reversed when cropland is converted back.

- CO_2 concentration in the atmosphere and CO2 fluxes from and to the soil from the atmosphere, which affects net primary productivity and soil respiration intensity.

- Increasing temperatures are expected to have a higher impact on soil carbon decomposition than on plant production, since soil respiration is considered more vulnerable to changes in temperature than photosynthesis.

SOM content was modelled on three pilot sites in three valleys located in southern parts of the country, identified as the most prone to SOC depletion (Figure 5-50). The highest content of the SOM was detected on mountainous locations (above 6%) while the lowest contest of less than 2% are detected in the lowest parts of the valleys especially in Prilep test site. These findings are in line studies stating that low levels are particularly evident in southern Europe where 74 % of the land is covered by soils that have less than 2 % of organic carbon in the topsoil (0–30 cm).

Figure 5-50. Soil organic matter distribution on three pilot sites in North Macedonia



Ohrid pilot site | Prilep pilot site | Strumica pilot site

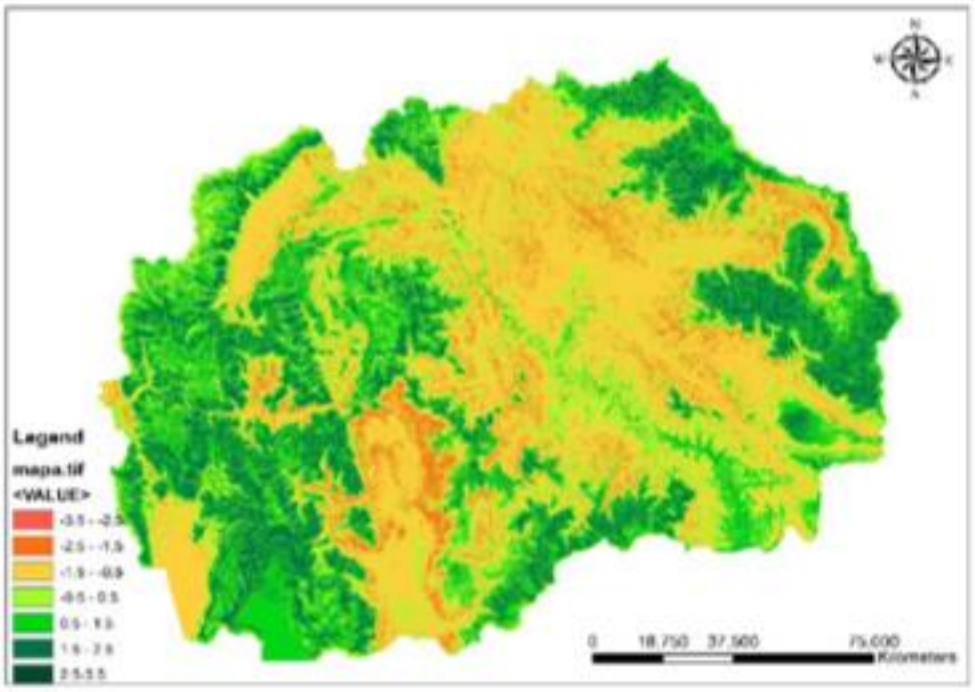
Vulnerability and climate impacts on agricultural soil

It is very challenging to identify the contribution of climate change to measured changes in soil carbon. Measurements of soil carbon changes are characterized by a substantial uncertainty, and it is well known that land use and land management changes have large effects on soil carbon, masking the impact of climate change.

Field data for soil quality and land use were collected for 942 locations. Values for the soil carbon were extracted from the historical datasets, for the each of the preselected 942 locations, comparing the period before 2010 and another data set for the period from 2010 until present.

The results are presented in Figure 5-51, which shows that during the last 10 years, the most vulnerable areas to SOC depletion are high agricultural regions, especially in the central part of the country, the south-east region and the Pelagonija and the Polog valleys. The depletion of SOC is in the range of 1-2%. In the mountainous regions in the western part of the country and in the northern-east part like Osogovo and Plackovica mountain and the regions of Berovo and Delcevo, as well on Kozuf mountain, higher levels of SOC are noticeable under forest vegetation and pastures. This situation leads us to a conclude that climate actions should be implemented in order to protect these areas from further loss of soil carbon.

Figure 5-51. Soil organic carbon depletion map



Adaptation of agricultural soils

A range of soil management practices, including soil fertility improvements and soil erosion control, have been developed and applied by farmers and researchers in different parts of the world with a goal to achieve sustainable food security. However, while soil management practices may solve some problems, it is essential to have integrated soil management, and monitoring and evaluation tools to drive the development of evidence-based policies and adaptation practices.

Soil conservation is a set of measures striving to preserve the overall soil fertility. Three main principles are—less tillage, more soil cover and improved crop rotations. Increasing soil protection by using cover crops, adding organic matter to the soil through manure application, green manure, or crop residues, coupled with other elements of the farming system (fertilizers, pesticides, tillage equipment) can improve soil quality. Modern agricultural practices, including cover crops and crop rotation with green manuring, can help to achieve sustainable and efficient production.

5.2.2.4 Livestock

Overview

Livestock production, as part of the agricultural sector, is substantially contributing to greenhouse gases emissions. Greenhouse gases emissions are mainly due to activities related to livestock production depending on species, specifics of the production system, as well as the type and intensity of production. Cow, sheep, goat and horse production systems are moderately intensive. However, in some dairy, and most pig and poultry farms, the system is far more intensive. Livestock production results in emissions of CH_4 and N_2O. CH_4 emissions are directly linked to the physiological nature of ruminants, caused by enteric fermentation upon digestion of plant-based fodder. At the same time N_2O emissions are due to metabolic processes in domestic animals. Additional N2O emissions happen upon storage, processing and managing manure.

The number of domestic animals in the Republic of Macedonia is declining, primarily due to the socioeconomic changes in the state over the past decades. However, animal husbandry is emitting approximately 50% of the total greenhouse gases in the agricultural sector. Close to 80% of greenhouse gases emissions from livestock production activities is in the form of methane from enteric fermentation in cattle. On the other hand, methane and N_2O emissions from manure mainly originate from dairy and pig farms.

The livestock sector is characterized by a large number of small, subsistence-oriented farms, and commercially oriented family farms. However, intensive production systems are major market suppliers in cow milk, pork and egg production. In last decade, there has been rapid development in pig and poultry farms, which have adopted the latest technologies, resulting in high productivity.

In order to maintain a high level of production over the seasons, farms are forced to provide an optimal environment in terms of temperature, humidity and ventilation, required for particular technological process and biological status of the animals. Due to the mixture of influence of the Continental and Mediterranean climate, producers are faced with cold winters and hot summer periods.

Pastureland, is the dominant category of agricultural land use, covering and area of more than 748,413,00 ha under pastures in 2017, more than 77.69% are managed by agricultural enterprises and cooperatives, while only 22.31% are managed by farm holdings. Pastures are governed by the Public Enterprise for Pastures Management, which is divided into 15 main regional branches.

In terms of production the total production of hay is 512,518 tons/year with average production of 685 kg/ha, which is result to the absence of human factor as a corrective of the production. Although very modest yield, this production of fresh forage is still used as a solid base for grazing animals during summer months. There is no organized management of pastureland in terms of clearance of bushes and tree species and increase of passive area, improvement of degraded natural grasslands. This leads to a gradual decrease in their productivity.

National livestock production in North Macedonia has been predominantly organized on small farms, and it is characterized with intensive production systems in dairy cattle, pigs, and poultry.

- Dairy cattle production is currently decreasing in terms of the number of farms. Challenges include lack of investment for farm modernisation, feeding, access to land and milk quality.

- Pig production provides national self-sufficient in fresh pork meet. It is organized on several large farms (40% of all hogs) that are applying intensive and modern production system, based on genetically superior animals. In pig farms the investments are continuous in modernization of the technology, feeding and biosecurity. The sector is growing but challenged by diseases spreading and market instability.

- Layers are the most dominant in poultry production. The production of eggs is intensive and national demand self-sufficient. Broiler production is very limited (only 2% of national market). The layer population size decreased for 29% from 2014 to 2019. Sector is under pressure of instability of the market and trends.

Production systems in beef cattle, sheep and goats are less intensive, and closely related to near farm pastures. Beef production mainly is organized on rural areas and provides about 20% of national demand for beef meat. It is mostly based on crossbreeds, kept extensive, exploring natural pastures and alternative feedstuffs. Sheep and goat production is extensive, traditionally exploring mountain pastures. It has never been intensified, and due to national socio-economic trends, the population size is constantly decreasing (from 740.457 in 2014 to 684.558 in 2019). In last 5 years the average farm size was increased by 20%. Sheep production is based on local sheep breeds and their crosses, while in goat production locally adapted breeds are predominant.

Vulnerability and climate impacts on the livestock sector

Climate change has a severe negative effect on livestock's productivity and welfare, resulting in frequent and prolonged heat stress. The heat stress is more pronounced for modern, high-productive breeds than local breeds that have adapted to the local environment. Heat stress on livestock is dependent on temperature, humidity, species, genetic potential, life stage, and nutritional status. Livestock in higher latitudes will be more affected by higher temperatures than livestock located in lower latitudes because livestock in lower latitudes is usually better adapted to high temperatures and droughts. Heat stress decreases forage intake, milk production, the efficiency of feed conversion, and performance. Warm and humid conditions cause heat stress, affecting behaviour and metabolic variations on livestock or even mortality. Heat stress impacts on livestock can be categorized into feed nutrient utilization, feed intake, animal production, reproduction, health, and mortality.

Addressing the negative consequences on livestock systems requires access to many technical solutions that care used to affect the farms' air physical parameters. The technical solutions approach increased ventilation, air conditioning, air recirculation, and insulation to influence climate parameters such as air temperature, velocity, humidity, and conditions for radiation heat exchange.

In dairy, exposure of dairy cows to a thermal environment is a major risk factor for decreased milk production, especially in high-yielding cows than low-yielding ones due to combined accumulation of heat gained from the environment and metabolic heat.

Physiologically pigs can be more tolerant to lower than higher temperatures because they are homeotherm animals and can maintain their body temperature and cannot sweat. The cooling is done by excessive ventilation through breathing when water evaporation is happening. The particular problem is cooling when the air temperature exceeds 30 °C in combination with high air humidity when the process of water evaporation is more difficult.

Farms are practicing intensive ventilation on days when the outside temperature is higher than 25 °C since animals are also radiating heat and the indoor temperature is above optimal range. Heat stress is provoked on pigs when exposed to higher than the optimal temperature for a longer period. In the case of adult categories, heat stress occurs when the air temperature is 2-4 °C higher than the optimum range.

The less intensive production systems possess higher adaptive capacities to severe weather events, due to exploration of locally adapted breeds (local, imported or crossbreds between locals and imported ones) and its higher tolerance to nutrition requirements (diverse feeding regime, feed components, less selective to different feeds, etc.). It has been proven that the locally adapted breeds can much easily adapted to future climate change then imported ones.

Due to climate change, the vulnerability of intensive livestock production systems will be comparably higher. In the last decade, it has been noticed changes in technology applied on larger dairy, pig, and poultry farms, adopting technologies resulting in higher productivity. In order to maintain high production levels over the seasons, farms are forced to provide an optimal environment, ideally, within the comfort zone for specific species, physiological status, and production level, maintain temperature, humidity, and ventilation. Due to the mixture of influence of the continental and Mediterranean climate in the country, the producers are faced with cold winters and hot summer periods. Since intensive livestock farming incorporates a controlled microenvironment, buildings and facilities are constructed according to specific requirements, ensuring additional heating during the winter periods and excessive ventilation and cooling in the summers.

Climate change could also have an impact on diseases outbreaks in livestock. The occurrence of diseases can be directly on animals exposed to extreme weather conditions, or indirectly by the presence of vectors which spatial distribution is usually very dependent of climatic condition. The direct influence of climate change is one of the preconditions of the livestock environment, that can be observed through disturbance in feeding, availability of water, and water quality, but also ensuring favourable conditions for the occurrence of many parasites and diseases.

A study on the impacts of climate change on livestock was for first time conducted to assess both dairy cows and pigs over three different scenarios for three periods of 30 years, for 249 centralized points in North Macedonia. The daily meteorological data for all points were used for calculation of the daily Thermal Humidity Index (THI), expressing the relative significance of air temperature and humidity on heat stress among confined livestock. A THI threshold value of 72 in dairy cows was determined as the alert phase. Higher threshold values of 74-78, 78-83, and 83+ were used as categories for alert, emergency, and dangerous THI loads, respectively. The findings from this study are as follows:

Dairy:

- For RCP 4.5 and 8.5 scenarios, the maximum average annual THI load in all periods had been estimated for the period 2046-2075. The highest annual THI load over the emergency phase would last 64 days in scenario RCP 4.5, while in PCR 8.5 - 72 days. However, the spatial distribution of three different THI loads over the country are not equally distributed.

- Under all scenarios, the emergency phases would be more prominent along Vardar River, Pelagoina, and the regions of Kumanovo and Strumica. However, under the scenario RCP 4.5, the emergency phases of over 50 days could also be expected in Ovcepole, Kochani, and Radovish.

- The 74+ THI load of over 50 days can also be expected in higher lands, except for the country‘s west mountainous area. Under the RCP 8.5, the 74+ THI loads of over 2 months could be expected in most of the lower lands in the country in the period 2016-2045.

- In Pelagonia, where 23% of the national population of cattle is kept, for all three scenarios and different increases in temperature, it is evident that cattle production would be faced with an annual 74+ THI load of over 70 days with dangerously THI load for over 6 days. It can be expected that annual direct loss due to failure of productivity would be up to US$ 190 per dairy cow.

Pigs:

- The spatial distribution of three different THI loads over the country suggest an increased number of days where THI over the emergency phase will increase over time.

- The increases in lowlands are more evident. Under all scenarios, the emergency phases would be more prominent along Vardar River, in the regions of Kumanovo, Ovchepole, Radovish, and Strumica, while in Pelagoina will be less evident.

- Under scenario RCP 4.5, the emergency phases of over 30 days are projected. The most extreme scenario (RCP 8.5) would affect all lowlands in the country, where THI loads will be increased by 10% in 2016-2045 and 2046-2070, compared to RCP 4.5.

- The impact of increased THI load on the animals will cause a reduction in their performance including a decreasing reduction of body mass at the end of the fattening period, dry matter intake, and the increase of the mortality.

Adaptation of livestock sector

Projections of high seasonal temperatures and heatwaves will lead to productivity losses in the regions most vulnerable to climate change. However, there is limited knowledge and experience at the national level, and research should be focused on adaptation measures. Proposed options include:

- Genetically heat-tolerant breeding animals.

- Adoption of special feed and feeding techniques in the period of excessive heat should be considered. Since in excessive heat, the needs of the live animal would change dramatically, the conventional feed compositions need to be upgraded to specific conditions of ambient and animal category.

- Improvement in housing conditions by adopting proper ventilation, in-house conditioning, and cooling systems installation

would be required. These adaptive measures need investment in installation and energy. However, to meet the criteria of energy-efficient proper thermal insulation and use of renewable energy are needed.

- The introduction of continuous monitoring is needed to follow the farms' productivity level concerning heat waves and high temperatures. That can ensure data collection for precise loss calculation. The results can be used to determine the threshold loss level to balance lost income and investment.

Manure management of small diary and pig farms

Larger dairy and pig farms are obliged by law to apply environmentally acceptable methods of manure management. However, according to official statistical sources, over 90% of dairy cows are kept on small farms with less than 30 heads. In addition, about 50% of the total production of fattening pigs in the country comes from small pig farms with a capacity of up to 50 sows.

A study was conducted on a representative sample of over 2% of the total number of heads and facilities for dairy cattle and pigs in North Macedonia to assess manure management methods at small dairy and pig farms, and to observe and assess their greenhouse gases emissions.

The study concludes that farms fail to take special care for a proper manure treatment on farms. Small farmers mainly treat manure in a very traditional way, without care for greenhouse gases emissions, but also the loss of useful substances from it. It is mainly treated as waste, failing to recognize its true beneficial value. Hence, there is a need to define mitigation measures to train farmers how to collect, dispose and use manure correctly. These measures include the retention of nutritious matter in manure and its correct application. There is also a need to promote gas plants (digesters) to use manure as a source of biogas. This would reduce total CH_4 and N_2O emission from livestock breeding.

There is also a large difference in over-applying manure in the soil, and in some cases even higher than amounts of 40 t/ha annually. Such quantities are more damaging than they are beneficial for crop production. Hence there is a need to raise awareness of farmers and educate them to better manage manure and use it correctly when applying manure to different cultures. This is of great significance since over-application of nitrates in the soil (quantities, frequency and form) has been prescribed in the EU Nitrates Directive, and our country will have to adapt to it.

5.2.3 Forestry

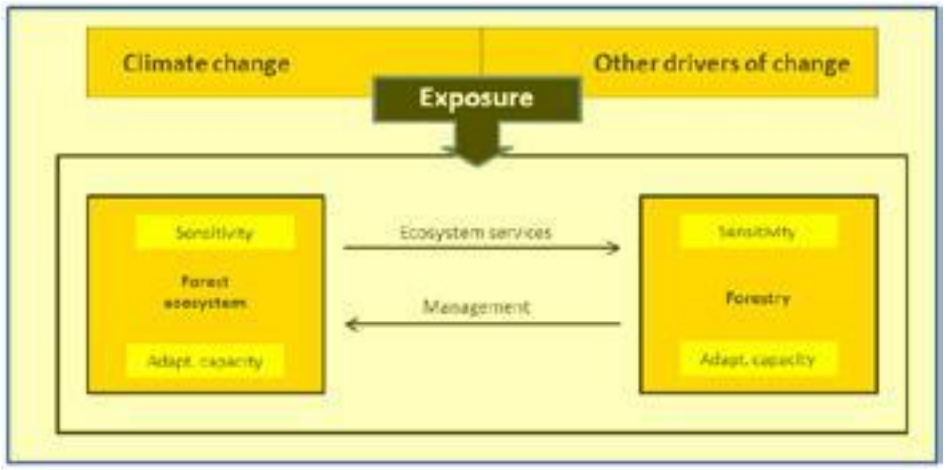
Overview

As of 2017, the total area of forest, forest land and barren land is 1,122,258 ha out of which 1,001,489 ha is forest, 109,126 ha is forest land and 11,643ha is barren land. During the period of 2009 to 2017, 43,252 ha of other woodlands were changed to forest. This process of land cover changes (especially from other land cover to forest) is very important for planning mitigation and adaptation measures. In terms of ownership, 90 % of the forests are state owned and the rest are private forests. This means that the planning and conduction of measures of mitigation and adaptation on climate change mainly will be through the state-owned forests and forest land.

Vulnerability and climate change impacts on forestry

Vulnerability of forest growth to temperature changes can be from the increase in temperature, the sensitivity of tree dynamics to temperature, and the changes of ecosystem composition following changes in tree dynamics. This analysis on forestry focuses on coupled sectorial-ecological systems, defined as integrated and complex systems in which ecosystems and sectors interact. As the provision of ecosystem services influences the vulnerability of society, and society positively or negatively affects the vulnerability of ecosystems, adaptation policies should aim at reducing the vulnerabilities of both ecological and sectorial systems at the same time. Vulnerability assessment should consider the links between these two systems, in our case forests and forestry (Figure 5-52).

Figure 5-52. Representation of a coupled socio (forestry) – ecological (forest) system



It is difficult to project the future vulnerability of a complex system such as a forest and forestry, given the number of parameters that must be taken into account. These parameters can include the optimal conditions for a species, the type of ecosystem, human activity, institutional and economic factors, and forest management. The vulnerability of a system to a specific risk can be determined by one factor or, more often, several combined.

Forest fires provide a good example. Drought increases the risk of forest fires. The vulnerability of the forest will depend on the amount of dead biomass, which in turn depends on the way the forest is managed, the amount of dead trees resulting from previous droughts and/or pests, the spatial organization of the forest (e.g. the presence of buffer strips and fire breaks), which could facilitate or constrain the spread of the fire, and the openness of the forest to human activities. Finally, its vulnerability will depend on the means of preventing and monitoring fires and addressing them at an early stage.

The importance of potential impacts is determined by a combination of biophysical, economic and institutional factors which can either augment or limit one another. Landscape, community and institutions can all buffer the consequences of hazards, thus helping to reduce the vulnerability of households. Analysis of such combinations is particularly important in determining areas of action; it can lead to the identification of links among different vulnerabilities and risks. For example, forest degradation and deforestation increase the vulnerability of a forest to many of the impacts of climate change.

In modelling the impact of climate change on forest health, crown transparency and water availability were used as the main parameters. Three future 20-year long periods were used: the near-future period 2016-2035, the middle of the 21st century 2046-2065, and the end of the 21st century 2081-2100, In order to find correlation between climate change, forest and forestry all of these scenarios will be analyzed with the spatial distribution of the most represented forest types in Macedonia oak and beech forests on two different soil's substrata-carbonate and silicate. These types of trees (oak and beech) in some areas are mixed with other trees such are pine, fir or some less represented broadleaf or coniferous that means with this map are spatially presented almost all forest types in Macedonia except afforestation. A summary of the findings is as follows:

Overall:

- By Decreasing precipitation, increasing temperatures, more frequent heatwaves, increasing spatial variation of growing days, increasing extreme precipitation events will without exception influence the forests of Macedonia.
- By For the period 2016-2035 (especially under RCP 4.5) there is an increasing trend of growing season length and average annual air temperature, and the frequency of heat waves in the western and eastern parts of Macedonia will increase.
- By From the increasing growing season length and average annual air temperature, we can expect higher productivity of the forest. In the western and eastern parts of Macedonia, heat waves will be more frequent, and the forest productivity will be lower.
- By During the next period 2046-2065, the forest productivity will decrease more significantly. The process of decreasing forest productivity will be accelerated by the insects and diseases.

Crown transparency:

- Increasing length of consecutive dry days for the period 2046-2065 from between 10 to 30 days under RCP8.5 indicates a higher risk for drought onset.

- According to the data in the Table 53 we can conclude that the health condition of the forest in the period between last National Communication on climate change and this one (2014-2021 year) is decreasing.

- In 2011, 50% of trees in the study didn't have signs of crown transparency (no loss of needles or leaves), compared to 45% of tress in 2019. Also, there is increase in the small loss of needles or leaves from 27% in 2011 to 33.5% in 2019.

- Tree mortality is higher. In 2011 the percentage of dead trees is 0.7 % and in 2019 this is more than double, at 1.6%.

Table 5-3: Crown transparency

Year of assessment	Scale of loss of needles/leaves		Class	Percentage of assessed trees
2008	no loss of n/l	from 0 – 10 %	0	**42.1%**
	small loss of n/l	>10<25%	1	**34.2%**
	moderate loss of n/l	>25<60%	2	**19.9%**
	high loss of n/l	>60%	3	**3.1%**
	dead tree	100 %	4	**0.7**
2009	no loss of n/l	from 0 – 10 %	0	**53.7%**
	small loss of n/l	>10<25%	1	**25.8%**
	moderate loss of n/l	>25<60%	2	**17.2%**
	high loss of n/l	>60%	3	**2.7%**
	dead tree	100 %	4	**0.6%**
2011	no loss of n/l	from 0 – 10 %	0	**50.1%**
	small loss of n/l	>10<25%	1	**27.3%**
	moderate loss of n/l	>25<60%	2	**19.1%**
	high loss of n/l	>60%	3	**2.8%**
	dead tree	100 %	4	**0.7%**
2018	no loss of n/l	from 0 – 10 %	0	**45.2%**
	small loss of n/l	>10<25%	1	**33.5%**
	moderate loss of n/l	>25<60%	2	**16.7%**
	high loss of n/l	>60%	3	**3.2%**
	dead tree	100 %	4	**1.4%**
2019	no loss of n/l	from 0 – 10 %	0	**45.5%**
	small loss of n/l	>10<25%	1	**33.5%**
	moderate loss of n/l	>25<60%	2	**15.9%**
	high loss of n/l	>60%	3	**3.5%**
	dead tree	100 %	4	**1.6%**

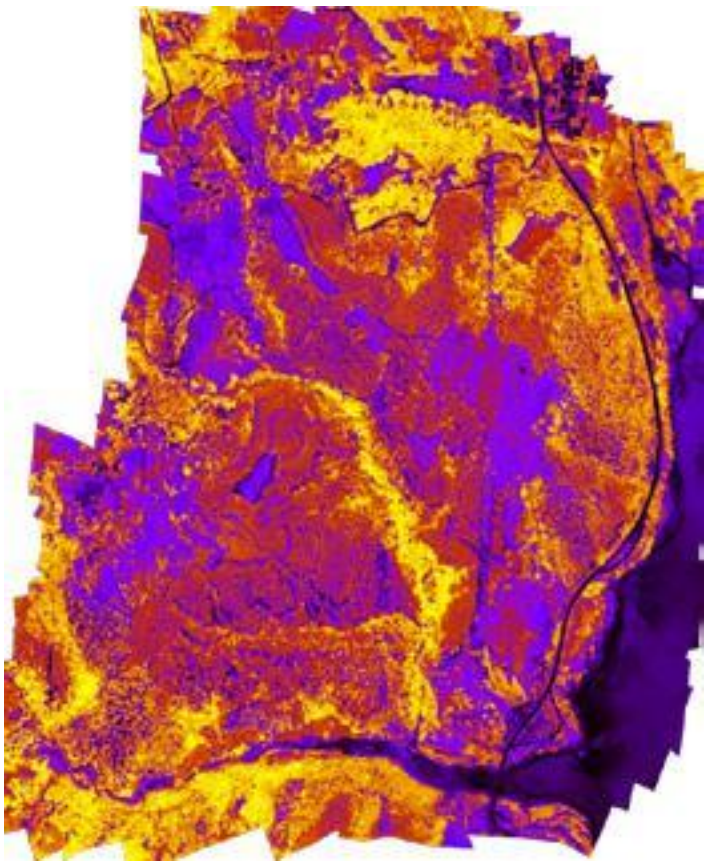
Water availability:

- In 2019 around 75% of the assessed trees have insufficient water availability.

- It is projected for the period 2046-2065 that health condition of Macedonian forests will worsen with more significant dieback and a higher % of tree mortality. Due to the weak health condition of the trees this process will be followed and accelerated by insects and fungi infestation.

- Drone tests (using SenseFly technology) were carried out to survey a mixed forest (native oak stand and pine afforestation) near to Makedonska Kamenica, to determine the characteristics of healthy or dead trees (Figure 5-53). This technology has been proven to be a suitable and efficient tool for monitoring health condition of the forests, particularly tree mortality, to monitor the effects of climate change on forests going forward.

Figure 5-53. Thermal image of a mixed forest, used to monitor forest health



Forest fires:

- Table 54 shows that over the past 2 decades, an increase in frequency and intensity of forest fires has been recorded in N. Macedonia. In the period of 1999-2021 each year, an average area of 8837.0 ha has been affected by forest fires in Macedonia with average damage estimated around 7.8 million EUR.

- In the period of 2015 to 2019 the average number of forest fires and damage caused by them has increased by 3%.

- The increasing frequency of the severe fire season in the last five years (2017-2021 year) has changed in N. Macedonia. In this period each second fire season is severe in contrast to the previous almost two decades where each fifth fire season was severe. This has been impacted by changing land use and weak fire protection capacities.

Table 5-4: Forest fires in Macedonia for the period 1999-2021 year

Year	Number of fires	Burned area ha	Burned wooden mass m3	Total costs	
				MKD	EUR
1999	69	2.414,80	1.905	105.837.151	1.720.929
2000	476	46.235,73	711.782	969.852.057	15.769.952
2001	161	6.263,30	88.260	610.814.677	9.931.946
2002	65	1.186,30	24.661	18.531.939	301.332
2003	144	1.068,88	10.987	15.594.691	253.572
2004	94	892,05	4.322	91.083.591	1.481.034
2005	182	1.368,00	1.063	25.287.638	411.181
2006	138	2.085,95	12.978	148.712.782	2.418.094
2007	652	35.248,06	617.678	1.311.167.722	21.319.800
2008	249	7.411,70	35.653	280.083.235	4.554.199
2009	61	1.990,60	1.551	29.746.064	483.676
2010	106	2.239,45	2.033	30.635.825	498.143
2011	302	17.812,84	55.743	355.053.834	5.773.233
2012	367	16716	102.160	181.927.609	2.958.173
2013	160	5.069,26	15.268	109.500.306	1.780.493
2014	109	818,04	19.152	24.655.527	400.903
2015	194	5.766,32	32.494	1.282.348.110	20.851.189
2016	150	3.585,15	17.574	213.596.388	3.473.112
2017	364	13.316,01	82.981	1.911.308.151	31.078.181
2018	129	2.822,99	5.786	69.368.610	1.127.945
2019	472	15.675,00	95.938	808.669.316	13.149.095
2020	102	1.233,92	8.138	81.071.150	1.318.230
2021 (till October)	192	12.042,74	487.038	2.342.637.539	38.091.667
Total:	**4.938**	**203.262,66**	**2.435.145**	**11.017.483.912**	**179.146.079**
17-21	252	9.018	135.976	1.042.610.953	16.753.024
99-21	**215**	**8.837**	**105.876**	**479.021.040**	**7.788.960**

Vulnerability and climate change impact on forest ecosystem services

In the next decade it is expected the productivity of forests will increase, however, insufficient forest management, illegal logging, and forest fires present challenges for the sector. Illegal logging has a significant negative influence on productivity and is a challenge for sustainable forest management. Illegal logging is closely related with the social, economic, and political circumstances of the country and mainly depends by the strong political will in order to be solved. Aside from these socioeconomic barriers, improved forest management will have a significant influence on the carbon storage potential of Macedonian forests. The national forest inventory, and the principals and methodologies for evaluation of the carbon stock potential the forests, is still under preparation.

Vulnerability and climate change impact on forest management

Since the last National Communication, forest fires remain the biggest concern of the forestry sector in Macedonia. This is evident by the damage caused by fires (UER/year) and burned area (Table 5-45). Forest fire trends have changed, with the period between two severe fire events shortening. In line with the observed changes in the forestry sector and projected

climate change scenarios, by 2035 the Macedonian forestry sector will also be faced with: higher mortality of trees, insects and fungi infestation, larger number of heavy rain days and more forest fires.

Adaptation of the forestry sector

In the last two years some extreme events have been observed. In 2018 forest management activities were significantly interrupted because of heavy rain days. It disrupted wood production and required additional financial costs for road network maintenance. In the summer period of 2019, many of the water springs into the forest area in the region of Shtip dried up. The same was noticed in other regions. It was accompanied with strong attack of fungi and insects of the conifer forests and afforestation (reported in annual report for health condition of the forests in 2019). Other adaptation needs in the forestry sector include:

Forest management planning: the forest management planning (10 years management plans) mast account for the impacts of climate change and future scenarios, however, there are still no significant activities in that direction.

Forest harvesting: As mentioned, there is already disturbances caused directly by climate change (heavy rains) and indirectly (insects, fungi, fires etc.). These disturbances will become more intense till 2035 and will make harvest operations more difficult.

Forest protection: To protect the forest, physically (forest fires) or its health (insects, fungi, dieback process etc.), will be a real challenge. Capacity building is required to overcome these challenges, particularly to maintain forest monitoring and establish new processes to monitor the impacts of climate change.

Silviculture: Many of forest management activities and techniques have been established over long term of between 20 to 60 years. These will have to be adapted with the changing climate (species selection, silvicultural methods, etc).

In the last decade, especially in the last five years, there has been a trend to establish new protected areas (with a different level of protection), such as a new National Park in Shar Planina. This is a positive move towards nature protection and forests. However, excluding these forests out of the forestry management system could exclude them from mitigation and adaptation measures. This is important especially for protective measures and silviculture.

Further descriptions of adaptation plans in the forestry sector are included in the table below.

Table 5-5: Adaptation plans in the forestry sector

Action (adaptation measures that maximizes the economic benefit and minimize the climate change impact per sector)	**Type** Policy Legislation Capacity building	**Stakeholders** (Clear distinction of responsibilities among the relevant stakeholders)	**Timeframe** Short term/long-term	**Financing** (Financial means for implementation of the measures) –Euro-	**Constraints** (identification of possible barriers and risks, including legal arrangements, institutional management, financial and technical aspects)	**Sectorial/ institutional relationship**
1. Develop a program for adapting forestry to global climate change	Policy, Capacity building	HEF, MAFWE, PENF	Short term	150,000	Capacity, finance, sector coordination	Forestry, Agriculture, Environment, Energy,
2. Education/ training for the climate change of the engineers on PE National forest	Capacity building	HEF, MAFWE, PENF, MOEPP, UHMR	Short term	250,000	finance, sector coordination	Forestry, Agriculture, Environment,
3. Education/ training for climate change of the engineers in the Sector for design, planning and hunting in the PE National forests (as a precondition for adaptation of the management plans in the forestry in agreement with the climate change)	Capacity building	HEF, MAFWE, PENF, MOEPP, UHMR	Short term	50,000	finance, sector coordination	Forestry, Environment, Energy,
4.Develop a program for improvement of the forest road network in line with the climate change scenarios, case study PENF "Babuna"-Veles		HEF, MAFWE, PENF, UHMR	Short term	1,000,000	Lack of finance	Forestry, Local self-governance, Agriculture, Environment, Energy
5. Adaptation of the Management plans in the forestry in agreement with the climate change	Legislation, Capacity building	FFS, MAFWE, PEMF	Long term	300,000	Law of forestry, education of stuff, lack of finance	Forestry, Environment, Energy
6. Purchasing of drones for monitoring of the forest condition and climate change	Capacity building	HEF, MAFWE, PENF,	Short term	600,000	Financial and technological	Forestry, PENF, Environment
7. Introduction of technologies for efficient biomass using in the forestry	Legislation, Capacity building	HEF, MAFWE, PENF	Long term	1,000,000	Educational, financial, technological, legal	Forestry, Environment, Energy,
8. Introduction of the Landscape fire management concept , case study PENF Berovo and Kavadarci	Legislation, Capacity building	HEF, MAFWE, PENF	Midterm term	1,000,000	Different Laws, Financial	Forestry, Local self-governance, Environment, Agriculture,
9. Develop educational (training) center for sustainable forest utilization	Capacity building	HEF, MAFWE, PENF	Short term	500,000	Financial and technological	Forestry, Environment

Action (adaptation measures that maximizes the economic benefit and minimize the climate change impact per sector)	**Type** Policy Legislation Capacity building	**Stakeholders** (Clear distinction of responsibilities among the relevant stakeholders)	**Timeframe** Short term/long-term	**Financing** (Financial means for implementation of the measures) –Euro-	**Constraints** (identification of possible barriers and risks, including legal arrangements, institutional management, financial and technical aspects)	**Sectorial/ institutional relationship**
10. Promotion of the possibilities for production of "green " energy	Promotion, Legislation,	HEF,FASF, MAFWE, PENF, MOEPP	Long term	100,000	Financial, institutional	Forestry, Energy, Environment
11. Implementation of pilot project for renewable energy production from forest and agricultural biomass	Legislation, Capacity building	HEF,FASF, MAFWE, PENF MOEPP	Long term	10,000,000	Financial, institutional, technological, legal,…..	Forestry, Environment, Energy, Agriculture
12. Forest inventory (last one was done in 1977)	Capacity building	HEF, MAFWE, MOEPP	Short term	1,500,000	Financial	Data needed for higher Tier calculations: annual biomass growth (all types of forests, grasslands, croplands), DOM, Carbon fraction of biomass, Fraction of biomass oxidized Fraction of biomass burnt on-site and off-site, Fraction of biomass left to decay, harvest of industrial round wood (logs) and fuel wood, production and use of wood commodities, and establishment and operation of forest plantations as well as planting of trees in urban, village and other non-forest locations
13. Introduction of new environmentally friendly technologies for forest harvesting (electric saw chains, electric harvesters, forwarders, case study NP "Mavrovo" sustainable management zone, and PE National forest – Berovo)	Capacity building	HEF, MAFWE, MOEPP	Short term	1,500,000	Financial, institutional, technological,	New technologies of forest harvesting are developed, and it should be introduced in the country. Forestry, Environment

5.2.4 Biodiversity

Overview

Biological diversity is constantly exposed to climate change impacts, and it reacts according to its own adaptation capacity. The Republic of Macedonia has a specific geographic position on Balkan Peninsula where different climatic influences (continental and Mediterranean) on a small area in separate parts of the country intertwine. In combination with other ecological and historic factors they have led to development of a specific and very rich biological diversity. Beside its intrinsic value, biodiversity in the country has other values, especially economic, and it provides a lot of goods and services.

With the adoption of the Nature Protection Act, intensive efforts have begun to bring national legislation in line with EU legislation in the field of nature protection. According to this law, the valorization and revaluation of the natural value of protected areas is underway, as well as the adoption of new approaches to the management of protected areas. Protected areas are established to protect biodiversity within natural habitats, processes that occur in nature, as well as abiotic characteristics and landscape diversity. Article 66 of the Nature Protection Act accepts has six categories of protected areas, in line with the categorisation of the International Union for the Protection of Nature.

A new Nature Act is ready (but has not yet been adopted), where the requirements of the EU Birds and Habitats Directive have been fully transposed, and 5 draft legal acts have been drafted, 3 of which are directly related to the establishment of the Nature 2000 network. Furthermore, a by-law was adopted to establish strictly protected and protected wild species of plants, fungi and animals. A draft rulebook for the designation of protected areas in the country is being prepared, which will allow continued progress of national legislation on the protection of nature and compliance with the EU‘s requirements of the Birds and Habitats Directive.

The National Strategy for Nature Protection (2017–2027) is a strategic document that aligns national needs with the ratified international treaties of the Republic of Northern Macedonia in the field of nature protection and the European Union‘s vision for biodiversity. This strategy provides guidance on establishing an integrated system for the protection of the country‘s geodiversity and geoheritage, as well as other components of nature (biological and regional diversity), conservation and management of protected areas, rational use of mineral raw materials, sustainable use of wild species and ecosystems, preservation of regional diversity in accordance with the requirements of the Convention on the Landscape, establishment and development of environmental networks for effective protection and management of natural heritage.

Vision 2027

The National Nature Protection Strategy will contribute to an efficient implementation of national legislation and EU legislation obligations, i.e. the implementation of EU directives on habitats and birds. The strategy also has a positive impact on the implementation of the three UN Framework Conventions (the Convention for the Protection of Biological Diversity, the Convention on Climate Change and the Convention on Desertification), as well as international ratified documents in the field of nature protection. From the point of view of establishing integral protection of nature (geodiversity and biodiversity), the strategy will contribute to improving the implementation of the Convention for the Protection of World Cultural and Natural Heritage (UNESCO), as well as the European Convention on the Landscape in the Direction of Protection, management and planning of borders and organising European co-operation on issues relating to the area.

Undoubtedly one of the most important strategic principles is the implementation of measures to protect and sustainably use biodiversity in all relevant sectors in the country (together with economic and social development). In practice, this means that effective implementation of the Biodiversity Action Plan requires the inclusion of all relevant stakeholders and interested parties.

Implementing the concept of green infrastructure – two pilot corridors, will facilitate the connection of habitats, as well as the migration movement of animal species from one place to another, especially species that are threatened by climate change.

Progress since the Third National Communication

The following updates have been implemented since the Third National Communication[18]:

Legal framework

During 2015-2021, significant progress has been made concerning the legal framework for biodiversity protection, regarding the harmonization of national legislation with the EU on nature protection.

A new Law on Nature has been prepared (but not adopted yet), where the requirements from the EU Birds and Habitats Directive have been transposed fully, and 5 draft bylaws have been prepared as well, of which 3 are directly related to the establishment of the Natura 2000 network. Furthermore, a bylaw was adopted – Lists for determination of strictly protected and protected wild species of plants, fungi and animals, which requires revision. A Draft Rulebook for marking and visualization of protected areas in the country has been prepared, which will enable continuous progress of national legislation on nature protection and the fulfilment of EU requirements from the Birds and Habitats Directive.

During this period, three documents for proclamation of new protected areas were adopted, thus increasing the protected areas from 8.9% to 13.47% of the total territory of the country:

- Law on proclamation of a part of Shara Mountain for National Park (Official gazette of Republic of N. Macedonia 151/2021 from 06.07.2021).
- Decision for proclamation a part of the Osogovo Mountains for a protected area in category V – protected landscape (Official gazette of Republic of N. Macedonia 277 from 20.10.2020).
- Decision for proclamation of a part of Maleshevo for a protected area in category V – protected landscape (Official gazette of Republic of N. Macedonia 286 from 20.12.2021).
- Decision for temporary protection of Studenchishko Swamp (Official gazette of Republic of N. Macedonia 164 from 19.07.2021).
- A procedure for declaring part of Vodno for a protected area in category V – protected landscape, has been initiated
- The procedure for designation of Canyon-Matka and Mavrovo as protected areas is underway

The system of protected areas includes 81 areas, which cover an area of 346,317 hectares or about 13.47% of the territory of the Republic of Northern Macedonia (Table 5-6).

Table 5-6: Number and area of protected areas by protection categories

Categories of protection according to IUCN	Number of areas	Area (ha)	% of the territory of RNM
Ia. Strict nature reserve (SNR)	2	10,583.2	0.41
Ib. Wilderness area (WA)	-	-	-
II. National Park (NP)	4	177,575	6.91
III. Monument of nature (MN)	60	77,014.5	3.0
IV. Nature Park (NP)	12	3,039.8	0.12
V. Protected landscape	2	52,799.66	2.05
VI. Multipurpose area	1	25,305	0.98
Total	**81**	**346,317.16**	**13.47**

[18] Report prepared by the UNDP for the Fourth National Communication. Biodiversity and Climate Change in North Macedonia.

Figure 5-54. Map of protected areas in the country

National plans

In the period 2015 - 2021, two new strategies were adopted in terms of protection of national natural resources, the National Strategy for Biodiversity with an action plan for the period (2018 - 2023) and the National Strategy for nature protection with an action plan (2017 - 2027). The National Strategy for Biodiversity with an action plan for the period (2018 - 2023) had 19 national biodiversity goals which were identified, and grouped into the following 4 strategic goals:

- overcoming the root causes of biodiversity loss through its integration into society as a whole,
- reduction of direct and indirect pressures on biodiversity,
- improving biodiversity status by conserving ecosystems, species and genetic diversity to increase the benefits of biodiversity and ecosystem services, and
- improving the knowledge and availability of all relevant biodiversity information

National Strategy for Nature Protection with Action Plan (2017-2027): The National Strategy defines a number of specific goals that include:

- preservation of natural units in terms of geological and geomorphological properties of nature,
- rational use of mineral resources,
- ensuring sustainable use of wild species and ecosystems,
- strengthening and improving the system of protected areas,
- preservation of landscape diversity in accordance with the requirements of the Landscape Convention,
- strengthening the institutional capacities for nature protection at central and local level,
- establishment and development of ecological networks for effective protection and management of the natural heritage,
- alignment of the Nature Protection Strategy with other strategic development documents from other sectors (forestry, agriculture, animal husbandry, fisheries, transport, energy, industry, mining, tourism, construction, etc.) by integrating nature protection policy,
- achieving integrated nature protection by promoting a holistic approach to biodiversity, geodiversity and landscape diversity protection.

Red Lists

IUCN categories for species threat levels have been integrated into the Law on Nature Protection. During the 2018-2019 period, in collaboration with UNEP the IUCN ENCARO office in Belgrade, as well as local experts, an assessment of all amphibian and reptile species on a national level was undertaken (46 species), in accordance with the IUCN criteria, and the first National Red List of Herpetofauna was prepared. Furthermore, an assessment of 14 species of vascular plants of international and national importance has been made, and a Priority List of flora taxa on a national level was prepared, to serve as the basis for further selection and determination of a final list of priority taxa for the Red List of Flora of the country http://redlist.moepp.gov.mk/pocetna/.

Activities implemented from the Third National Communication

Activities that have been implemented from the Third National Communication have included the following:

- Monitoring of the status of alien (and invasive) species of plants
- Adoption of policy instruments for implementation of corridors management plans into national and regional spatial planning
- Definition of possible routes (bio-corridors) for movement and movement and migration of threatened plant and animal species by the climate change
- Adaptation of the Management plans in the forestry sector to incorporate climate change factors.
- Study of the historical and current line of trees and modelling of future climate change.
- Detailed revision of the system of protected areas in Macedonia regarding the adaptation to climate change.

5.3 Climate vulnerability assessment

Vulnerability is a complex and multidimensional concept. Studies suggest that climate impacts could slow down or reverse past development achievements; hinder global efforts on poverty reduction; and lead to human and environmental insecurity, displacement and conflict, maladaptation, and negative synergies. Stronger adaptive capacity has the potential to reduce exposure and sensitivity, and hence reduce vulnerability.

It is of particular importance to assess the vulnerability to stimuli such as climate change in the AFOLU system in North Macedonia through the interaction of exposure and sensitivity, and the adaptive capacities to deal with the associated effects or risks, and to estimate its distribution along the different territorial and community levels in North Macedonia. There are regional disparities across the development, demographic, and social-economic indices.

Three basic indices for ranking and comparing the development level of the different regions across the country have been developed (Table 5-7). The indices indicate Skopje as the most developed region from all aspects i.e., development, economic-social and demographic level, followed by the Southeast, East and Pelagonia region. The Northeast, Polog and Vardar regions have the lowest development, particularly the socio-economic index. The largest regional disparities are evident across demographic index.

Considering this regional disparity, which further diverges at municipality level, the livelihood approach coupled with the climate impacts in the AFOLU sector can be used to monitor vulnerability. It can further serve as a basis to evaluate policy frameworks. The framework is an initial effort to estimate the climate/livelihood vulnerability in the country and to help reduce vulnerability from future climate change.

Table 5-7. Classification of the regions in North Macedonia according to the development level

	Developing index	Economic-social index	Demographic index
Vardar region	73.5	70.5	75.9
East region	96.1	136.4	65.5
Southwest region	81.4	97.7	69.0
Southeast region	97.1	129.5	72.4
Pelagonia region	91.2	109.1	79.6
Polog region	82.4	50	106.9
Northeast region	62.7	27.3	89.7
Skopje region	151.0	147.7	153.5

Note: higher value indicates higher development levels.

5.3.1 Livelihood Vulnerability Index

To estimate the climate change vulnerability, a common approach is used to estimate the complexity of the differential impacts of climate change on different territorial units through composite measures. The Livelihood Vulnerability Index (LVI) and similar adaptations of its concept enable derivation of a composite indicator based on a diverse combination of variables connected to exposure, sensitivity, and adaptive capacity to climate change.

LVIs were calculated for 8 regions and 71 municipalities in North Macedonia. Variables were grouped into three major components: exposure, sensitivity, and adaptive capacity. Each is comprised of several sub-components (the adaptive capacity component includes socio-demographic features and social networks; the sensitivity component includes food, health and water aspects; exposure refers to soil, precipitation and temperature). Data was collected from literature reviews, desk research, official statistics and surveys. LVI was calculated using the IPCC vulnerability framework, where exposure, adaptive capacity and sensitivity is scored for each municipality from -1 (least vulnerable) to 1 (most vulnerable).

5.3.2 Results

The findings confirm high regional and municipality disparity. Demographic factors, such as population density and birth rates have the highest variation across the municipalities (154.5% and 257.2%, respectively) and between different regions, which significantly impacts the local adaptive capacity and sensitivity. In general, the human capacity to cope with the effects of climate change is not equally dispersed and varies greatly across the municipalities, especially in line with indicators on primary education (almost 40% variation) and people engaged in agriculture (50% variation). This is directly connected with the local availability of schools (60% variation), with incidences of municipalities with less than 1 school and some with more than 5 school facilities per 1000 inhabitants. Economic factors and infrastructure are also unequally distributed (GDP per capita 30.1%; Roads infrastructure 90.5%).

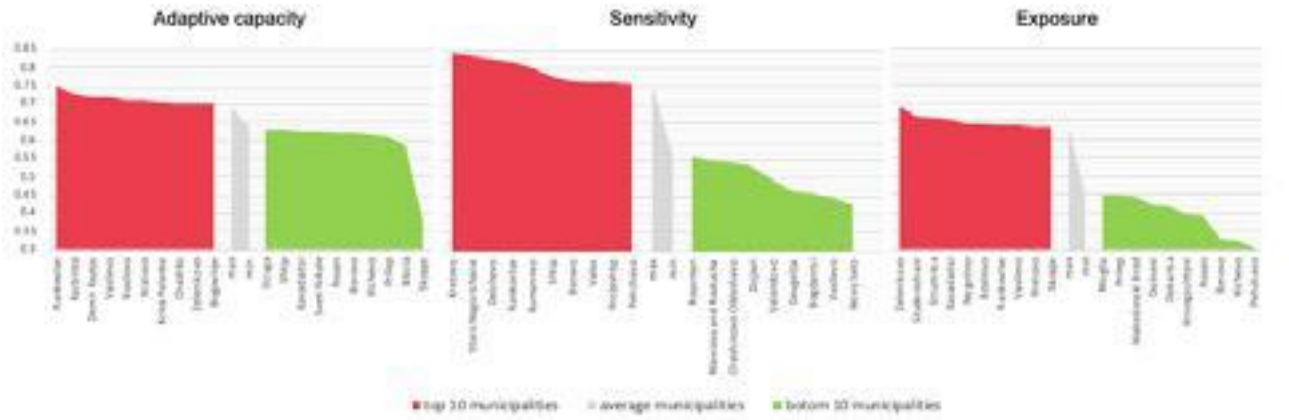
There is significant variation of the social capital concentration, with the availability of social networks and presence of the NGO sector as important part of the local adaptive capacity. It can be noticed that in some municipalities no agriculture or ecology and rural development associations exist, while in others more than 100 or even 200 such associations are registered.

Differences between municipalities are also evident in terms of the value added by the agricultural sector, with more than 60% variation in the contribution of the agriculture sector to national GDP. In addition, the potential for irrigation and irrigation practises as important aspects for dealing with climate change are not equally dispersed and vary from almost no irrigation to more than 90% of the utilized agricultural area with irrigation access.

As can be seen from Figure 5-55 and Figure 5-56, the municipalities with the lowest adaptive capacity (Rankovtse, Karbintsi, Vasilevo, Bosilevo, Kratovo and Kriva Palanka) are settled primarily in the East and Southeast part of North Macedonia, which are the regions that are most sensitive and most exposed (including Staro Nagorichane, Delchevo, Kumanovo, Shtip, Berovo, Probishtip and Pehchevo for sensitivity; and Strumica, Bosilevo for Exposure). It can be noticed that some of the municipalities from Skopje and Vardar region are also ranked in the top 10 vulnerable areas.

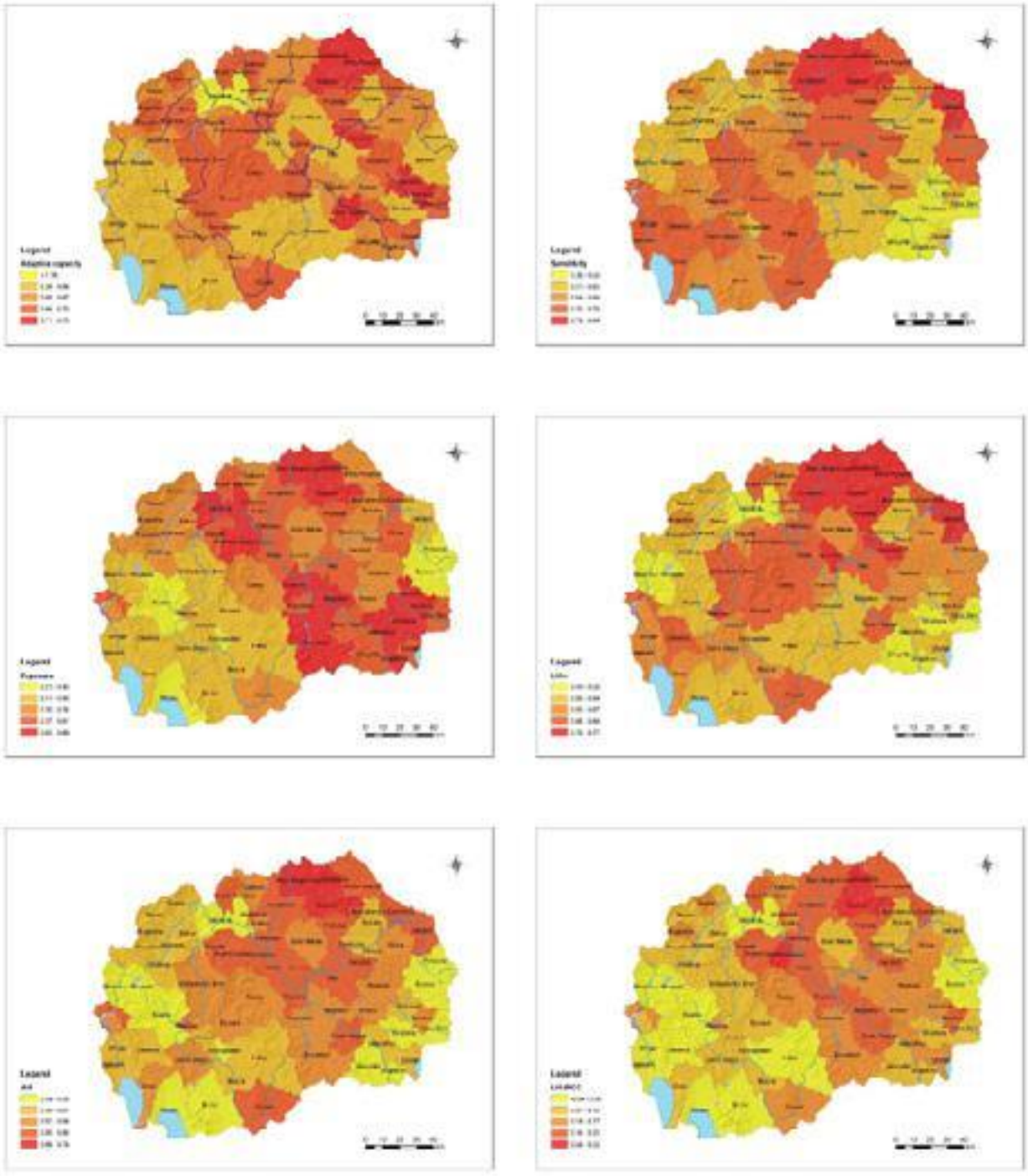
The municipalities that can be evaluated as least vulnerable are mainly from the south-west and Pelagonia region (as Prilep, Bitola, Kichevo, Resen, Struga, Mogila), mostly as a result of more favourable adaptive capacity and exposure scores, while the lowest sensitivity scores are for municipalities from the south-east region.

Figure 5-55. Adaptive capacity, sensitivity and exposure across municipalities (most vulnerable to least vulnerable)



The climate vulnerability assessment through the Livelihood Vulnerability Indices proves to be a useful tool for a multidimensional analysis, providing evidence for programming and implementing tailored policy instruments and measures for addressing more targeted local level needs. Policy response options should account for the uneven distribution of impacts across different territorial units and ultimately the affected population in different regions and municipalities, since the multidimensional character of the climate change effects requires a comprehensive understanding of the economic, social and environmental vulnerability specifics.

Figure 5-56. Components of vulnerability to climate (adaptive capacity, sensitivity and exposure) and three approaches to Livelihood vulnerability index (LVIm – weighted average of vulnerability component, AVI – Average Vulnerability Index and LVI IPCC – the IPCC vulnerability framework)



5.4 The Water-Food-Energy Nexus

The water-food-energy (WFE) nexus is a novel concept in resources management. The "nexus" term in the context of water, food and energy, according to the United Nations Economic Commission for Europe (UNECE, 2018), refers to "these sectors being inseparably linked so that actions in one policy area generally have impacts on the others, as well as on the ecosystems that natural resources and human activities ultimately depend upon". According to the UN Food and Agriculture Organization (FAO, 2014), the added value of a nexus approach is that it "provides a cross-sectoral and dynamic perspective and that it helps us to better understand the complex and dynamic interrelationships between water, energy and food, so that we can use and manage our limited resources sustainably". By applying a multi-dimensional approach such as this, adaptation planning can be facilitated across the sectors, helping to understand how one sector may impact another.

The WFEN-related sectors include the following:

- Water management sector relates to management of water and public water estate, protective and hydro-ameliorative water structures (notably irrigation and drainage systems), protection against water pollution and harmful effects of water.
- Food sector relates to primary agricultural production of crops and livestock, food processing, and food consumption.
- Energy sector relates to the production and distribution/supply of energy used in the food and water sector. This also includes on-farm energy production from renewable energy sources (RES) farm by-products.
- Climate change sector –the inclusion of mitigation and adaptation aspects of climate change – as these are essential for providing a comprehensive WFEN analysis.

At present, North Macedonia is in the early stages of implementing WFEN-related practices. There is hardly any cultivation of energy crops used for production of renewable energy and the production of renewable energy from farm by-products is insignificant. Water is used for irrigation, but renewably energy (except electricity produced from hydropower) is rarely used in agriculture and food processing.

About 10% of the agricultural land has irrigation systems. However, these are outdated, and water and energy-use inefficient. Approximately 60% of the irrigated area uses sprinkler irrigation systems, while on the other 40% are surface irrigation methods are practiced. However, most irrigation systems are in poor condition. Nearly one-third are completely out of use, 22% face serious deterioration, 19% moderate deterioration and only 27% are fully serviceable (FAO, 2022). Smart, modern and resource use-efficient irrigation systems are hardly in use. There is no information on energy efficiency of the irrigation systems. Information on small-scale, low-cost, environmentally friendly irrigation schemes is scarce, but recent projects suggest that these can be successfully employed and are feasible (FAO, 2021). Long-term investments in reconstruction and extension of dams and irrigation schemes are on the way[19]. The Government considers the expansion and rehabilitation of existing and construction of new irrigation systems as a priority (MAFWE, 2020). The same goes for protection of water resources from adverse agricultural practices, including irrigation, and pesticide and fertiliser use. Management of livestock manure at many farms is not up to the task, leading to surface and water pollution by nutrients (FAO, 2021).

Besides irrigation, other adaptation to climate change practices in agricultural production are not widely spread. Although several adaptation techniques proved to be successful, they are not sufficiently promoted and largely adopted. A national fund for financing testing of adaptation measures in agriculture (notably introduction of drought resistant species) has not yet been established and not enough resources and efforts have been invested in adaptation-related research and innovation (Mukaetov, D et al., 2021).

19 Many of these are financed by international donors, such as rehabilitation of irrigation in Southern Vardar Valley (KfW bank), and EU supported a project (IPA) for construction of small irrigation systems.

5.5 Spatial Planning

5.5.1 Introduction

The need to incorporate the nexus between climate change and spatial planning has been determined in several climate change strategies across the world. Building climate resilience by mainstreaming climate change and climate variability is one of the guiding principles for spatial planning in North Macedonia. Spatial planning also has a vital role to play in the move to a low carbon energy future and in adapting to climate change. To do this, spatial planning must develop and implement new approaches. The Agency for Spatial Planning within The Ministry of Environment and Physical Planning is mandated to develop spatial plans for North Macedonia. Key objectives of spatial planning include:

- Co-ordinating the spatial dimensions and impacts of other sectoral policies
- Establishing the integrated and functional organisation of land uses and their regulation
- Balancing the demand for socio-economic development with the need to protect the environment

Broad strategies for integrating climate change considerations into spatial planning are;

1. Climate change and extreme events preparedness through risk identification, risk reduction and mitigation
2. Adaptation strategies for resource security in future scenarios of resource risk
3. Protecting natural resources of national importance and value
4. Conserving and rejuvenating regional landscapes and resource regions
5. Integrating regional and localised plans through adaptation recommendations for urban and rural areas

Climate change is predicted to impact the different geographic regions of North Macedonia slightly differently in term of; intensity, frequency and duration of rainfall; temperature changes/variables in terms of duration, intensity. A major requirement is to translate these projected regional variables in terms of impacts and consequences to landscapes, ecosystems, human settlements, infrastructure etc., by examining local drivers that exasperate these climate change variables. Spatially identifying and mapping vulnerable areas and impact areas is critical to enable decision makers and spatial planners integrate climate change into development plans. Some best practices include:

- Spatial identification of vulnerability and risks for existing and future scenarios of extreme events and climate change
- Develop spatial strategies; to mitigate risks, enhance resilience and lower emissions. This is anchored on strengthening and facilitating ecosystem services performed by landscapes across scales and habitats including urban areas.
- Emphasis on better management of landscape systems and natural systems across scales (from national, regional to urban and local) from urbanization, industrialization or land conversions
- Need for integration and coordination among various scales of spatial plans

Spatial Plans should be able to advocate planning practices that are climate-change sensitive and provide valuable information to other lower level plans. The type of spatial assessments suggested for North Macedonia are;

- Natural potential and capacity based spatial assessments
- Vulnerabilities and impact analyses which are specific and cumulative
- Assessing suitability of land for different types of interventions (agriculture, urbanisation, industrial development, mining, etc.)
- Landscape systems and maintaining their functional capacities
- Compatibility of different land uses and development types

Decision making regarding development choices, intensity of development, type of development etc. has to be informed by the findings of spatial assessments and evaluation that considers climate change and other extreme events. Given this complexity of the nexus linked to climate change and human actions/interventions; it is critical that a system based assessment practice is adopted for spatial planning. Planning being a cross-sectoral and multi-scalar practice, is best suited to functions as a platform that can bring together this interdependency between sectors. System based planning and assessment frameworks are hence important in planning practice and associated research.

5.5.2 Spatial Planning in North Macedonia

For the successful implementation of recommendations for mainstreaming climate change considerations in spatial planning, it is critical that the above recommendations align with the legal frameworks and all applicable laws. Spatial planning cuts across scale and sector. The larger context and driving forces which emerge at global, national and regional scales influence and impact communities locally and differently. Similarly, the combined and cumulative role of many different local actions; correlate, interact and influence the larger systems differently. This impact-response cycle cuts across scales and differently influence and react to local conditions. This is very much systemic and dynamic.

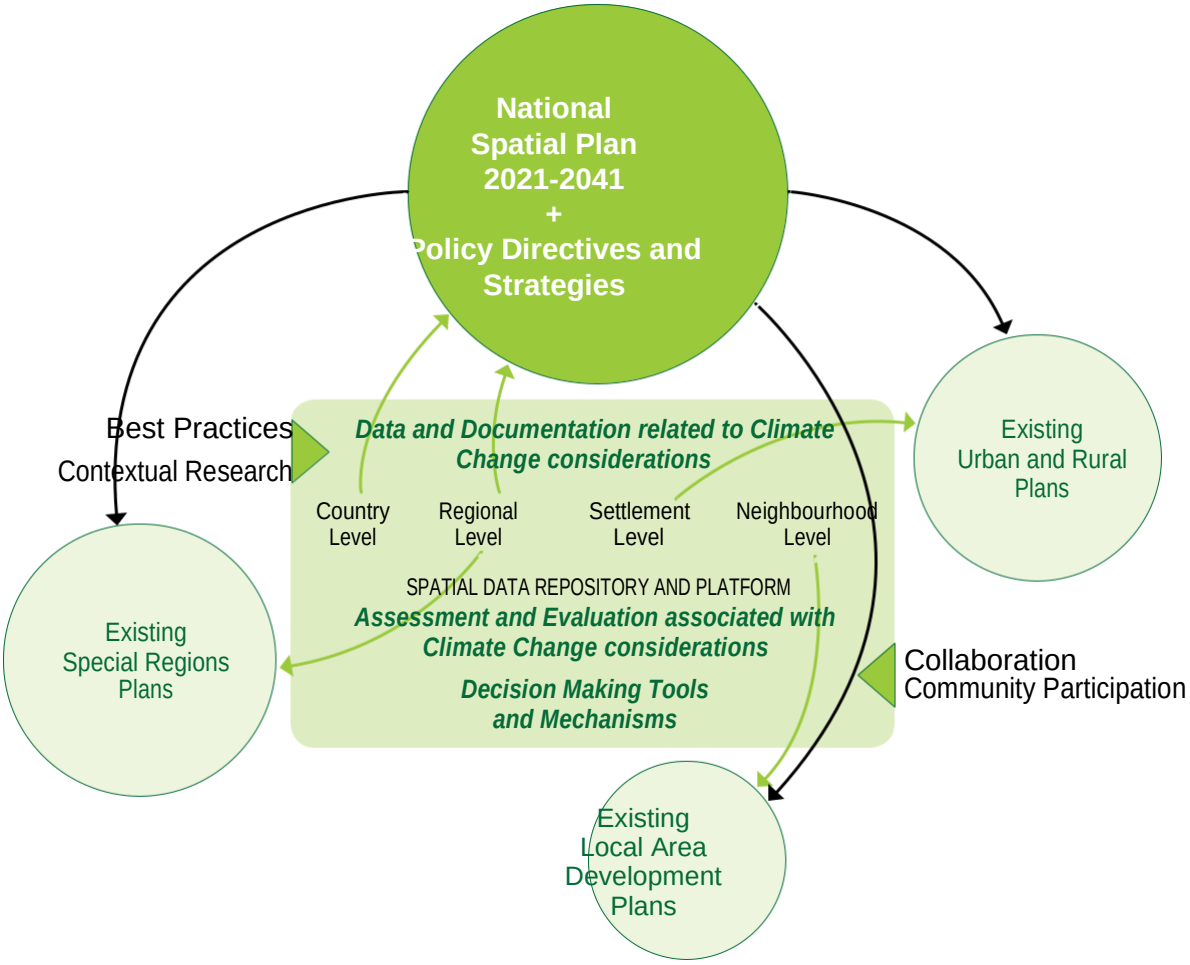
Figure 557 illustrates the layout of proposed components in the framework of spatial planning. The framework proposes that climate change consideration for spatial planning be integrated across different scales, from country to region to city and village to neighbourhood level.

Specific spatial implications, risks, decision-making tools and strategies at country and regional scales can be found in North Macedonia's Mainstreaming Climate Change into Spatial Planning report[20]. In summary, the following spatial assessments integrate spatial aspects with climate change risks in the country:

- Areas with elevated drought risks
- Areas with higher heatwave risks
- Areas with additional flood risks
- Areas with additional landslide and avalanche risks
- Habitat vulnerability
- Areas of industrial disaster risks
- Catchments with elevated risks for dam breach

20 UNDP, 2020. Mainstreaming Climate Change considerations into Spatial Planning. Available at: https://api.klimatskipromeni.mk/data/rest/file/download/802f1a43e84dff9a911d3a874b7bb01852b11caef00533fc37057257af3be7f0.pdf

Figure 5-57: National Spatial Plan within the Spatial Planning Framework and points of entry for lower level plans to integrate climate change considerations



Decision making tools mainly comprises of decision-making spatial maps, regional landscape structure plans, strategies, protocols, policy suggestions, development control regulations etc.

These tools can be derived based on cumulative analysis of various spatial maps which help identify intrinsic land and space-based risks, which can help identify critical spaces and landscapes that can built resilience, require adaptation or need restoration and protection.

Example national tools include:

- National comprehensive hazard zonation maps
- National resource management region maps
- National adaptation region maps
- Suitability based strategies for sectoral development
- Spatial guidelines and strategies for
  - national reserves, parks and sanctuaries

  management o hazard zone management

  o risk management and adaptation

  o resource regions management
- Recommendations to inform sectoral strategies to address climate change

Example regional tools include:

- Regional landscape structure plan
- Buffer zone delineation and regulation
- No-development zones
- Regulated development zones
- Guidelines for density management
- Recommendations to urban and rural areas municipalities

The role of spatial planning is to identify areas and locations that would be most affected so as to take proactive precautionary measures with respect to development planning, adopt planning strategies that can integrate and assimilate the resilience of natural environment into human settlements/systems and take proactive adaptation measures (sectoral and spatial) so as to be prepared for the changed future.

5.6 Loss and damage

5.6.1 Introduction

There have been 12 natural disasters in North Macedonia over the last two decades, taking 72 lives and affecting 1.3 million people. Eight of these events have cost over half a billion USD in terms of damage[21]. Furthermore, the 1993 drought led to a crop failure that cost 7.6 per cent of the total national income.[22] In addition to these, many other, smaller-scale extreme whether events occur throughout the year, which continually erode the resilience of communities and citizens by draining their limited resources and capacities.

Loss and damage is most commonly defined as “the residual effects of climate change that cannot (or will not) be avoided through mitigation and adaptation”[23]. Loss and damage can be caused by extreme weather events (floods, droughts, storm surges, cyclones, heatwaves) and slow-onset climatic processes/events (for example desertification, rising temperatures, salinization, loss of biodiversity, land and forest degradation)[24]. Losses can be economic (for example business operations, agricultural production, infrastructure, tourism) or non-economic (for example life, health, cultural heritage, ecosystem services) and the IPCC has acknowledged that “even if mitigation and adaptation can reduce warming to 1.5 °C there will still be losses and damages that will have a greater impact on the most vulnerable people, communities and countries”[25]. The Warsaw International Mechanism on Loss and Damage (WIM) is the main vehicle and dedicated policy mechanism in the UNFCCC process to address loss and damage for climate change.[26] It promotes the implementation of various approaches to address loss and damage which include:

- enhancing knowledge and understanding of risk management
- strengthening dialogue, coordination and coherence
- enhancing action and support, including finance, technology and capacity-building

21 Popovski, Vasko. DRR Chapter for the 4th National Communication on Climate Change (Report). UNDP. 2021. p.5

22 WMO. 2012. Strengthening Multi-Hazard Early Warning Systems and Risk Assessment in the Western Balkans and Turkey: Assessment of Capacities, Gaps and Needs. Geneva.

23 Ibid. p.4.

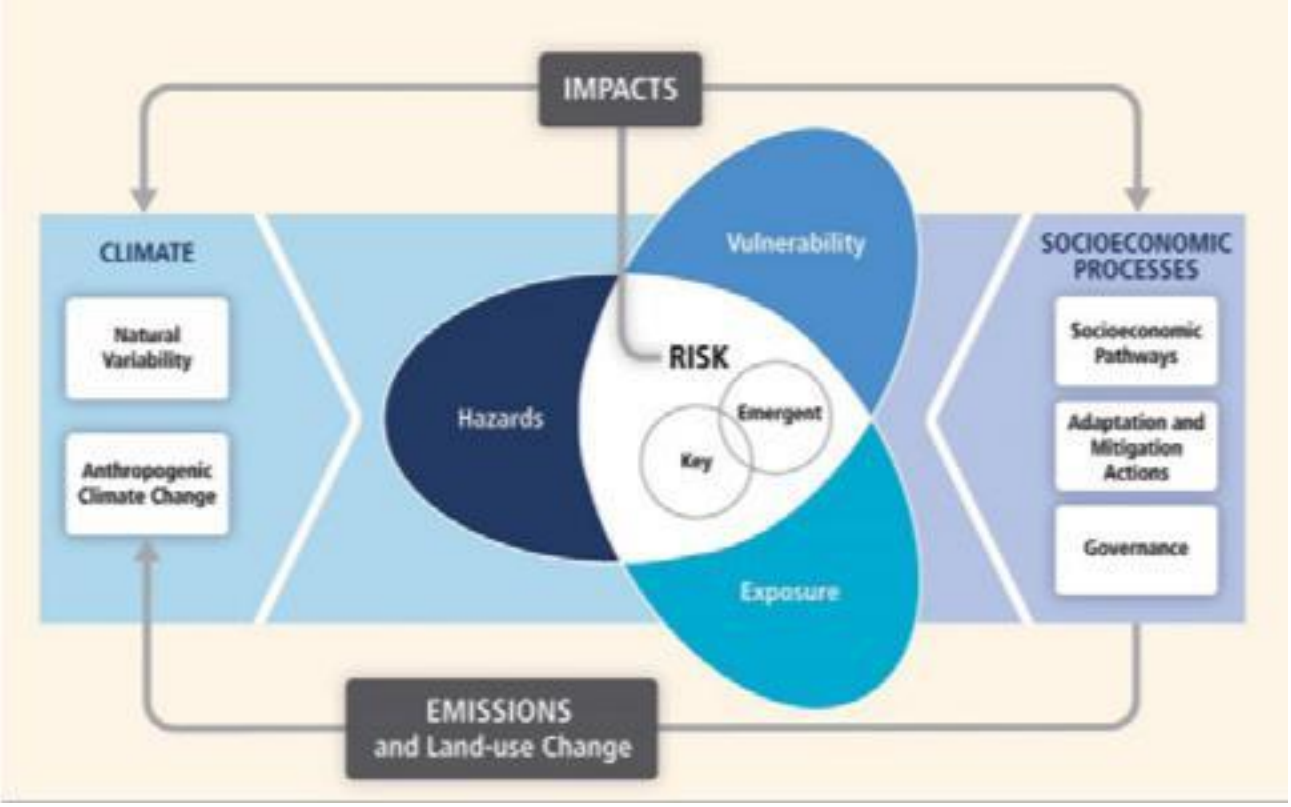
24 https://unfccc.int/sites/default/files/resource/Online_Guide_feb_2020.pdf

25 https://www.lossanddamagecollaboration.org/whatislossanddamage

26 https://unfccc.int/resource/docs/2013/cop19/eng/10a01.pdf

The extent to which a country is susceptible to loss and damage is determined by the occurrence of climate change hazards, how exposed the country is to those hazards, and the vulnerability of the human and natural systems (Figure 5-58). Therefore, new approaches to reducing the disaster and climate risks are needed, varying from enhanced risk governance, systemic, multi-hazard, multi-risk and multi-sector assessment, anticipatory actions, sustainable risk financing, increased disaster prevention through structural and non-structural measures, better preparedness, timely response and resilient recovery. This chapter provides recommendations for the way forward in building the climate resilience of North Macedonia's society and the communities.

Figure 5-58. Interaction of climate-related hazards with the vulnerability of human and natural systems direct the impacts and the scope of loss and damage[27]



5.6.2 Existing mechanisms in North Macedonia

North Macedonia has not until now engaged sufficiently with the benefits of the WIM mechanism, although it "plans to develop a National Adaptation Plan (NAP) based on nexus approaches in the following areas: water, food, energy, health, biodiversity, tourism, forestry, disaster risk reduction, loss and damage, built-in infrastructure."[28] From the normative aspect, North Macedonia has not sufficiently designed solutions to comprehensively address climate change loss and damage, or if they do exist, they are stand-alone mechanisms with limited coherence across policies and sectors. Below summarises the country's limitations to manage loss and damage:

Risk assessment:

- Insufficient integration of climate scenarios and models into risk and hazard assessments
- Insufficient participation of at-risk communities
- Poor mainstreaming of hazard assessments into the private sector (for example insurance) and development plans

27 Ibid. p.3

28 https://tinyurl.com/2vktzybt p.20

Risk reduction:

- Measures mainly address extreme weather events rather than slow onset processes
- Climate risk analyses are insufficiently integrated into the design and implementation of risk reduction actions

Risk transfer:

- There is no ex-ante systematic disaster and climate risk insurance system (the exception being agricultural or crop insurance which is subsidised by the government)

Budget:

- There are limited funds allocated by the state and municipalities for risk reduction
- Contingency planning is limited and is not linked to insurance mechanisms
- Climate budget tagging has been initiated to provide transparency on expenditure for climate change mitigation and adaptation programmes

Preparedness:

- Meets the basic requirements but lacks integration across sectors

Social safety nets:

- Only 0.02% of the population are eligible for financial assistance in the event of a shock or disaster.
- Social safety nets are insufficiently used

Loss and damage assessment:

- Lengthy reimbursement process with limited compensation for loss and damage
- Not all climate change loss and damage events are eligible

In order to benefit from the Warsaw Implementation Mechanism, North Macedonia can undertake the following actions to build the country's capacity to take action against loss and damage:

- Appoint a loss and damage contact point at a national level
- Active participation in WIM bodies and technical working groups
- Inclusion of national experts and organisations (insurance companies, NGOs, financial associations) in an interactive risk transfer community and network (FIJI Clearing House)

5.6.3 Actions to reduce loss and damage

There are many actions that national and local authorities can implement to address loss and damage. Some of the recommended actions are presented in Table 5-8:

Table 5-8 – Potential loss and damage actions on national and local levels[29]

Active engagement with the WIM	National level
Integration of climate risk & information into policymaking & planning	National level
Mainstream CCA and DRR	National/Local level
Capacity building	National/Local level
Risk assessment	National level
Disaster preparedness	National/Local level
Risk transfer mechanisms	National level
Assessment of damages and losses	National/Local level
Finance mechanisms	National level
Microfinance	Local level
Social protection & safety nets	National/Local level
Application of ICT solutions	National/Local level

Integration of climate risk and information into policymaking and planning:

- Inclusion of climate risks in development sector policies, not just risk reduction policies
- Establish partnerships with stakeholders including the private sector and academia to improve risk governance, policy coherence, inclusiveness and participation

Mainstream Climate Change Adaptation:

- Mainstream adaptation and disaster risk reduction objectives into policy documents, operational plans and practices

Scale-up knowledge and education:

- Awareness raising of vulnerable communities
- Develop knowledge of practitioners and professionals, key policy- and decision-maker on climate risks, and loss and damage

Risk and hazard assessments:

- Take a proactive approach to risk management: streamlined data collection and sharing, develop risk models and scenarios
- Enhanced collaboration and facilitated analysis with stakeholders for example academia, research institutions, and private sector
- Enhance inter-sectoral consultation
- Inclusion and participation of at-risk communities
- Dissemination of assessments among civil society and businesses

29 The table with potential loss and damage actions on national and local levels was made by the Author based on Byrnes and Surminski (2019) Source: https://tinyurl.com/bdfxatpw

Enhance disaster preparedness:

- Design specialised approaches to climate hazards
- Provide professional training to practitioners and responders
- Sustainable financing of actions and resources
- Awareness raising and knowledge dissemination to civil society
- Community-based preparedness schemes aligned with needs and capacities of the communities

Risk transfer mechanisms:

- Enhance policy, normative and institutional frameworks for:
  - adoption of risk insurance
  - partnerships between national and local authorities and insurers o Inclusion of actuaries in risk assessments
  - Development of risk models
  - Establish mandatory or quasi-mandatory risk insurance through a National Insurance Pool which will transfer risk from the state to insurers
- Subsidies scheme for slow-onset climate processes

Assessment of loss and damage:

- Develop loss and damage indicators
- Design and apply technology solutions and tools for digitizing and developing a loss and damage database

National financial landscape:

- Create sustainable financial mechanisms for addressing loss and damage
- Better utilisation of national and local budgets for financing climate change activities including:
  - Climate bonds to raise funds to address climate impacts o Climate budget tagging
  - Climate-related levies
- Scale-up access to financial resources
- Enable local-level microfinancing schemes to strengthen community resilience

Enhance innovative technology solutions:

- Design and apply solutions through the disaster risk management cycle (prevention, early warning, preparedness, response and recovery)
  - Develop rapid onset weather-related events solutions that allow feedback mechanisms from users. For example, users such as farmers' organisations can input whether early warnings are addressing their needs and alerting them sufficiently

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6 Financial, technological, and capacity needs

In recent years, the country has made progress in developing climate change actions for adaptation and mitigation, through the articulation of strategies at the sectoral, national and regional levels. Despite these advances and the recognition of the problems facing the country's future, there are still some needs to be met and challenges to be overcome in terms of financing, capacity and technical assistance in the different areas of climate change management. Meeting these challenges will make it possible to increase the installed technical and financial capacities, the generation and implementation of public policies, and the enhancement of technical capacities. It will further improve the performance of the institutions in charge of managing the processes associated with climate change mitigation.

In the strategy for energy development up to 2040 of North Macedonia, as well as in Third BUR there is a measure for introduction of a carbon tax which will be the first step towards Carbon Market Mechanism. Energy Community Treaty works to integrate Contracting Parties into the EU energy market via harmonization of the legal and regulatory framework, but still the crucial element is missing – a carbon pricing mechanism. Initial analyses have been provided within an Energy Community study on carbon pricing for South Eastern Europe[30]. However, this study is general and does not provide specific recommendation for North Macedonia. Therefore, introduction of a carbon tax shall be explored in more details within the development of the Macedonian enhanced NDC[31].

6.1 Enabling Environment

6.1.1 Relevant policies

The main directions of current research policy were introduced in the Programme of the Government of the Republic of North Macedonia for the periods 2011-2015 and 2017-2020. The priorities for country-level activities related to research and development (R&D) include increasing investments in scientific-research infrastructure; encouraging and supporting science through fiscal policy; and supporting technological development through the development of new technologies, technology transfer, innovation, continuous upgrade and transfer of knowledge, information, and ICT technologies.

More focused research policy goals are specified in the Law on Scientific and Research Activities (LSRA), which was adopted in 2008 and amended in 2012, and the Law on Encouragement and Support of Technological Development (LESTD), which was adopted in 2011 and then repealed with the Law of Innovation Activity in 2015. These laws emphasize the following: the development of new technologies, products and services; environmental protection and improvement; improvements in the institutional and organizational effectiveness of entities involved in technological development; support for entrepreneurship; strengthening the institutional, educational, scientific and technological infrastructure; improved communication and cooperation between entities involved in technological development; and communication and cooperation between ministries and other institutions in charge of technological development.

The Law on Higher Education that addresses R&D activities in the higher education sector was adopted by the Ministry of Education and Science in January 2013. The changes define the criteria necessary to fulfil the requirements of the Bologna process and 2012 Bucharest Communiqué 2012. These criteria should strengthen R&D and ensure monitoring of the quality of the R&D activities performed by the higher educational institutions. One of the mandatory requirements for universities is the establishment of new Faculty boards, which consist of all important stakeholders involved in educational and R&D activities. The boards are supposed to ensure that university curricula are aligned with the needs of industry. Furthermore, public universities are obligated to allocate 40% from tuition fees to R&D activities, international cooperation, capital investments and faculty and student exchanges with Top 500 world universities (as determined by the Shanghai Jao Tong University ranking).

The National Programme for Scientific R&D Activities 2012-2016 and the National Strategy for Scientific R&D Activities 2020 were prepared by the Ministry of Education and Science on the basis of broad public discussions organized in the country.

30 NewClimate Institute (2019): De-risking Onshore Wind Investment – Case Study: South East Europe. Study on behalf of Agora Energiewende.

31 More details on the financial, technical, and capacity needs for climate change management can be found in the analysis "Rapid Assessment Report: Current status of the research, development, innovation and technology transfer related to climate change in the Republic of North Macedonia" and in the 3rd BUR.

They are more citizen-centric and propose new thematic priorities and new R&D targets for the country. The Innovation Strategy of the Republic of North Macedonia for 2012-2020 was adopted by the Government in October 2012. The strategy was prepared by the Ministry of Economy with support from the Organization for Economic Co-operation and Development (OECD). One of the main strengths of the policy is the involvement of all relevant stakeholders from the country in its preparation.

The Law on Innovation Activity, adopted in May 2013, determines the innovation activity, as well as principles for commercialization of the results of the innovation activity, scientific research, the technical and technological knowledge, and inventions. The Law outlines the establishment of a Fund for Innovation and Technological Development, which coordinates finance and logistically support the innovative projects in order to improve the competitiveness. The law also calls for the establishment of a new Department of Competitiveness, Entrepreneurship and Innovation in the government that, along with the Committee on Entrepreneurship and Innovation, monitors the development and commercialization of innovations.

The Innovation Strategy of the Republic of North Macedonia for 2012-2020 also aims to bolster innovation in the country. The strategy defines the four strategic objectives: (i) Strengthening of the propensity of business sector to innovate; (ii) Strengthening of the human resources to innovate; (iii) Strengthening of environment for innovation; (iv) Strengthening of knowledge transfer between innovation stakeholders. The Action Plan aims to establish Centers for Technology Transfer at the lead universities in the country to support industry – academia cooperation through knowledge transfer, technology transfer and straitening commercialization of R&D and innovation results.

National Industrial Strategy of 2018-2027 is another R&D-related policy which has five main pillars: 1) strengthening of the manufacturing foundations; 2) improving productivity and facilitating innovation and technology transfer; 3) stimulating green industries and green manufacturing; 4) boosting export-oriented manufacturing; and 5) building up a “learning manufacturing sector”. The Strategy is the biggest national strategic document for enhancing the innovation framework conditions for Macedonian industry and SME development in order to attracting the region for new investment and new jobs creation. The Strategy enforces development of the new national Smart Specialization Strategy (3S)13, according to the European Platform for 3S, in order to detect the key potential technologies of national industry sector as a focus to fostering the economic grown of the country and the region. The Strategy envisions the Fund for Innovation and Technology Development (FITD) as the potential National Technology Transfer Office (NTTO).

6.1.2 Relevant institutions

The **Ministry of Economy** is the institution responsible for creating and implementing documents and programs regarding economic policy, industrial policy, SME competitiveness and innovation enhancement. Within the ministry, the **Department for Industrial Policy** is responsible for the creation and monitoring of industrial policy in Macedonia. This department works with the **Department for Entrepreneurship and Competitiveness of SMEs** to create the Innovation Score Board and established a detailed implementation schedule related to all areas of government activity in industrial policy, including innovation enhancement.

Other ministries also have an impact on Innovation, R&D, and technology transfer in line with their responsibilities. The **Ministry of Education and Science**, specifically the **Department for the Advancement of Science and Technological-Technical Development**, is responsible for strategic planning in the field of science and technology. It supports and encourages the development of scientific research infrastructure in Macedonia. Research priorities related to climate change include energy, transport and ecology, agriculture, and water resource management. The ministry is also responsible for overseeing the EU Framework Program for research (FP) in Macedonia. The **Ministry of Environment and Physical Planning** as the designated entity for climate change and environmental concerns is closely associated with the international R&D activities, technological development and innovations. The **Ministry of Information Society and Administration** coordinates activities for the development of the information society and measures from relevant government strategies.

Other government entities involved in R&D include the following:

1. Agency for Financial Support in Agriculture and Rural Development (IPARD)
2. Agency for Foreign Investments and Export Promotion of the Republic of North Macedonia, (Invest Macedonia);
3. Agency for Promotion of Entrepreneurship of the Republic of North Macedonia (APERM)
4. Energy Agency of the Republic of North Macedonia (EARM)
5. Research Center for Energy, Informatics and Materials of the Macedonian Academy of Sciences and Arts (ICEIM-MANU)

6. Centre for Applied Research and Permanent Education in Agriculture (CIPOZ), Faculty of Agriculture and Food Sciences, Skopje

7. Centre for Research, Development and Continuing Education: Mechanical Engineering Systems – Centre of Excellence (CIRKO-MES CE)

8. Centre of Technology Transfer at the Faculty of Electrical Engineering and Information Technology (FEEIT), Ss. Cyril and Methodius University, Skopje

9. Centre of Technology Transfer at the Faculty of Technology and Metallurgy (TMF), Ss. Cyril and Methodius University, Skopje

In addition to state entities, the **Macedonian Academy of Sciences and Arts (MANU)** is the highest scientific and research institution in the country. It deals with strategic and fundamental research and planning, advice to governmental institutions. The Research Centre for Energy, Informatics and Materials (ICEIM) within MANU is focused on the areas of energy, environment, bioinformatics and materials. The Centre was involved in the development of the previous national communications. MANU has developed all relevant strategies for the energy sector. The Centre was involved in many other national, regional and international projects related to climate change. The president of the NCCC originates from this institution.

There are also several "good practice" initiatives to establish organizations that foster innovation. For example, the first **Regional Hub for Social Innovation** opened in June 2013 at the Faculty of Computer Science and Engineering at the University of Ss. Cyril and Methodius with support from UNDP launched the first Regional Hub for Social Innovation in the country. The Hub was established to encourage development of innovative information technology solutions to social and economic problems. Projects aiming at environmental protection and mitigation of the climate change will be among the hub's priorities. The **Foundation Business Startup Centre Bitola**, which is financed by the USAID, was established to contribute to the economic development of the country through promoting entrepreneurship in small and medium enterprises (SMEs). The foundation supports potential and existing entrepreneurs in establishing or growing their businesses and provides training, exchange of information and investments in innovative projects. The **Foundation for Management and Industrial Research (MIR)** is part of a consortium that has been awarded the first project from the European Commission's Competitiveness and Innovation Framework Programme to establish the European Information and Innovation Centre in Macedonia (EIICM). The EIICM, as a part of a large European Network (Enterprise Europe Network), provides services primarily to SMEs through the dissemination of information on EU legislation, business contacts with potential European partners, facilitating technology and knowledge transfer and promoting the possibilities for participation in EU research programmes. The **Macedonia Innovation Centre** was established by the USAID Competitiveness Project in April 2010. Its main goals are, on the one hand, to assist innovators and innovative companies in adopting innovations, developing new products and services, and commercializing existing innovations and, on the other hand, to create an innovation "ecosystem" supporting innovative ventures. The **National Centre for Development of Innovation and Entrepreneurial Learning (NCDIEL)** was established in November 2009 with financial support from Austrian Development Cooperation. Located at the Faculty of Mechanical Engineering, NCDIEL supports the realization of innovative, technology-based and profit-oriented ideas through the provision of capital for start-ups and counselling and coaching of established enterprises in order to increase survivability. Finally, the

Gauss Institute – Bitola is a foundation supporting new technologies, innovations and knowledge transfer that was established in 2006. This foundation continues activities of previously active foundation Euro-regional Technology Centre – Bitola, and is considered to be one of most active organizations in the region related to innovations, technology and knowledge transfer.

6.2 Capacity building

The government of the Republic of North Macedonia has not nominated a National Designated Entity under this UNFCCC mechanism for climate technology yet. The initial investigation of the potential of numerous organisations in the public and private sector resulted with nominating the top 10 organisations[32]: (1) Fund for Innovation and Technology Development (FITD); (2) RCESD – Research Centre for Energy and Sustainable Development, part of Macedonian Academy of Sciences and Arts (MANU); (3) CIRKO – Centre for Research, Development and Continuing Education (Faculty of Mechanical Engineering (MFS), UKIM); (4) INNOFEIT – Centre for Technology Transfer and Innovations, at the Faculty of Electrical Engineering and Information technology (FEIT), UKIM; (5) Ministry of Environment and Physical Planning; (6) National Centre for Development of Innovation and Entrepreneurial Learning (NCDIEL); (7) Regional Environmental Centre (REC); (8) Regional HUB for Social Innovation, at the Faculty of Computer Science and Engineering (FINKI), UKIM; (9) Centre for Climate Change; and (10) Foundation for Management and Industrial Research (MIR).

According to the selection criteria and subsequent ranking of possible NDEs, the highest-ranked organisation to become the NDE for Republic of North Macedonia is the Fund for Innovation and Technology Development (FITD). On the other hand, the analysis of the national legislation has indicated two similar measures:

- The Action Plan of the Industrial Strategy 2018-2027 provides a measure to establish the National Technology Transfer Office (NTTO) either as part of the FITD or else as a separate institution; and
- Work Plan of FITD (2020) provides a measure to establish NTTO with the same goal.

The NTTO should play a key role for the conversion of science, R&D and innovation results into competitive products and processes in industry, as well as tackling climate change and sustainable development issues.

The second place in the ranking of the NDE assessment analysis were two Technology Transfer Centres established at the technical campus of UKIM, CIRKO and INNO FEIT, and the Research Centre RCESD at the MANU.

Continuous improvement of infrastructure with a special consideration to technology transfer and climate change components, as well as an ultimate focus of EU and worldwide commitments, requires building of the appropriate legal and institutional set-up in the country.

The capacity strengthening needs for the various sectors are provided in previous chapters of this National Communication. Other capacity needs have been identified in the areas of innovation, R&D, and technology transfer related to climate change. Recommendations from a report commissioned on this subject (MOEPP 2013) include the following:

- Establish a National Climate Technology Centre and Network which will serve as national and regional climate change centre of excellence, with the aim of providing continuous transfer of technology, sustainable financing for R&D and innovation activities in the country as a knowledge hub and information resource.
- Nominate a National Designated Entity (NDE) to serve as a focal point on technology transfer with the UNFCCC.
- Enhance partnerships and information exchange between research institutions, academia and administrations at national and regional level and between the public and private sectors and create a centralized project database for climate change-related activities in Macedonia.
- Expand cooperation with EU initiatives such as COST Action 11011 and COST ESSEM.

[32] For more information on the analysis of possible NDEs, please see the report "UNFCCC TT: Clear Mechanism Summary Report" (2020)

6.3 Financial resources and technical support

Accurate assessment of climate finance is the most difficult problem facing all non-Annex I countries reporting to the UNFCCC.
In this respect, the Republic of North Macedonia is no exception. Most non-Annex I countries do not present any information on
climate finance in their biennial reports that are officially published despite the commitment to the Convention set out in FCCC / CP / 2002/7 / Add.2 and Dec.2 / CP. 17 Annex III. The Republic of North Macedonia is one of the few countries that has presented a climate finance assessment in BUR1 and BUR2, and in the third BUR it intends to present a climate finance assessment using the OECD DAC Rio Climate Marker methodology in the field of public climate finance.

North Macedonia as a non-Annex I country of the Convention is obliged to report on international support for climate activities obtained from bilateral and multilateral sources. This requirement of the Convention is aimed at measuring the realization of the commitment of developed countries to allocate USD 100 billion annually to underdeveloped non-Annex I countries, thereby achieving the principle of „ Common but differentiated responsibilities and respective capabilities". According to the requirements of the convention, it is also necessary to report on the domestic resources that the country spends on climate activities.

The synthesized data on financial, technological, technical, and capacity building support obtained from international sources show that in the period 2018 and 2019 there were a total of 38 climate related projects funded with international support. Support to the Republic of North Macedonia committed / received in the two-year period 2018 - 2019 is estimated at USD 25.14 million. Of these, 21 are climate-specific projects and account for as much as USD 15.6 million, which is 62% of the total. The remaining 17 projects totalling USD 9.5 million or 38% are climate change relevant.

North Macedonia also received non-monetary support in the form of technical support, technological support, and capacity building support. There are 14 projects registered in this category.

At the national level, there was inadequate data for a precise assessment of the Republic of North Macedonia's domestic public finance spent on climate change by the Government, line ministries, government agencies and the other government public sector entities. However, it is evident that the Ministry of Environment and Physical Planning (MOEPP) is one of the largest implementers of climate change projects at the national level funded by international bilateral and multilateral support.

In terms of national climate action resources, the assessment has been carried out at the level of the state capital - Skopje, which has shown a strong commitment in recent years to combating climate change. In the analysed period 2018-2019, the City of Skopje implemented a total of 37 climate change projects. The total amount of funds invested by the city itself in these projects was USD 8,928,109. By applying the OECD Rio methodology, the projects were evaluated in terms of climate relevance and appropriately weighted. According to this methodology, the total amount of climate finance of the City of Skopje for 2018 and 2019 is estimated at USD 5,608,527. Climate finance in 2018 amounted to USD 2,302,659 and represents 4.65% of total spending in the city's own budget. Whereas, in 2019, climate finance had a significant absolute increase of USD 1 million, amounting to USD 3,305,869, accounting for 5.17% of total budget expenditures[33].

Despite the clear need and benefits for countries to develop a procedure at the national level to track and monitor climate finance, this task is not straightforward:

- There is definitional ambiguity as to what constitutes a relevant climate change action.
- Public sector climate change funds do not always pass through the national budget system, and therefore lie outside its reporting systems (e.g. investments by public utilities)
- Records of climate change finance frequently lack sufficient detail to allow the climate-relevant component to be identified. As a result, the identification of climate finance in public expenditures has not been institutionalized.
- Actual expenditures in public budgets (as opposed to the budget allocations) are often not readily available.
- International sources (grants; loans; equities; guarantees etc.) of climate change finance are not coordinated / monitored by a single entity or system, which makes it complicated to monitor them.
- Private finances are difficult to monitor in the absence of a mandate to report such expenditures.
- Governments and other international actors are usually reluctant to report on negative or "brown" finance.

[33] More information on climate finance received and domestic financial flows can be found in the report: "International financial, technological, technical and capacity-building support for climate change response actions in the Republic of North Macedonia in the period 2018 – 2019"

It is noteworthy that in the period of 2019 to 2022, N. Macedonia implemented the project "Strengthening institutional and technical Macedonian capacities to enhance transparency in the framework of the Paris Agreement" as part of the Capacity-building Initiative for Transparency (funded by the Global Environment Facility). This project allowed for many tools to be taken up and incorporated for better information gathering and dissemination amongst stakeholders related to climate change broadly and the national communication process more specifically. This included - amongst other things – development of a measurement, reporting, and verification (MRV) platform to track measures and the main-streaming of gender considerations within the analyses of various sectors.

6.4 Climate budget tagging

Tracking climate budget expenditure is important for monitoring and reporting. However, it can be a difficult process since public sector activities relevant to climate change adaptation and mitigation are often scattered across a number of ministries. This dispersal of climate change activities demonstrates a lack of ownership by concerned ministries and poses challenges for the Public Financial Management (PFM) system to facilitate planning, identifying, and reporting on climate change expenditure.

North Macedonia is preparing to initiate the process of integration of environmental, energy, and climate change issues into its national plans and budget in order to allocate climate-related budget in a more judicious way and simultaneously generate the information required for monitoring and reporting on the progress made on climate mitigation and adaptation. It has prioritized the continuous upgrading of existing monitoring and reporting systems for climate change as well as the upgrading and integration of policy. For this, the Republic of North Macedonia has planned to implement Climate Budget Tagging by establishing criteria for identifying climate change related programmes / projects / activities as well as tracking climate-related expenditures in the national budget system.

Climate Budget Tagging (CBT)[34], which is a government-led process of identification, measurement, and monitoring of climate-relevant public expenditures, helps mainstreaming climate change in the PFM system in order to mitigate and adapt to the economic, social, and environmental impacts of climate change in a systematic manner. By marking budget lines, CBT enables estimating, monitoring, and tracking climate-related proportion of government expenditure allocated and spent to implement climate activities. Additionally, CBT also provides an entry point to track resources for sustainable development goals (SDGs), which is closely linked to climate change in achieving most of the SD goals as well as to mitigate activities linked to the NDCs.

North Macedonia currently does not have a tagging system; however, it has carried out assessment of climate-related budget expenditures while preparing the 2nd BUR for the UNFCCC, by individual activities in the budget for the capital city Skopje, using the Rio Markers approach. International support was estimated on a project-based level and was considered climate-related when climate change was the main purpose of the project. Accordingly, the City of Skopje, for example, implemented 37 climate-related projects in 2018-2019. The total amount of climate finance in 2018 was about 4.65% of total budget expenditure, while it increased to 5.17% of total spending in 2019 indicating a strong commitment by the City of Skopje to address climate change.

[34] For more information on CBT in the Republic of North Macedonia, please see the report "Climate Budget Tagging in the Republic of North Macedonia" (2021)

6.5 Needs related to climate observation and reporting

The institutions in the Republic of North Macedonia have demonstrated progress and increased capacity in climate change management and monitoring activities to fulfil the UNFCCC's requirements. However, new needs and challenges have been identified that need to be overcome in order to optimize the development of the reporting mechanisms at the internal or national level. These needs include (i) capacity building, (ii) financial resources, and (iii) technology transfer. The country continues to depend on international cooperation sources for the preparation of national reporting to UNFCCC.

The analysis of the institutional capacity needs is based on the outcomes of the European Commission Report (2020) as well as a study carried out with the support of the Green Climate Fund (GCF) by the Austrian Hydrometeorological Institute specifically looking at the capacity of the hydrometeorological service in North Macedonia. The analysis looks at the internal organization and structures of the institutions and their capacity to perform monitoring and reporting. It also addresses aspects like coordination or cooperation, both within and between institutions.

The leading institution for climate action in the country is the Ministry of Environment and Physical Planning (MoEPP), which has a Unit for Climate Change under the Department for Sustainable Development and Investments. The MoEPP is the main institution responsible for policies, legislation preparation, planning, regulatory action, and reporting on the climate situation and climate action. The Ministry is also designated as the main institution responsible for coordinating inter-institutional cooperation for the preparation of the national plans on climate change and climate action, including the preparation of the GHG inventories and reporting obligations towards the UNFCCC.

The Macedonian Environmental Information Centre (MEIC), which forms part of the MoEPP, has an important role to play in monitoring and reporting. However, MEIC does not have a specific department or unit for climate action and the responsibilities are covered by the existing departments. Although MEIC is collecting, processing, and disseminating data, it is only regarding air quality and does not involve the National GHG inventories. Instead, the Research Centre for Energy and Sustainable Development, part of Macedonian Academy of Sciences and Arts (MANU – RCESD) often prepares the assessments required for the national reporting to UNFCCC (BURs, National Communication, GHG inventories and Nationally Determined Contributions). This engagement is project based, given that the country's reporting to the UNFCCC has been funded by GEF and is supported by UNDP.

At the government level, there is a lack of a permanent technical team for the development of the reports. Additionally, at regional and sectoral level, there is low capacity in the systematization of quality information and timely delivery for the reports. These are longstanding limiting factors, with regards to capacities for MRV. At present a draft proposal foresees a Senior Associate for the Preparation of a GHG Inventory from the Industry Sector and several other positions with tasks related to climate change management, monitoring and reporting (European Commission, 2020)[35].

The first organized meteorological and climatological measuring and monitoring on the country's territory was initiated in 1923, although there was occasional measuring in the period between 1891 and 1898 (in Skopje) and between 1886 and 1912 in Bitola. In 1947, a decision was made to organize the Hydrometeorological Service in the Republic of North Macedonia, and that same year saw the establishment of a network of metering stations that formed the basis for the current system.

Pursuant to the Law on Hydrometeorological Activities, the Government of North Macedonia oversees a unified meteorological monitoring system. This system forms an integral part of the global monitoring system, and its activities are determined by the regulations and standards of the World Meteorological Organization. The meteorological monitoring system in the Republic of North Macedonia consists of a national network of stations operated by professional monitoring staff. This network consists of 19 main meteorological stations and 2 meteorological radar centres for hail detection. In addition to this network, there is also a network of stations with part-time observers, consisting of 12 regular (climatological) stations, 116 rain metering stations, and 24 phenological stations, which measure periodic biological phenomena. In the past several years, the monitoring system has been upgraded with 14 automated meteorological stations (two of them are used for air traffic services).

Several types of constraints and gaps have been noted in the system of observation and monitoring. Due to increasing demands for high-quality climate-related data, there is a need to strengthen the capacity of the National Hydrometeorological Service. Capacity needs include the following:

- **General support:** providing sustainability of the Meteorological monitoring system in order to monitor the climate and its changes (variability, fluctuations and trends), developing a network of automated meteorological stations in order to upgrade the existing system by unifying certain technical and software components, in agreement with the guidelines and recommendations of the World Meteorological Organization; installing automated meteorological stations at all main

[35] A draft proposal for new staff in the MEIC was prepared in 2019 but has still not been adopted

meteorological stations and climatological stations and gradually replacing the classical measuring with automated measuring; installing automated meteorological stations outside of the existing meteorological network;

- **Lack of staff:** The Sector on Meteorology in the National Hydrometeorological Service struggled to implement its mandate because of a lack of staff. At the same time, there are unemployed meteorology graduates, and the educational program for meteorological technicians is no longer available. Staff shortages have brought the operation of the monitoring system to a minimum level, which has reduced the availability of climate data. This situation is likely to worsen given the trend of an aging work force in the sector and increases rates of retirement, which also hinders re-assigning staff to high-priority locations. In three locations, monitoring has actually been halted, and continuous operation of the main meteorological stations in Shtip, Bitola and Skopje in the future is uncertain. Because meteorological measuring and monitoring at these stations are both a national mandate and an international commitment (to the WMO), cut-backs represent an extremely serious problem. In particular for climate change, it seems necessary to carry out the following: the establishment of a climate change unit in order to monitor climate change and to prepare climate forecasts and reports; education of personnel in different areas; employment of expert staff (university graduates with a qualification in meteorology).

- **Lack of funding:** The budget allocated for this activity has been insufficient in previous years, resulting in late payments to observers. *Lack of funding* has also led to a reduction in the number of stations where the occasional observers work. For example, the network of rain metering stations previously consisted of 300 stations, which were reduced in 2003 from 196 to 155, and in 2012 to 116. These stations provided information that is critical to flood planning, climate monitoring and water resources monitoring, feasibility studies for the construction of key health facilities, agro-climatic zoning, forestry, biodiversity, and the environment in general.

- **Difficulties with maintenance of monitoring stations:** While the quality and the quantity of the meteorological data have improved with the use of 24-hour automated monitoring in some stations, these stations have experienced difficulties that include the following: difficulties with maintenance, calibration, procurement of sensors and procurement of other spare parts; problems with data collection and processing given the different software programs for communication with different stations; and collection, processing and archiving data that are submitted in different formats. Finally, the systems themselves are difficult to maintain due to a lack of properly trained staff and a shortage of funding for maintenance and spare parts.

- **The lack of field vehicles:** causes serious problems for the National Hydrometeorological Service. The vehicle fleet of the Service is quite old, and it cannot meet quality standards during regular work periods and during interventions when there is a defect or halt in meteorological measuring.

- **Technical/equipment needs:** establishing special – safer communication channels within the services of mobile providers; establishing a laboratory for controlling, maintenance and calibration of meteorological instruments and sensors of automated meteorological stations; providing two field vehicles for operational activities and maintenance of the meteorological monitoring system;

- **Data processing needs:** maintenance and upgrade of the climatological data database CLIDATA; digitalization of the basic climatological data and information; preservation of historical meteorological and climatological data as a national treasure; using GIS format when presenting climatological conditions for different parameters.

As climate action is cross-sectoral, responsibilities need to be shared and effectively coordinated between ministries. The National Climate Change Committee (NCCC) is the coordination body, which provides high-level support and guidance for overall climate change policies in the country. The NCCC is an intergovernmental body that consists of representatives from all relevant governmental institutions, NGOs and academia. The NCCC has participated in the development of the three national communications and two biennial update reports submitted by the country so far. Generally, most of the relevant institutions are given mandates for climate actions meaning that they have responsibilities and tasks. While the existence of an inter-ministerial coordination mechanism on climate change is worthwhile, participating Ministries do not have units/departments dedicated to climate change. Therefore, the lack of adequate specific structures and resources in terms of sufficient and qualified staff, illustrates the constrained capacities of the Ministries on climate change. This is likely an obstacle to an effective cooperation in climate action matters in the government.

6.6 Recommendations

Based on the analyses conducted for the 3rd BUR and for this National Communication of the current country status of research, development, innovation and technology transfer related to climate change on one hand, and the possibilities offered by the utilization of the UNFCCC technology mechanism on the other, it is more than evident that the country will benefit greatly from the utilization of the Technology Transfer mechanism. Therefore, it is highly recommended to select and nominate a National Designated Entity (NDE) as a focal point for the Technology Transfer (TT) mechanism as soon as possible. Establishing the NDE will serve as a national focal point with the goal of providing continuous information about financing through donor programmes for R&D and Innovation activities related to the climate change actions. Also, the NDE will develop networks between implementers and beneficiaries (end users as well as companies and industry) for technology transfer. As a main financial source for facilitating the NDE's functioning and operability, the EU Green Deal's Investment Plan should be considered. To establish and reach full operability of the NDE, the following 6 main recommendations are provided:

1. Development of a central platform (portal) with a comprehensive dataset of the projects by donors and implementing agencies, with mechanisms for updating and reporting. NDE should establish a portal for logging, tracking and reporting of all implemented and ongoing environmental and climate change projects. The system should be consisted of a database where the list of implemented/ongoing projects on a national level will be maintained and a user friendly interface which will facilitate the NDEs staff and/or implementing organizations to insert the required data for the projects. In addition to this, the portal should be equipped with certain number of functionalities that will enable manipulations with the records and generating different views and reports, such as filtering the projects per time period, theme/area, amount, region, type of action, programme etc., extracting the data of interest in various formats, such as word, excel, pdf, also providing certain analysis presented in NDE should raise national funds for co-financing the donor financial opportunities. Majority of the donor programmes for projects and grants require co- financing, which in most of the cases refers to the implementer's own funds. Often, the national authorities in charge for the specific area provide national contribution that covers the co-financing part. It is recommended to establish a collaboration between the NDE and the Ministry of Environment and Physical Planning to ensure the national cofinancing funds.

2. NDE should maintain list with various funding opportunities that are available and forthcoming calls for proposals, which are either dedicated to addressing environmental and climate change issues, or beside the call primary objectives, also encourage activities that might tackle the environmental and climate change issues. Furthermore, the NDE should promote the calls widely and ensure that various types of organizations from different parts of the country participate in the project proposals, as well as to assist the beneficiaries in networking and selecting the most appropriate partner organizations.

3. One of the key activities of the NDE is having a role of a gateway to different climate-specific advanced practices and technologies from the modern societies. For achieving this, it is highly recommended that the NDE will establish and maintain intensive collaboration with a wide range of relevant initiatives from various parts of the world. As a result, the NDE should keep up with the novel technologies implemented for climate change and should be able to provide assistance and advice to the national organizations in adopting these technologies and adjusting them to the local conditions and particularities.

4. The NDE should be a strategic partner of the Macedonian Government in its strategic goal to enhance the development of the environment and address climate change, environmental protection and pollution, as well as sustainable development goals. The NDE should act on a strategic manner by collaborating with the major stakeholders and national authorities, such as the Ministry for environment and physical planning.

5. In addition to this recommendation, due to the interdisciplinary nature of the relevant area, the NDE should also boost and promote the inter-sectoral collaboration among various national, regional and local authorities, as well as among organizations from different societal spheres: citizenship, private, public and educational sectors to synergize their efforts in achieving better environment and society.

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7 Education,awareness information, and public

This chapter describes the current and ongoing activities related to education, information, and public awareness of climate change with a broad range of stakeholders. The need for communicating climate change related issues was described in the Second National Communication with the following text "the main objective of this Strategy shall be not only to raise the awareness about climate change, but also to mobilize and promote new partnerships in order to achieve higher level of public awareness and motivate all stakeholders (the Government, private sector, donor community, civil society, media and the general public) to take appropriate activities".

Taking this into consideration, Macedonia engaged in different initiatives to map the current state and improve the climate related content included in the education system, facilitate access to information and climate reports, and map public awareness and effectively communicate the ongoing initiatives. Some of the actions presented in this chapter were implemented in the framework of the project "Strengthening institutional and technical Macedonian capacities to enhance transparency in the framework of the Paris Agreement" (CBIT PROJECT), with support from UNDP.

7.1 Education

This subchapter is a summary of the Summary of the research Report "Rapid assessment of the climate change integration in the education" prepared within Macedonia's Fourth National Communication and Third Biennial Update Report on Climate Change under the UNFCCC.

Quality education is a basic human right for all and a foundation of social-economic development. All developed societies aim to achieve a sustainable development. The sustainable development is based on creating a "knowledge-based economy" that depends on knowledge, information and a high level of skills and competences. For individuals, to cope with the global challenges, including the consequences of climate change and implementing green technologies, it is necessary to have an appropriate knowledge and attitude. Additionally, enabling people to develop such competences has become necessary component in the education and training systems. Those systems need to be reformed and adapted to the requirements of the knowledge-based economy. Therefore, the Macedonian education system is also responsible for the future of the new generations in the country.

Including climate change in the education curricula, contributes to clarifying the concept and helps students and all members in the educational process to understand its causes and consequences. The aim is to get them prepared to live a life impacted by the effects of climate change and encouraged them to take appropriate measures to achieve a more sustainable lifestyle.

The Economic and Investment Plan for the Western Balkans and the *Guidelines for the Implementation of the Green Agenda for the Western Balkans* state: "Education is key to positively affect behaviours regarding the environment, starting from an early age as well as to reskill workers from transition industries. **Curricula need to include key competences and skills necessary to perform in the green economy.** To be successfully implemented, the Green Agenda for the Western Balkans needs to be reflected in the reforms of the education systems to guarantee that people are equipped and prepared for the labour market and society of tomorrow."

The analyses conducted in the N Macedonian educational system were based on research in both segments of education:

- analysis of **formal educational**: online research of the available curricula and available textbooks of preschool, primary, and secondary education, as well as study programs of accredited higher education institutions.
- analysis of **non-formal educational**: review of verified programs of the Adult Education Centre and of subject related trainings of non-governmental organizations.

The research and analysis performed in **formal education** showed that a certain level of development has been achieved in relation to climate change teaching in the education system in North Macedonia, especially on **primary and secondary education**. The subjects that include this content are varied, for example: geography, physics, chemistry, biology, languages, civil society, life skills, ethics, and arts. However, the inclusion of this content in formal education is segmented in individual subjects, without a holistic approach. A more detailed analysis is required to establish if the content transmitted provides

transversal knowledge on the matter, and if the didactic methods and techniques are appropriate.

An analysis of universities' study programs of the three cycles of **higher education** (undergraduate studies, postgraduate studies, doctoral studies), was also conducted to verify the inclusion of climate change content in the studies, specially within the technical and natural sciences. An appropriate formulation should include climate change concepts as an upgrade to the already existing notions, aligned with environmental protection and sustainable development. The analysis proved that these concepts are already included in the study programs in some universities on the three cycles.

The analysis conducted on **non-formal education** has identified around 20 training programs that are verified in the **Adult Education Centre** containing keywords related to climate change. During the verification process, the Centre can significantly influence training providers by suggesting the inclusion of more climate-related content in the programs.

Civil society, as in most of the developed countries, is the driving force of change in numerous topics. Several trainings and other forms of non-formal education on climate change were identified in non-governmental organizations.

Summarizing all the conducted analyses related to the inclusion of climate change education in the formal and non-formal educational sector, it was concluded that:

- Climate change-related content is included in every educational segment, but there hasn't been made an assessment on its quality this far. Such a review could provide information about how detailed this content is in different education levels or programmes is, whether it is fragmented or offers a holistic approach, how updated and aligned is with scientific evidence, etc.

- There is an additional challenge for teachers to use appropriate didactic methods, forms, and techniques, based on modern tools and technologies to better present it to students and interested parties.

Important recommendations that would contribute to improve climate education and increase the climate literacy include:

- Inclusion of climate change education in key strategic documents from the Government, as a long-term goal excluded from political discussions.

- Alignment between educational initiatives and sustainable development policies.

- Update of the existing Education Strategy of RNM for 2018-2025 and the Concept for development of primary education with a holistic approach on the matter and including the latest recommendations from relevant international institutions, related to the development of "green" competences and climate literacy.

- Establishment of a coordination group for climate change education in the Macedonian Ecological Society (MES), to work on an operational level including representatives from Ministry of Education and Science, Bureau for Development of Education, Centre for Vocational Education, Training, Adult Education Centre, NGOs, and the business sector. The aim of the group would be supporting from the Ministry of Education and Science while realizing activities related to the content of education on climate change.

- Development and implementation of appropriate tools and mechanisms for assessing the development level of key competences at different stages of the educational cycle, especially on "green" competences.

- Introduction of a subjects on climate change at universities, especially the ones related to future teacher's education. The expected result is "green" competences and climate literacy among future teachers, that could then transfer the knowledge to their students.

- Educational systems in synergy with the climate activities undertaken at national level, with special emphasis in the alignment with the United Nations and European strategies.

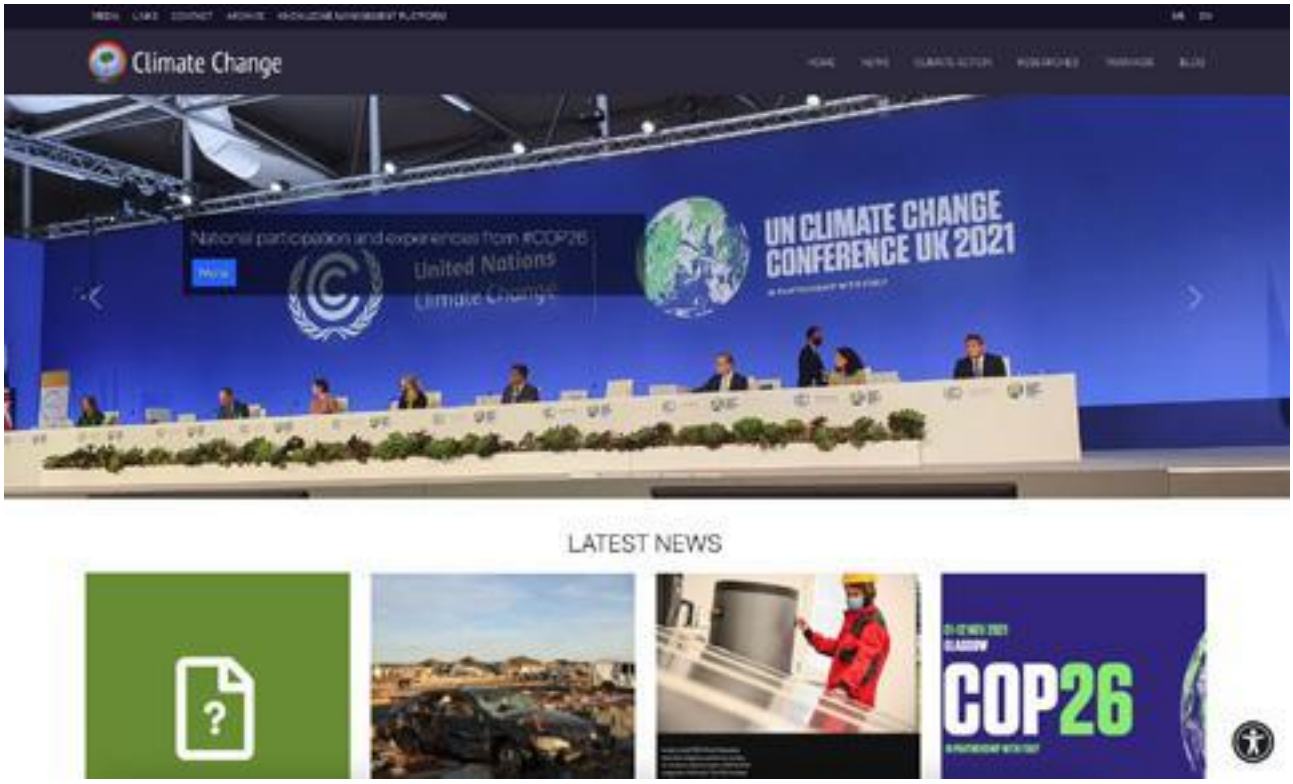
7.2 Information and transparency

This subchapter is a summary of the Knowledge Management Plan on climate transparency Report implemented in the framework of the project "Strengthening institutional and technical Macedonian capacities to enhance transparency in the framework of the Paris Agreement" (CBIT PROJECT).

In the context of the implementation of the project "Strengthening institutional and technical Macedonian capacities to enhance transparency in the framework of the Paris Agreement" (CBIT PROJECT), UNDP and the Ministry of Environment and Physical Planning (MOEPP) have taken actions to meet enhanced transparency requirements, as it was defined in the Article 13 of the Paris Agreement.

The initiatives undertaken had the aim to strengthen institutional and technical capacity for measuring and reporting on emissions, mitigation, and adaptation activities; and to propose ways to share the project results and knowledge products more broadly and effectively. The project included the development of a Knowledge Management plan, using a Knowledge Management Platform (Figure 7-1).

Figure 7-1: Knowledge Management platform



https://www.klimatskipromeni.mk *(accessed April 5, 2022)*

Information Management entails Capture, Organization, Storage and Governance of content and aims to be timely and transparent. A Knowledge Portal's broad functions are to codify explicit knowledge in a logical manner and to direct the user to enabling sources which may guide and inform the knowledge seeker. Being educational and organized with the capability to surface key documents and information efficiently to help end users. The current Knowledge Portal has a wealth of useful information, however there are structural gaps as they relate to taxonomy, metadata, and search.

Furthermore, Macedonian Government has committed in 2011 to the global voluntarily initiative for Open Government Partnership (OGP). Following the responsibilities under this initiative, the Government adopted four action plans in 2012, 2014, 2016 and 2018 for the subsequent two years, respectively. The country was among the seven pioneers in the world that has included Climate Change Action within OGP Action Plan, thus confirming its commitment to put as much as possible open data sets relevant to climate change on the newly established national open data portal. The Ministry of Information Society and Administration (MISA) has also created a central government open data portal (https://data.gov.mk/), where all

state institutions in the country will make their open datasets available electronically at no cost to the public. This provides the users with a single point access to all open public data.

The projects findings disclosed that the climate change website is a good foundational step towards centralizing knowledge and sharing this more broadly. The recommendations established that, as it happens with any knowledge portal, it is important to embed knowledge capture, sharing and transfer with a good user interface. Ease of access and a clear understanding of what is new, key knowledge products with robust search are essential. The focus of the recommendations was oriented to ensure that knowledge that has been captured and shared is easily accessible and consumable, aiming to catch the attention of practitioners, academics, the Scientific and Technical Advisory Panel, and other key organizations.

The key opportunities identified are:

- A key need for optimization of the website to improve search, consistency, and organization.
- Improvement of the user interface.
- Opportunity to develop additional product types
- Need for governance related to information management to ensure the most relevant content is presented to end users.

7.3 Public awareness and outreach

This subchapter is a summary of the Report "Perception of climate change and level of awareness: Online survey of the citizens of the Republic of North Macedonia" implemented in the framework of the project "Strengthening institutional and technical Macedonian capacities to enhance transparency in the framework of the Paris Agreement" (CBIT PROJECT).

In November 2021, UNDP and MOEPP conducted an electronic survey to obtain the latest data on the perception and level of public awareness of climate change. The results of this survey, in a way, are an update of the information obtained from surveys conducted in 2014, 2016 and 2019, which provided basic data on what is the motivation and what are the challenges in the behavior of citizens in relation to protection of the environment and the climate. Several new sets of questions have been added to this survey related to current developments in the field that are considered important for monitoring its public perception. The new addition of questions included queries regarding the public recognition on the ways to transition to the use of renewable energy sources; the attitude towards adaptation policies, especially in the agricultural sector; the opportunities for new green jobs creation; the relation between adaptation measures and public health; the inclusion of climate change and environmental topics in the education system.

The questionnaire was distributed on the Internet through social networks, Facebook and Instagram and Twitter, on the websites of the Ministry of Environment and Physical Planning, the communication platform www.klimatskipromeni. mk., through professional lists with e-mail addresses, e-newsletters. In the period from October 30, 2021, to November 19, 2021, 3089 completed questionnaires were collected, which in relation to 583 completed questionnaires from the survey conducted in 2016, and 1158 in 2019 is a noticeable increase in interest in the topic. The sample composition showed that 41% of the respondents in this survey are from the 10 municipalities of the City of Skopje, a significant reduction from the 71% in the 2019 survey; in terms of gender, women dominated again with 74%; the participants belong to different age groups, being those from 40 to 54 years the ones with the highest representation (Figure 7-3); and regarding education, like it happened also in previous editions, the participants are highly educated, 58.8% of them have undergraduate and 17.8% postgraduate education (Figure 7-4).

Figure 7-2: Gender distribution

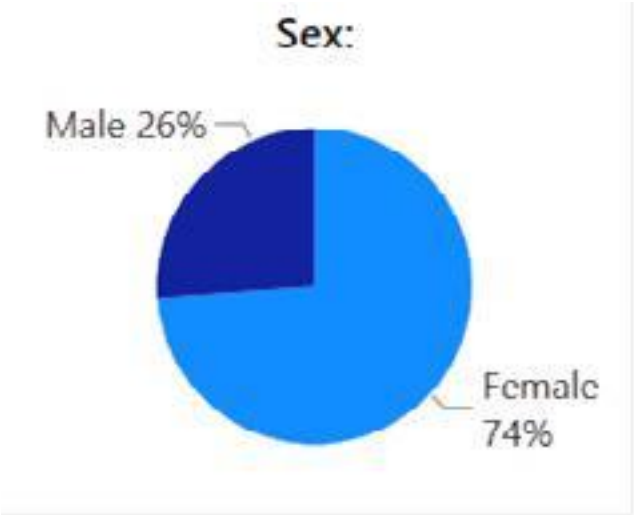


Figure 7-3: Adult distribution

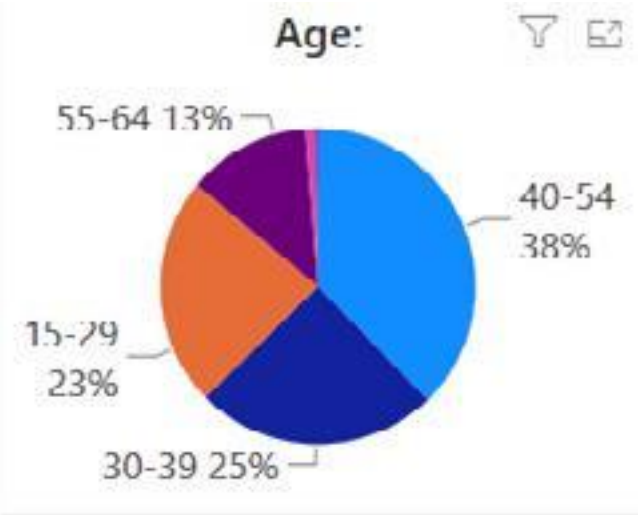
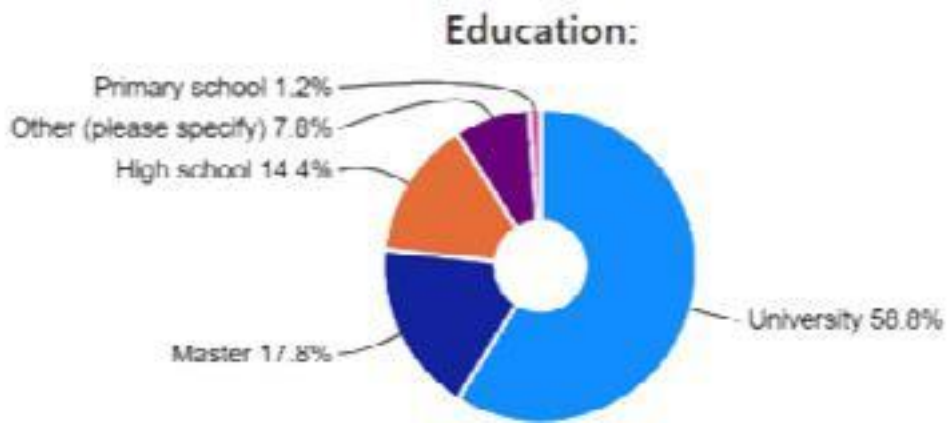


Figure 7-4: Education distribution



In addition, it was the first time that the survey applied models for machine learning in the results, to get a new perspective on the data obtained. The method of applying a different, advanced approach to response analysis aimed to „discover" specific patterns of behaviour and target groups related to climate change. For instance, analysing the characteristics of the respondents depending on the preferred way in which they are informed about climate change, several typical profiles were defined.

The survey showed that:

- The respondents' perspective on the biggest social problem placed lack of clean water first, followed by climate change. The following topics included corruption and crime, degradation of nature, and extreme weather conditions. It is interesting to note that despite the serious threat of the COVID 19 virus and the global pandemic, the respondents still recognized climate change as a more serious threat from the spread of infectious diseases.

- Around 11% of respondents believe that they are not sufficiently informed about the various impacts and consequences of climate change, while 18% stated that they are not sufficiently informed about the ways they can take Climate Actions, and 27% stated that they are not informed on how they can adapt to climate change.

- Regarding the most visible consequences of climate change, extreme temperatures, irregularities in the change of seasons, and precipitation are recognized.

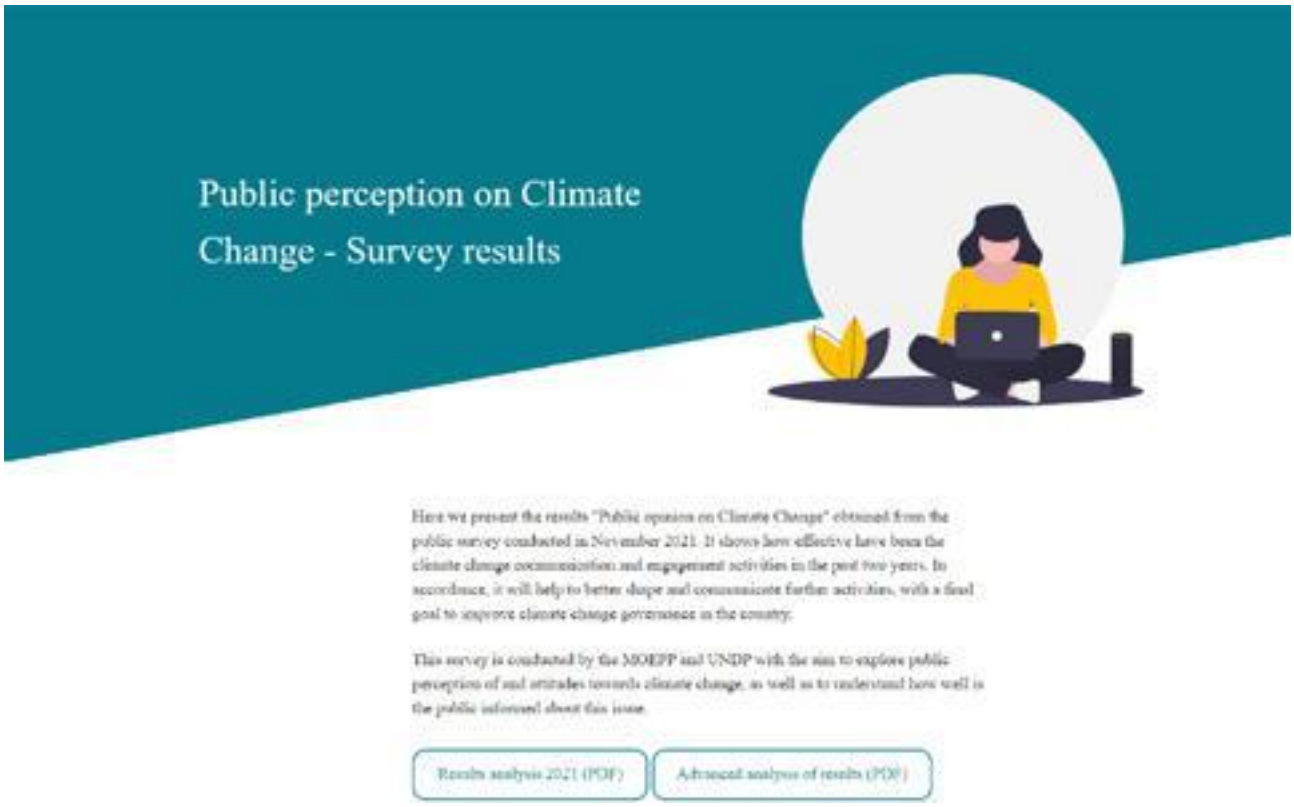
- The respondents perceived that there is an increase in the presence of the topic of climate change in the media and unlike previous surveys. Internet and social networks remain the best way to share information, ahead of television and specialized portals. Compared to the previous survey, the number of those who receive information through reports and studies has decreased.

- Most of the respondents stated that they have heard and some of the measures implemented by state and local authorities in the matter, and have used the subsidies, which shows that the information about the measures was well communicated and reached the target and wider public.

- A significant proportion of respondents (70%) believe that the cost of compensation for the damage caused by climate change is much higher than the investment needed for a green transition, and 69% believe that a green transition can generate a large number of new green jobs, but according to the largest percentage of respondents neither the Government, nor the local authorities, nor the business community invest enough in the development of green businesses (over 70%).

The results of the survey are available on the interactive online platform (Figure 7-5) which allows to combine different parameters to get a clearer picture of the needs and ways of perception, but also of behavior of different target groups in terms of undertaking.

Figure 7-5: Official site of the survey results on public perception of Climate Change



Source: http://anketa2021.klimatskipromeni.mk (accessed April 5, 2022)

The results were used in the management of the contents of the communication platform for climate change (http://www.klimatskipromeni.mk), and in the realization of the campaign activities in the period between two surveys. The subsequent actions included the electronic campaign on the social networks of the MOEPP: „All in action for quick reaction „, the three-day Conference: „ Real DISCUSSIONS on real SOLUTIONS for ambitious CLIMATE ACTIONS“, the hashtags #ВозможноЕ: #Itspossible and many others, and will assisted in the preparation of the Report on the implementation of the Climate Change Communication Strategy for the period 2017-2021 and the Climate Change Communication Strategy.

7.4 Update on the "Climate Change Communication Strategy and Action Plan"

This subchapter is a summary of the Progress Report on the Climate Change Communication Strategy and Action Plan, implemented in the framework of the project "Strengthening institutional and technical Macedonian capacities to enhance transparency in the framework of the Paris Agreement" (CBIT PROJECT).

The Climate Change Communication Strategy and Action Plan were adopted in 2013, within the Third National Climate Change Plan, which was prepared by the Ministry of Environment and Physical Planning with the financial and technical support of the GEF and UNDP. The communication strategy aimed "to improve the agenda for greater accessibility, conducting research activities and raising public awareness in the Republic of North Macedonia, in order to involve key and target groups at the national and local level and to raise their awareness of issues related to climate change."

There is an ongoing initiative in the Ministry of Environment and Physical Planning, with the support of UNDP, to develop a new Climate Change Communication Strategy to 2030. In the meantime, a progress report was released in November 2021, monitoring the level of implementation of the envisaged activities in the period from 2017 to 2021.

The analyses are made regarding the four strategic goals and the three main target groups: the city, the workplace, and the households. The report showed progress in all four strategic goals, but in addition to the realization and achievement of the goals, the need for better communication was observed in terms of the target groups, coordination of activities, as well as mutual provision of information between the actors. In addition, the need to strengthen human and technical communication capacities was recognized, to improve the system for monitoring and data collection from the communication activities.

One of the key findings is the need for greater recognition and use of the communication platform klimatskipromeni.mk and the importance of sharing information in one place for greater insight and creating complementary and non-repetitive communications. The report showed significantly increased interest and engagement regarding climate action in recent years, the number of actions has increased and there has been greater engagement of a growing number of actors.

The period until 2030 is called the "Decade of Climate Action", which shows the urgency to reduce greenhouse gas emissions. By adopting the revised Nationally Determined Contribution (NDC) for climate change in 2021, the Republic of North Macedonia has set an ambitious goal to reduce its net greenhouse gas emissions by 82% by 2030. The successful implementation of this climate action must be accompanied by equally ambitious and "smart" communication.

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8 Gender and climate change

Women are more vulnerable to climate change due to existing gender inequalities and disproportionate levels of poverty, which can become exacerbated from the impacts of climate change. The intersection of gender and climate change recognizes that women are more affected by climate change, but also that their contribution leads the charge on climate change adaptation and mitigation, and builds a more sustainable future for all.

Within the UNDP/GEF projects[36], a systematic methodology of intersecting gender and climate change was developed, upon the previously developed Draft Action Plan for Gender Equality and Adaptation / Mitigation to Climate Change - Excerpt from the First Biennial Update on Climate Change[37] and [38]Draft Action Plan for Integrating Gender Aspects Responsiveness in the Preparation of the 4th National Communication/ 3rd Biennial Update Report (2019).

The following products were developed:

1. Intersections of gender and climate change policies analysis provides step by step guidance to developing gender responsive climate policies and climate resilient gender policies (weaknesses, recommendations for improvement, proposed body to monitor and support implementation of planned activities). An analysis on the inclusion of gender perspectives into national climate change policies was conducted, with a view to international standards, national institutional set-up, an overview and analysis of the gender-based roles, needs, challenge and barriers of women and men in 4 sectors: Energy use in households, Transport, Agriculture and ICT (information and computer technologies). The research also provides a plan to strengthen the implementation of the Draft Action Plan on Gender and Climate Change. The purpose of the analysis was to assess all the points where actions are needed to strengthen the implementation of the Plan.

2. Work Plan to strengthen the implementation of the Draft Action Plan on Gender and Climate Change, with concrete activities and timelines.

3. Qualitative analysis for the purpose of supporting the implementation of the Draft Action Plan on Gender and Climate Change, to identify the obstacles and the needs for its implementation, in the period September-October 2019, in addition to the above-mentioned research with a view to the following:

   - Gender and climate change intersection in the existing and planned national strategic and legal framework in both areas (gender and climate change)

   - The level of institutional (inter/intra) cooperation on gender mainstreaming in climate change planning processes.

4. Recommendations for Strengthening the Implementation of the Action Plan on Gender and Climate Change which were presented to the key stakeholders and the members of Parliament.

5. Innovative approaches for collection, analysis and visualization of data related to households heating practices in Skopje have provided a comprehensive pool of sex-disaggregated data. Complemented with socio-economics analysis that pinpointed the most vulnerable groups, it resulted in the first "how to" guidance for transforming governmental policies using gender sensitive climate data[39].

36 "Macedonia's Fourth National Communication and Third Biennial Update Report on Climate Change" and "Strengthening Institutional and Technical Macedonian Capacities to Enhance Transparency in the Framework of the Paris Agreement" (CBIT project)

37 Draft Action Plan for Gender Equality and Adaptation / Mitigation to Climate Change - Excerpt from the First Biennial Update on Climate Change , available at: http://www.unfccc.org.mk/content/Documents/Action%20Plans/MK-FBUR-gender.pdf

38 Draft Action Plan for Integrating Gender Aspects Responsiveness in the Preparation of the 4th National Communication/ 3rd Biennial Update Report, available at: https://api.klimatskipromeni.mk/data/rest/file/download/9d2deb47ef993e8856e2b6e00bab2727993f42e596519ba75156915277c8249a. pdf

39 https://www.skopjesezagreva.mk/wp-content/uploads/2018/07/Document-2-Socio-economic-analysis-of-households.pdf

6. The first Training Manual - Gender and Climate Change in the country was developed[40]. The module provides methods and training content on gender mainstreaming for institutional representatives working in the field of climate change. From this, the relevant national stakeholders will gain knowledge on gender perspectives in climate change and the methods of implementation of the Draft Action Plan on Gender and Climate Change. Training of all the relevant stakeholders on this issue is one of the crucial and basic steps in purpose of effective implementation of the plan.

7. Macedonian Gender and Climate Change Indicators, with a purpose to introduce and establish gender perspectives in National Communications, with a focus on the following indicators in the Biennial Update Reports (under 4th National Communications to the UNFCCC)[41]:

   a. Sex-disaggregated data and gender indicators in National Mitigation Assessment and respective NDC reports

   b. Sex-disaggregated data and gender indicators in Vulnerability and Adaptation assessments

   c. Gender responsive measures in legal and strategic framework intersecting gender and climate change

   d. Gender data in the energy and transport related governmental subsidies (Mitigation activities)

   e. Gender and the National GHG Inventory.

8. Integration of gender aspects into the Third Biennial Update Report on Climate Change of the Republic of North Macedonia - Climate Change Mitigation Report. This was the first national mitigation report to include a chapter (5.3) on gender with concrete measures to make the climate change mitigation process more gender responsive. A separate climate change chapter on gender mainstreaming was also included in the Gender Equality Strategy 2021-2026, which provided information on how other ministries can mainstream climate change in their sphere. This included reference to the Macedonian Gender Indicators which provides a template for the collection of national sex-disaggregated data. This is one of the key aims of the Strategy for Gender Equality. The chapter also included research that fed the national survey on climate change and gender and included micronarratives on the daily challenges of the Macedonian citizens regarding climate change ("Narrative Study – Gender and Climate Change, Macedonia').

9. Project unit on Gender and Climate Change established at Ministry of Labor and Social Policy (MLSP). The Unit supported the development of the Gender and Climate Change strategic objective into the new Strategy on Gender Equality, provided gender perspective into the new national Long-term Strategy on Climate Action and supported integrating Gender into the national Climate Change MRV System.

10. A network has been established of 319 persons working in the field of gender and climate change at the national and local administrative level (61% of the network participants are women).

11. Two sets of trainings:

   a. Firstly in 2020 for local municipality climate change and gender representatives, covering 34 municipalities with 97 participants over four online two-days trainings.

   b. Secondly trainings targeted for local public utilities in the eastern, south-eastern, Vardar, Polog and Skopje regions.

12. Other educational materials developed for wider public:

   a. Gender and climate change journey map[42]

   b. Numbers and Narratives are equally gender unequal when it comes to climate change series: i. Part 1 – Women as agents of change[43]

40 Gender Equality and Climate Change Training Manual, 2020. Available at: https://api.klimatskipromeni.mk/data/rest/file/download/8327844cef4cb554 e67b90d99397aa76d417246b2f3ade61f74575a6c07575c1.pdf

41 Gender and Climate Change Indicators. Available at: https://api.klimatskipromeni.mk/data/rest/file/download/07015e39ea890385d9fb9786be635fa57 4f1313f56f64879be43002c9a8f6b7c.pdf

42 http://gendermap.klimatskipromeni.mk/

43 https://klimatskipromeni.mk/article/663

ii. Part 2 – Mitigating climate change: who benefits more?[44]

iii. Part 3 – Who emits more greenhouse gases: men or women?[45]

During 2021, a series of training sessions were given to strengthen the knowledge of climate change and gender, and to acquire skills about how to introduce gender perspectives into design measures, activities, and adaptation and mitigation plans. The aim was to support public enterprises and procurement administrative officials to:

- implement gender mainstreaming within strategic planning processes
- understand gender roles and stereotypes
- use sex-disaggregated data
- take into consideration the needs, priorities and benefits of all marginalized people: men, women and children in rural and urban areas.

The training helped to raise awareness of gender and climate change, resulting in 90% of the participants being more familiar with policies and measures for gender mainstreaming at the local level. The following Table 8-1 lists the given recommendations defined as a result of the Analysis on the Intersection of gender and climate change policies and the Parliamentary debate on gender and climate change *as well as the progress status.*

Table 8-1: Recommendations for strengthening the gender and climate change intersection at policy and administrative level

Recommendation	Explanation	Status
Creating a register of persons working in the field of gender equality and climate change at the administrative level	A database or register of persons at the institutional level (public and state administration), civil and private sectors and academia working in relevant and relevant institutions in the field of environment, climate change and gender equality is developed. Network of persons working in the field of gender equality and climate change at the administrative level, comprising 319 representatives on both national and local level (61% women).	Done
Gathering gender-disaggregated data in the area of climate change;	New Strategy on gender equality is in a phase of development. A new Strategic area "Gender and Climate Change" will be a separate strategic objective of the new Strategy. Law on Climate Action is expected to be gender sensitized. New Law on Equal Opportunities will include environment and climate change as separate areas of action (Under development). In that regard, mechanisms will be obliged to gather gender-disaggregated data in the area of climate change	In progress
Analyzing the gender perspective of the climate change by collecting statistics to create effective measures	By introducing new strategic area "Gender and Climate Change" into the Strategy on Gender equality, institutions will have a responsibility on analyzing the gender perspective of the climate change by collecting statistics to create effective measures in each area of climate change.	Repetitive measure
Gender and climate change policy intersections	New Strategy on gender equality is in a phase of development. A new Strategic area "Gender and Climate Change" will be a separate strategic objective of the new Strategy. Law on Climate Action is expected to be gender sensitized. Law on Equal Opportunities is expected to include climate change as an area of action.	In progress
Strengthening the administrative capacities on intersecting gender and climate change	Training module on gender and climate change was developed providing methods and content for trainings for the gender machinery and institutional representatives working in the field of climate change. Representatives of the Macedonian gender and climate change network at local and central level trained for the first time on gender and climate change intersection and its reflecting into the local and central policies and practice. The training ensured that the policymakers and implementers understand why gender is an important issue in tackling climate change, how gender is linked to climate change and how to incorporate gender perspectives into climate change policy documents.	Done
Ensuring efficient implementation, monitoring and evaluation through designed gender indicators;	Gender indicators are being developed for the: GHG Inventory, Mitigation Assessment, Vulnerability and Adaptation Assessment, NDC and MRV.	Repetitive
Appropriate budget reallocation for implementing the policies	The Strategic area "Gender and Climate Change" from the Strategy on Gender Equality, will have to be fiscally defined.	In progress.
Synchronization of the policies on gender and climate change	Law on Climate Action is expected to be gender sensitized. New Law on Equal Opportunities will include environment and climate change as separate areas of action (Under development).	In progress.

[44] https://klimatskipromeni.mk/article/678

[45] https://klimatskipromeni.mk/article/712

Recommendation	Explanation	Status
Inter-institutional and inter and intra departmental cooperation	Proposed model for establishing a body responsible for coordinating the implementation of the Strategic Area on Gender and Climate Change. That body will ensure the Inter-institutional and inter and intra departmental cooperation	In progress.
In a gender mainstreamed manner, new technologies and knowledge, as well as increasing awareness among agricultural producers of adaptive measures to climate change, should be transferred with the active involvement of agricultural advisory services as part of their regular practices in providing advisory services for successful planning and implementation of agricultural production	New national strategic documents set the framework for this activity: the National Strategy for Agriculture and Rural Development 2021-2027 and the Long-term strategy on climate action and action plan. Their implementation shall ensure follow up on this recommendation.	In progress
Safety nets, antifrost systems, fan installation, protective sheets - to be part of and increase support for Rural Development Financial Support Program – designed in a gender-positive manner;	The National Strategy for Agriculture and Rural Development 2021-2027 and the Long-term strategy on climate action and action plan have been adopted. Their implementation shall ensure follow up on this recommendation..	In progress
Develop a comprehensive policy and strategy for action against the adverse effects of climate change in line with the EU Framework 2030 – including gender mainstreaming into targets	The National Energy and Climate Plan adopted. Sofia Declaration signed.	In progress
Take part in all missions, debates on UN action plans to prevent migrant and refugee fluctuations from climate change;	Close cooperation with the International Organization for Migration.	In progress
Undertake more international obligations on human treatment and to provide more funding and action plans to protect more women and children from the adverse effects of climate change;	The new draft Gender Strategy incorporates climate change. Close coordination with UNICEF and UNDP established to engage youth and children in development of climate policies and to protect them from climate change effects.	In progress
Inclusion of gender topics in parliamentary committees holding public hearings on climate change.	Public debates are planned to be held with parliamentarian groups.	In progress

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