MONTENEGRO THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE

2020

GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

MONTENEGRO
MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM

UNDP

PODGORICA, 2020

PUBLISHER
Ministry of Sustainable Development and Tourism (MSDT)
United Nations Development Programme (UNDP) in Montenegro

UNDP partners with people at all levels of society to help build nations that can withstand crisis, and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in some 170 countries and territories, we offer a global perspective and local insight to help empower lives and build resilient nations.

This is an independent publication commissioned by UNDP. The views expressed in this paper are those of the authors and do not necessarily represent the views of UNDP.

The Third National Communication is the product of cooperation between UNDP and MSDT.

MONTENEGRO THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE

GLOBAL ENVIRONMENT FACILITY
INVESTING IN OUR PLANET

MONTENEGRO
MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM

UNDP

LIST OF EXPERTS

PROJECT COORDINATOR
Snežana Dragojević – UNDP
EDITOR
Seth Landau – consultant, UNDP

INTRODUCTION
Seth Landau – consultant, UNDP

NATIONAL CIRCUMSTANCES
Seth Landau – consultant, UNDP
Snežana Dragojević – UNDP
Sanja Elezović – consultant for gender and climate change, UNDP

GHG INVENTORY
Irena Tadić – Nature and Environment Protection Agency
Duško Mrdak – Nature and Environment Protection Agency
Ranka Zarubica – Nature and Environment Protection Agency

MITIGATION
Justin Goodwin – "Aether", UK
Melanie Hobson – "Aether", UK
Nebojša Jablan – "Aether", UK

VULNERABILITY AND RISK ASSESSMENT, IMPACTS AND MEASURES OF ADAPTATION TO CLIMATE CHANGE

AGRICULTURE
Mirjana Ivanov – *Concept of the agriculture report*
Miraš Drljević – *Soil temperature*
Tonka Kuč – *Impact of climate change on phenology*
Nataša Pažin – *Agrometeorological stations*
Mirjana Ivanov – *Summary of the adaptation profile*

SOIL
Mirko Knežević

INVASIVE SPECIES IN THE ADRIATIC SEA AS A CONSEQUENCE OF CLIMATE CHANGE – LEK METHOD (Local Ecological Knowledge)
Olivera Marković – *Climate change*
Zdravko Ikica ▪ Mirko Đurović ▪ Aleksandar Joksimović – *Description of allochthonous species of fish and crustaceans and their occurrence in Montenegrin waters*
Ana Pešić –*Analysis of vulnerability and adaptation*

REPORT ON FUTURE CLIMATE PROJECTIONS AND ANALYSIS OF CHANGES IN EXTREME WEATHER AND CLIMATE EVENTS

REPORT ON PROJECTIONS OF ADRIATIC SEA TEMPERATURE CHANGE
Vladimir Đurđević

CLIMATE CHANGE, VULNERABILITY AND ADAPTATION OF THE COASTAL AREA
Branislav Gloginja

VULNERABILITY AND ADAPTATION OF URBAN AREAS TO CLIMATE CHANGE
Mirjana Ivanov – *Scope of the document, determination of characteristic climatic regions of Montenegro*

Slavica Micev – *Analysis of air temperature and precipitation*

Mirjana Ivanov – *Capacity assessment and determination of indicators specific to each of the regions, Linking past extreme events, their consequences and measures taken in urban areas, Vulnerability assessment of identified regions and recommendations for future actions / responses*

REPORT ON VULNERABILITY AND ADAPTATION OF WATER RESOURCES OF MONTENEGRO TO CLIMATE CHANGE
Darko Novaković

CLIMATE CHANGE, VULNERABILITY AND ADAPTATION OF FORESTS IN PROTECETD AREAS
Milan Medarević

CONSTRAINTS AND GAPS: TECHNOLOGICAL, FINANCIAL AND CAPACITY BUILDING NEEDS AND SUPPORT OBTAINED
Justin Goodwin – “Aether”, UK

CONTENT

AFOLU – agriculture, forestry, and other land use
BAU – business as usual
BUR – Biennial Update Report
CC – climate change
ETS – Emissions Trading Scheme
EU – European Union
GEF – Global Environment Facility
GHG – greenhouse gas
GDP – gross domestic product
GVA – gross value added
GWh – gigawatt-hour
ha – hectare
HPP – hydroelectric power plant
INDC – Intended Nationally Determined Contribution
IPCC – Intergovernmental Panel on Climate Change
km – kilometre
kt – kilotonne
ktoe – kilotonne of oil equivalent
LDN – Land Degradation Neutrality
LPG – liquefied petroleum gas
LULUCF – land use, land use change and forestry
MASL – metres above sea level
MoE – Ministry of the Economy
MONSTAT – Statistical Office of Montenegro
MRV – measurement, reporting, and verification
MSDT – Ministry of Sustainable Development and Tourism
NCCS – National Climate Change Strategy
NEAS – National Strategy with Action Plan for Transposition Implementation and Enforcement of the EU Acquis on the Environment and Climate Change 2016–2020
NEEAP – National Energy Efficiency Action Plan
NŠS – National Forest Strategy (Nacionalna Šumarska Strategija)
NSSD – National Strategy of Sustainable Development to 2030
ODA – Official Development Assistance
RES – renewable energy sources
SDG – Sustainable Development Goals
SNC – Second National Communication to the UNFCCC
SOC – soil organic carbon
SPP – solar power plant
TNA – technical needs assessment
TNC – Third National Communication to the UNFCCC
TPP – thermoelectric power plant
TWh – terawatt-hour
UNDP – United Nations Development Programme
UNFCCC – United Nations Framework Convention on Climate Change
UNIDO – United Nations Industrial Development Organization
WAM – with additional measures (scenario)
WEM – with existing measures (scenario)
WOM – without measures (scenario)
ZHMS – Institute of Hydrometeorology and Seismology (Zavod za hidrometeorologiju i seizmologiju)

LIST OF FIGURES

EXECUTIVE SUMMARY

Introduction

Montenegro ratified the United Nations Framework Convention on Climate Change (UNFCCC) by succession in 2006 and became a non-Annex-1 party to the Convention on 27 January 2007. The Kyoto Protocol was ratified on 27 March 2007, and Montenegro became a non-Annex-B party on 2 September 2007. By ratifying the UNFCCC and the Kyoto Protocol, Montenegro joined countries that share the same concerns and are undertaking an active role in international efforts to address climate change (CC).

On 11 October 2017, the Parliament of Montenegro enacted a law ratifying the Paris Agreement. Thus, Montenegro became a party which has also ratified the Paris Agreement and has undertaken to contribute to a reduction in GHG emissions globally. Montenegro has committed itself to reducing GHG emissions by at least 1,572 kt CO_2eq to the level of 3,667 kt CO_2eq or less. Montenegro's contribution to international efforts to address CC issues, expressed through the Intended Nationally Determined Contribution (INDC) to reductions in GHG emissions, is set at a minimum of 30% by 2030 compared to 1990 as the baseline year.

With the presentation of the Third National Communication (TNC), Montenegro is once again fulfilling its international obligations under the UNFCCC. This report includes an update to the 2010 greenhouse gas (GHG) emissions inventories and the results of the new GHG inventories for 2017, as well as a general description of the measures formulated, adopted, and implemented by Montenegro for the management and planning of GHG emissions reductions.

This TNC also presents the country's climate profile, highlighting the sectors and regions that are most vulnerable to climate change impacts, while providing an analysis of the potential adaptation measures.

Finally, the report summarizes information on the processes related to capacity building at the national level and the promotion of investments and financing mechanisms in the country, among other relevant issues.

The information described in this TNC summarizes the efforts made in the country related to climate change management, with an emphasis on the period following the publication of the Second National Communication (SNC) in 2015.

National circumstances

Montenegro is located in the south-eastern part of Europe and, according to its latitude, belongs to the southernmost part of Europe, the Mediterranean, one of the most beautiful parts of Europe and the world. It is located at the junction of two significant geographical units – the Dinarides and the central Mediterranean.

The area of Montenegro is very complex in terms of landscape and has many natural contrasts, which together form a unique geographical whole. The distance between the southernmost and northernmost point of the mainland of Montenegro is 192 km, as the crow flies, and between the westernmost and the easternmost points is 163 km. The surface area of Montenegro is 13,812 km^2.

The **population of the country is 620,029 inhabitants** (2011 Census), of which about 62% lives in urban areas, while the rest of the population lives in rural settlements. During recent years, the migration of the population has increased from the less developed areas of the northern region to the central and coastal regions, where living conditions are more favourable. This migration has increased pressure on resources in urban settlements. This negative impact has also been reflected in rural areas, especially in the mountains, since a large amount of land is now uncultivated and has reverted to weeds, bushes, and trees.

Montenegro's population is experiencing **poverty and income inequality**. However, in the last few years the conditions have improved. The at-risk-of-poverty rate in Montenegro in 2017 was 23.6%, which was a decrease of 1.6% compared to 2013. There is no significant difference in the risk of poverty between males and females for the years 2013–2017. The population of the northern region is most exposed to the risk of poverty, with 37.9% of its population being at risk of poverty, while the population of the central region had the lowest risk of poverty (15.4%).

Forests cover more than 60% of Montenegro's territory, which makes it among the top three most forested countries in Europe. At present, around 67% of forests are state-owned. However, ownership is changing in favour of private forest owners.

Montenegro's **territory under protection** covers 13.41% or 185,269.69 ha. The biggest areas are the national parks: Durmitor, Lake Skadar, Lovćen, Biogradska gora, and Prokletije which represent a total of 7.27% or 100,427 ha, while nature parks cover 79,583.10 ha or 5.76% of the territory of Montenegro.

Water resources from the territory of Montenegro drain into two basins: the Adriatic Sea and the Black Sea. There are significant differences in the distribution and abundance of water resources ranging from arid karst areas to areas rich in both surface and ground water. The country is considered to be rich in water resources, given that the average annual runoff is 624 m^3/s (i.e. a volume of 19.67 billion m^3).

The period between 1990 and 2015 was accompanied by major changes in the structure of economic activity. The share of agriculture, and industry, has significantly decreased in terms of gross value added (GVA). By 2015, industry had reduced its share of GVA from 20.8% to only 12.9%. In 2030 the largest contribution to GVA is expected to be from the services sector, predominantly from tourism (67% of GVA, and 79% of employment) with some recovery in industry, up to 20% in 2020, and to 22% in 2030, with a growth in employment of up to 13%.

The **energy sector** is the main source of anthropogenic GHG emissions. The share of electricity produced in facilities using renewable energy sources out of the total electricity generation in 2018 was 61.44%. Montenegro's obligation under the Energy Community Agreement is to achieve the indicative energy efficiency target, which means savings of 9% of the average final energy consumption in the country, or of about 1% per year for the period 2010–2018. A preliminary analysis shows that the energy savings achieved in the period 2010–2018, account for 49.76 ktoe, which represents 84.5% of the achievement of the indicative target.

In the **metal industry sector**, the most prominent activities are aluminium and steel production. Other industrial facilities involve the processing of food, beverages, tobacco, textiles, agricultural lime, leather products, paper, medications, and rubber and plastic products.

Agriculture continues to be an important strategic sector within the economic development of Montenegro and has many economic activities that are linked to it, particularly in the rural parts of the country. In 2018, the agriculture, forestry, and fishing sector represented 6.7% of the gross domestic product (GDP). The total number of actively employed persons in agriculture in the country was 99,236 in 2016. Agricultural land in Montenegro covers an area of 309,241 ha and represents 22.4% of the territory (95.2% consists of family farms and 4.8% consists of registered agricultural businesses). However, utilized agricultural land in 2018 was 256,808 ha, of which perennial meadows and pastures areas prevail with a share of 94.3%, while arable land is present with 2.8% from permanent crops and 2.1% from others.

The **tourist sector** in Montenegro in recent years has experienced rapid development with an increase in the number of visitors and investments, becoming the main and most dynamic economic sector. Accommodation and food services alone accounted for around 7.5% of GDP for 2018.

In the **transport sector** there are many old vehicles (produced in the period 1980–1994). The current condition of the vehicle fleet in Montenegro, which had 235,385 registered vehicles in 2018, is unsatisfactory, with the average age of registered vehicles being around 16 years. Passenger and commercial vehicles make up the largest share in road traffic.

National policy and institutional framework for climate change

The National Climate Change Strategy (NCCS) to 2030 is the key policy instrument for the management of climate change in Montenegro and establishes the commitment of the Government to act against climate change in an integrated and multisector manner, complying with the international commitments assumed by the country before the UNFCCC. The strategy sets out a vision to 2030 to enable Montenegro to adapt to the adverse effects of climate change and promote low-carbon sustainable development. The NCCS has a strong focus on harmonization with the EU climate change legislative framework.

In order to lend continuity and legitimacy to the efforts being developed within the framework of the NCCS and to ensure long-term commitments, a binding framework must be put in place through legislative instruments. For this purpose, Montenegro adopted the Law on Protection against Climate Change in December 2019. The goal of the Law on Protection Against Adverse Impacts of Climate Change is to establish a National System for Monitoring, Reporting and Verification of greenhouse gas emissions, as well as the Emissions Trading System and to provide sectorial efforts sharing system for the emissions which are outside the Emissions Trading System. Also, this law will improve the use of ozone-depleting substances and fluorinated gases.

The Government of Montenegro issued the new Decree on Issued Activities for GHG Emissions on 6 February 2020 which entered into force on 21 February 2020. This has brought Montenegro even closer to the EU climate change acquis. Adoption of the regulation was also one of the preconditions for negotiations under Chapter 27: Environment and Climate Change in the EU accession process.

The Ministry of Sustainable Development and Tourism (MSDT) is the main national entity responsible for national environmental and climate change policy and the National Focal Point to the UNFCCC.

Montenegro has also established a high-level multi-institutional council, chaired by the President of Montenegro, which focuses on sustainable development. The council was established by the government in 2008, marking a positive development in inter-institutional coordination and cooperation. The council's 2013 reform strengthened its mandate in the field of climate change, as a strategic priority of the government towards the creation of a low-carbon society. In 2016, this became the National Council for Sustainable Development, Climate Change and Coastal Area Management (NCSDCCCAM).

The Environmental Protection Fund (Eco Fund) was established by the Decision of the Government of Montenegro (22 November 2018) on the basis of Article 76 of the Law on the Environment in order to provide funds for financing environmental protection and to respect the basic right of citizens to a clean and healthy environment.

Additionally, during the preparation of the Second Biennial Update Report (SBUR), a concept was developed to establish a National Monitoring, Reporting, and Verification System (MRV).

Gender equality and climate change

In 2017, the Ministry of Sustainable Development and Tourism, in collaboration with UNDP, began organizing activities to prepare the SBUR and the TNC. Within the SBUR development process, a study entitled "Women and Climate Change in Montenegro" was prepared, presenting the existing gender-disaggregated statistics. In 2017, Montenegro was included in a regional programme to support gender mainstreaming in the MRV, implemented by the United Nations Global Programme for Support. In Montenegro, this programme raised the level of knowledge and understanding of the correlation between gender and climate change and fostered the development of closer cooperation between the Ministry of Human and Minority Rights (which coordinates gender equality policies) and the Ministry of Sustainable Development and Tourism, which resulted in the drafting of the Action Plan for the gender mainstreaming agenda.

National GHG inventory

The figures below (total emissions and removal) shows the trends in GHG emissions and removals for the period 1990–2017. These trends have been derived from Montenegro's updated GHG emissions inventory that was prepared in 2019. Energy and industrial processes account for the largest shares of total CO_2eq emissions. Production of electricity and heat for manufacturing processes (including the aluminium production plant) has had the most significant impact on emissions. Transport emissions are increasing and are expected to continue to increase as a result of Montenegro's emerging tourist industry. PFCs in aluminium production, by-products of electrolysis, have been a major contributor to Montenegro's industrial process emissions.

The net emission removals in the categories of agriculture and land use are a result of Montenegro's forest land acting as a carbon sink. According to the latest data on logging and fires in the forest area, a recalculation of the entire time series (from the SBUR) with additional years for 2016 and 2017 has been carried out and the results indicate a much lower sink potential than was shown in previous calculations.

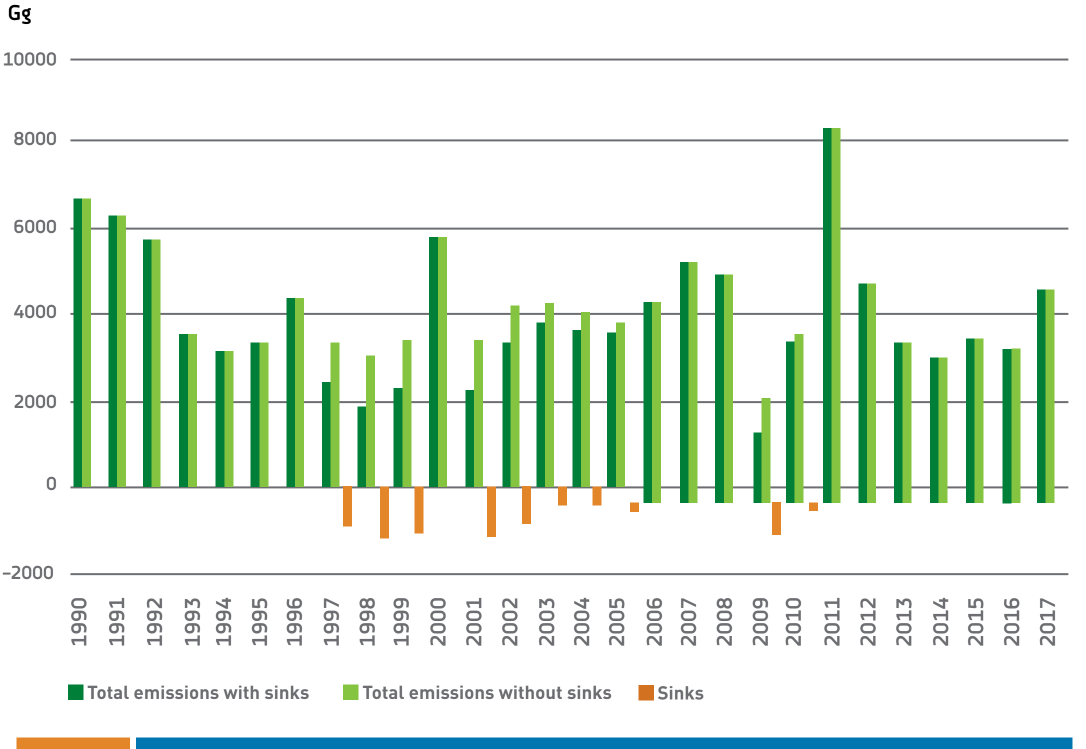


FIGURE ES1 Total GHG emissions expressed as CO_2eq with sinks, 1990–2015 (Gg)

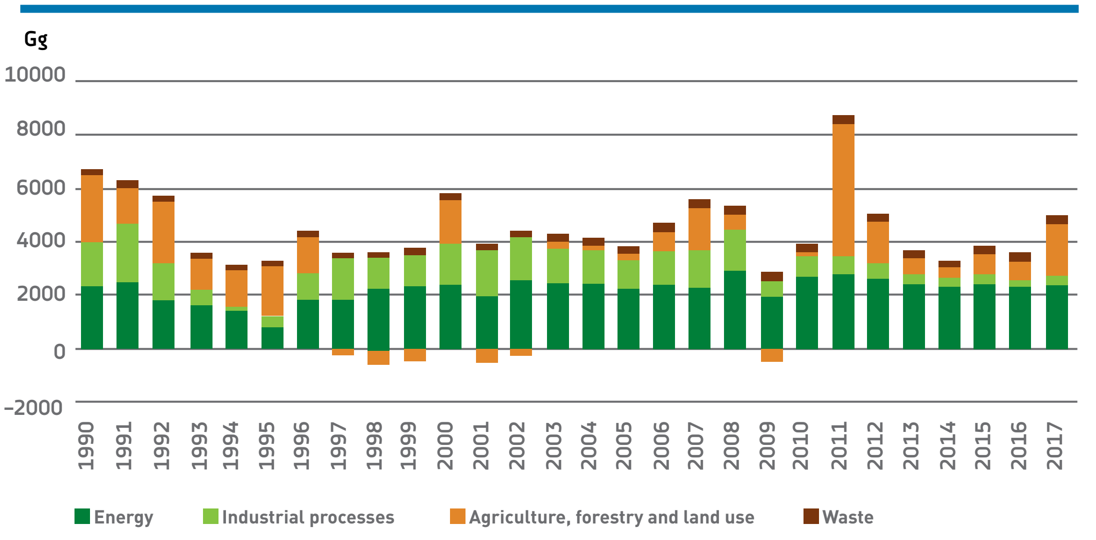


FIGURE ES2 GHG emissions expressed as CO_2eq by sector, 1990–2017 (Gg)

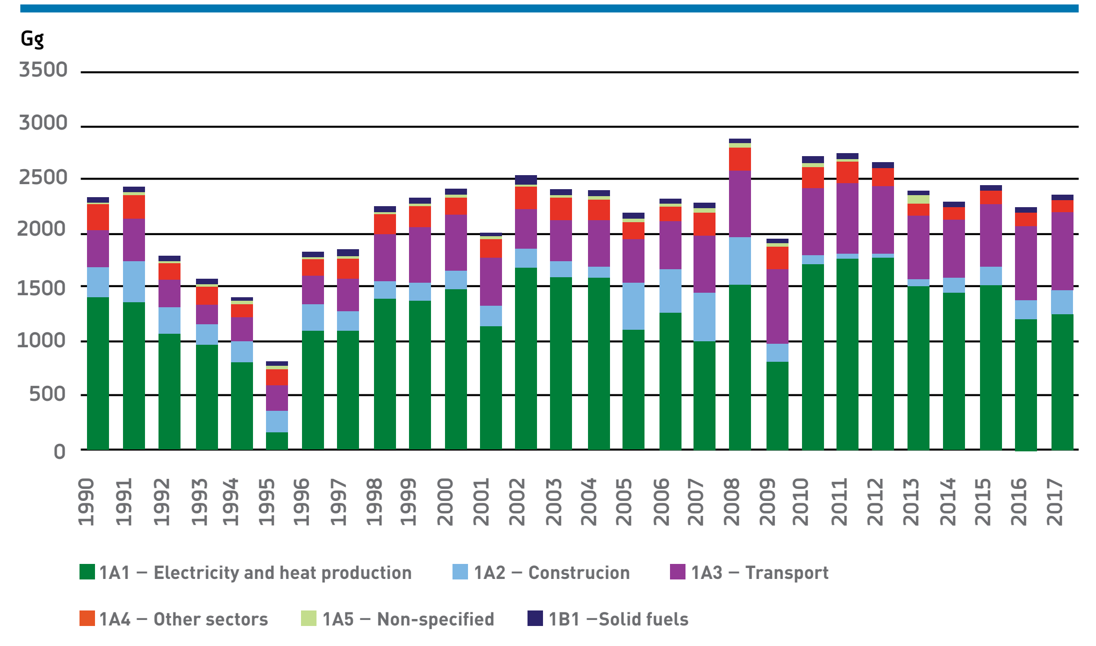


FIGURE ES3 Emissions CO_2eq from energy subsectors for 1990–2017

GHG projections and mitigation measures

All sectors recognized by the IPCC methodology (energy, industrial processes and product use (IPPU), agriculture, forestry and other land use (AFOLU) and waste) were assessed in order to estimate the mitigation potential of certain measures and policies. The GHG projections have been produced under low, medium and high economic growth scenarios for business as usual (BAU) (**without measures scenario – WOM**), with **existing measures (WEM)** and **with additional measure (WAM)** scenarios.

A summary of the BAU scenario until 2030 shows the following results:

- Emissions from the **energy combustion sector** across all years are dominated by those from the coal-fired electricity generation plant in Pljevlja and from road transport.
- In the **agriculture sector**, emissions from manure management make up approximately 50% of the GHG emissions in 2030.
- In the **land-use sector**, living biomass is an important sink of emissions.
- In the **waste sector**, the largest contribution is from solid waste disposal, with an 88% share in 2030.

Montenegro has committed to reduce by 30% GHG emissions by 2030 (compared to the reference year 1990) as part of its ambitious mitigation target through its NDC. Although Montenegro has already made considerable progress in reducing its GHG emissions, the country has dedicated itself to continuing its efforts in mitigation climate change. The forecast economic growth for 2017–2030 is based around clean energy (hydroelectric power plants (HPPs), wind, photovoltaic, biomass, and energy-efficiency programmes in transportation (building the national highway and other projects), industry (especially the metal industry), tourism (tourist resorts and hotels), and agriculture. Montenegro remains determined to use the energy resources trapped in the form of its coal deposits; hence plans for the modernization of its coal combustion plant to ensure the long-term stability of the power system and a reliable power supply from which to launch its low-carbon strategy. In the period 2017–2030, Montenegro aims to continue to reduce GHG emissions without jeopardizing economic growth through:

- **Energy sector:** (i) Energy-efficiency measures; (ii) Increase in the share of energy from renewables; (iii) Modernization of the energy generation and distribution sector; and (iv) Energy labelling and eco-design.
- **Industry sector:** Improvement of industrial technologies and processes.
- **Transport sector:** Promotion of electric cars and public transport.
- **Agriculture sector:** (i) Support for organic agricultural production; and (ii) Organic manure.
- **Land use, land use change, and forestry (LULUCF):** (i) Limitation of harvest amounts in state and private forests; (ii) Reduction in the area annually affected by wildfires; and (iii) Further increases in the share of industrial roundwood used for long-term products.
- **Waste sector:** (i) Reduce the share of bio-waste in municipal waste and (ii) Reduce the share of bio-waste in municipal waste + additional diversion to recycling/composting.

Overall, as a result of the WEM scenario, GHG emissions in 2030 are expected to decline from 3,321 Gg CO_2eq under the WOM (BAU) scenario to 2,301 Gg CO_2eq (including LULUCF). With LULUCF excluded emissions decline from 3,519 to 2,499 Gg CO_2eq. Therefore, under this scenario, the NDC 2030 GHG target is expected to be met.

Climate vulnerability and adaptation measures

The results from the climate projections show an increase of 1.5° C to 2°C in the mean annual temperature by 2040 throughout the country. By 2070 the mean annual temperature will increase by up to 3°C and by 2100 the increase is projected to be with 5.5°C. The mean annual rainfall is expected to decrease, especially during the summer months and to increase in the winter months in some parts of the country. By 2070, the country is expected to experience a decrease of up to 20% of the mean annual rainfall throughout the territory. Significant changes are expected in snowfall, which will decrease from −50% in the north to a change of more than −90% in central parts by 2070. At the same time, the number of days with snow is expected to decrease from −50% to over −70%.

Montenegro is particularly exposed and vulnerable to climate hazards, such as droughts, floods, forest fires, and heatwaves. Climate projections show that these climate extremes will increase in frequency and magnitude in the future.

Droughts in Montenegro have been more frequent since 1990s. Four major droughts occurred between 2003 and 2011. The drought of 2011 evolved into a social and economic challenge that affected the whole country and led to an extreme hydrological deficit in the Zeta-Bjelopavlići region, which includes the largest agricultural area in Montenegro. Additionally, heat waves will become more frequent and longer. In 2012, a strong heat wave hit Montenegro, affecting more than 4,500 people.

Montenegro has suffered three major floods (2007, 2009, and 2010). The damage and losses caused by the 2010 flood alone amounted to around €44 million (1.4% of gross domestic product). Flood risk reduction and management is not being adequately addressed in Montenegro so far, although the consequences are frequently significant.

Montenegro's forests have been affected multiple times by climate-induced forest fires. In the period 2005–2015, there were around 800 large forest fires in Montenegro, and more than 18,000 ha of forests and over 800,000 m^3 of wood mass were damaged or destroyed. Montenegro's fire season was the worst in 2017 with 124 fires covering over 30 ha, affecting a total of 51,661 ha, six times the area affected in 2016.

Montenegro is particularly vulnerable to climate change and variability as well extreme climate events. The sectors most at risk are the water sector, forestry, and agriculture sectors. In terms of geographical vulnerability, the coastal area is highly vulnerable to a rise in the sea level and a decrease in rainfall. Montenegro recognizes the urgent need to address the effects of climate change by promoting effective adaptation measures for the key vulnerable sectors. The summary of the vulnerability analysis and proposed adaptation measures by sector includes:

- THE WATER SECTOR shows a reduction in the water balance in all river basins in Montenegro. The decrease in rainfall and snowfall will drastically affect surface water availability. By the end of the 21st century a reduction in average annual flow of 27% is expected. Adaptation measures focus on applying an integrated approach to water resources and systems management, and a strengthening of cross-sector planning and activities.

- THE FORESTRY SECTOR is affected by climate change not only in the current developmental processes and growth, but often results in cumulative effects that can last for the lifetime of the tree. The greatest risk is to forests located in the coastal and central regions, where high air temperatures during the summer period and the typical vegetation create the necessary preconditions for forest fires to start. Adaptation measures for the forestry sector need to focus on promoting sustainable management of forests and strengthening information and monitoring systems.

- THE AGRICULTURAL SECTOR is highly vulnerable to climate change due to its dependence on specific temperature conditions and water availability, and it is also exposed to climate hazards such as droughts or floods. A large part of the agricultural areas in Montenegro are located in lowlands, which makes them particularly prone to regular floods. Possible adaptation measures in the agricultural sector include planning and capacity-building measures, while other measures require more technology- and information-oriented responses.

- THE FISHING SECTOR is highly affected by an increase in the temperature of sea water which favours the distribution, spread, abundance, and impact of invasive species. The adaptation measures to be taken relate primarily to the controlled capture of certain species that are new to the Adriatic Sea or have drastically increased their abundance, and the possibility is being examined of exporting new species to areas where they are valued as food.

- Good PUBLIC HEALTH depends on safe drinking water, sufficient food, secure shelter, and good social conditions, which may all be affected by a changing climate – and are particularly important in the context of economies in transition, such as Montenegro's. It is important to consider that climate change could affect the capacity of health services to deal with emergencies. Adaptation measures in the health sector should focus on the strengthening of existing institutional capacities, information dissemination, and monitoring systems to better understand the impacts of climate change on human health in Montenegro.

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

Montenegro has demonstrated progress in climate mitigation and adaptation, continuing such efforts to move towards meeting its obligations under the UNFCCC, which entail additional investments, technology, and capacity. While these needs can be partially covered by national resources (public and private), for Montenegro, as a country in transition, contributions from international cooperation are essential.

The need to prioritize climate financing in Montenegro arises, to a greater extent, from the scarcity of public and/or private resources to develop and support specific projects needed to comply with adaptation and mitigation targets under the UNFCCC.

To date, Montenegro has received support from the international community via different financial mechanisms, but predominantly in the form of loans and grants. Financial support from international organizations and knowledge transfer with other countries has enabled Montenegro to implement a series of climate change projects. Between 2014 and 2017, the state received Official Development Assistance (ODA) of more than €200 million from a number of partners for climate-change-related initiatives. Investments in mitigation actions are far higher than investment for adaptation actions.

Apart from climate finance, Montenegro requires a strong focus on promoting and adopting innovative technologies via technology transfer mechanisms. In 2012, the Republic of Montenegro submitted its Technical Needs Assessment (TNA) report.[1] This assessment was prepared by the Ministry of Economic Affairs, Agriculture, and Innovation of the Kingdom of Netherlands and the Montenegrin Ministry of Sustainable Development and Tourism. The TNA analyses the required technologies for both the mitigation and adaptation sectors and the risks and barriers for their deployment.

Montenegro has been granted significant capacity-building and technical assistance for a number of programmes, projects, and partnerships.

In 2016, the Government of Montenegro adopted the National Strategy with Action Plan for Transposition, Implementation and Enforcement of the EU acquis on Environment and Climate Change 2016–2020.[2] The aim of this strategy is to strengthen the capacities of relevant institutions regarding climate change.

Additionally, Montenegro is also currently part of the Regional Implementation of the Paris Agreement Project (RIPAP) which focuses on capacity building and support for participating countries for implementing the 2015 Paris Climate Agreement.

[1] Ministry of Economic Affairs, Agriculture, and Innovation of the Kingdom of Netherlands and the Ministry of Sustainable Development and Tourism of Montenegro (2012).

[2] http://www.mrt.gov.me/ResourceManager/FileDownload.aspx?rId=281718&rType=2.

INTRODUCTION

Montenegro ratified the United Nations Framework Convention on Climate Change (UNFCCC) by succession in 2006, and thus became a non-Annex-1 party to the Convention on 27 January 2007. The Kyoto Protocol was ratified on 27 March 2007, and Montenegro became a non-Annex-B party on 2 September 2007. By ratifying the UNFCCC and the Kyoto Protocol, Montenegro joined countries that share the same concerns and that are taking an active role in international efforts to address climate change (CC).

On 11 October 2017, the Parliament of Montenegro enacted a law ratifying the Paris Agreement. Thus, Montenegro became a party which has also ratified the Paris Agreement and has undertaken to contribute to reductions in GHG emissions globally. Montenegro has committed itself to reducing GHG emissions by at least 1,572 kt, to the level of 3,667 kt or less. Montenegro's contribution to international efforts to address CC issues, expressed through the Intended Nationally Determined Contribution (INDC) to reductions in GHG emissions, is set at a minimum of 30% by 2030 compared to 1990 as the baseline year.

With the presentation of the Third National Communication (TNC), Montenegro is once again fulfilling its international obligations under the UNFCCC. This report includes the results of new GHG inventories for 2016 and 2017, recalculation of previous time series from 1990. onwards, as well as general description of measures formulated, adopted, and implemented by Montenegro for the management and planning of GHG emission reductions. It also presents the climate profile of the country, highlighting the sectors and regions most vulnerable to climate change impacts, while providing an analysis of potential adaptation measures. The report summarizes information on the processes related to capacity building at the national level and the promotion of investments and financing mechanisms in the country, among other relevant issues. The information described in this TNC summarizes the efforts made in the country related to climate change management, with an emphasis on the period following the presentation of the Second National Communication (SNC) in 2015.

The compilation of the TNC was carried out with financial support from the Global Environment Facility (GEF) in the framework of the facilities for the elaboration of National Communications required by the UNFCCC; and under the leadership and coordination of the Ministry of Sustainable Development and Tourism as the national Focal Point for the Convention and the support of UNDP.

The TNC has included studies in different sectors to build information and capacities, promoting the integration of climate change into the public policies for development, competitiveness, and poverty alleviation. Through the TNC project, the official information of the GHG inventory has been updated; and detailed climate change projections were carried out as part of the evaluation of the vulnerability of key sectors to climate change.

This report consists of six chapters, the first being the introductory chapter. The structure and contents of Chapters 2–6 follow the UNFCCC guidelines for the preparation of National Communications.

In this regard, **Chapter 2** contains information on the country's national circumstances, emphasizing its diversity and the geographical, climatic, environmental, social, economic, political, and cultural wealth of Montenegro and describing the institutional and policy framework for climate change.

Chapter 3 presents the results of the national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using methodologies adopted by the Convention for the base year 1990.

Chapter 4 focuses on possible emission scenarios and mitigation strategies to reduce GHG emissions at the national level.

Chapter 5 provides an overview of the main findings regarding climate projections, vulnerability to climate change and adaptation measures.

Chapter 6 summarizes the key gaps and constraints with regards to climate finance, technology transfer and capacity-building needs.

NATIONAL CIRCUMSTANCES

2.1 General information

Montenegro is located in the south-eastern part of Europe and according to its latitude belongs to the southernmost part of Europe, the Mediterranean, one of the most beautiful parts of Europe and the world. It is located at the junction of two significant geographical units – the Dinarides and the central Mediterranean.

The area of Montenegro is very complex in terms of its landscape and has many natural contrasts, which together form a unique geographical whole. The distance between the southernmost and northernmost points of the mainland of Montenegro is 192 km, as the crow flies, and the distance between the westernmost and the easternmost points is 163 km. The surface area of Montenegro is 13,812 km^2.

Montenegro has a parliamentary political system. Administratively, it is divided into 24 political-territorial units – municipalities – which perform the function of local governance. The capital of Montenegro is Podgorica, which is also the largest city (with 186,000 inhabitants), while the city of Nikšić is the second-largest (with 72,450 inhabitants).

2.2 Demographic and population trends

According to the 2011 census, the population of Montenegro was 620,029, which gives a population density of 44.9 inhabitants per square km. The annual population growth is negative when compared to the 2003 population census; statistics show a negative growth rate of about 0.02%. Of the total population, 306,236 are male and 313,793 are female. The most recent statistics show that in mid-2018 there were 622,227 inhabitants in Montenegro, composed of:

- Children (0–17 years) make up 21.9% (136,357) of the total population;
- People aged 15–64 make up 66.9% (416,557) of the total population;
- People aged 65 or over make up 6.5% (40,381 people) of the total population.

Life expectancy at birth in 2018 was 77 years.

There are about 1,256 settlements in the country, of which 40 settlements are of a city type, where about 62% of the population lives, while the rest of the population live in rural settlements. Out of the total number of females, 65.5% live in urban areas, while for males this percentage is 63.2%.

In 2017, the migration rate was 8.4%, continuing the upward trend in population movements. Migration is mainly related to the movement of population from rural to urban settlements, and the negative consequences are twofold. On one hand, there is increasing pressure on resources in urban regions, and on the other hand, rural areas are being left without a population, especially in the mountainous parts – pastures are overgrown, land is left uncultivated, and is overgrown with weeds and forest vegetation. This further leads to a decrease in investment in uninhabited areas and less development of these parts of Montenegro.

Figure 2.1 shows the migration balance by municipalities in 2018 (MONSTAT, 2019). Only seven municipalities in Montenegro recorded a growth in population (Bar, Budva, Podgorica, Petnjica, Ulcinj, Danilovgrad, and Tivat), while all the other municipalities showed a decline in their populations. This is particularly evident in municipalities in the northern region where population levels declined by up to 51% (Šavnik).

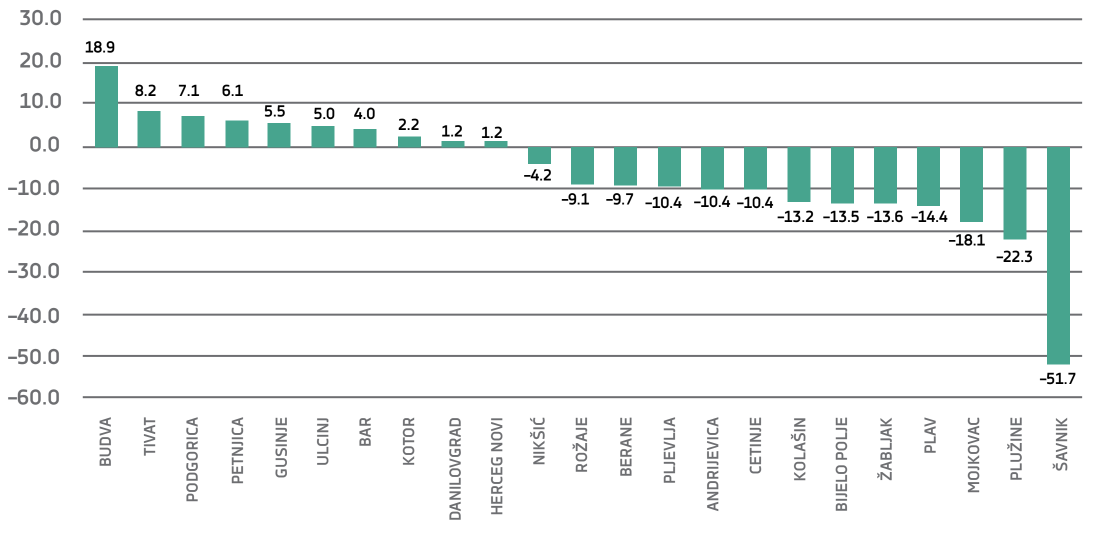


FIGURE 2.1 Migration balance rates by municipalities for 2018

The coastal area is the densest and most developed part of Montenegro. According to the 2011 Census, there were 148,683 inhabitants, which is 3.7% more than in 2003. MONSTAT's Montenegro Population Projection to 2061 predicts a continuous increase in the population in this area, with a growth index between 108.8 and 130.5, depending on the assumed scenario (Table 2.1).

TABLE 2.1:
Population projections in the coastal region of Montenegro until 2061 for different scenarios

COASTAL AREA	LOW FERTILITY	MEDIUM FERTILITY	HIGH FERTILITY	CONSTANT FERTILITY	CONSTANT MORTALITY
2011	148,630	148,630	148,630	148,630	148,630
2021	153,216	153,939	154,538	153,530	153,278
2031	155,424	158,322	160,570	156,669	155,820
2041	156,207	162,757	167,864	159,042	157,548
2051	157,778	169,292	178,545	162,742	160,749
2061	161,781	179,379	194,021	169,292	166,410
Growth index for 2061 (2011=100)	108.8	120.7	130.5	113.9	112.0

Source: MONSTAT

2.3 Land use

According to data from the Corine Land Cover (CLC) database as well as the MONSTAT Statistical Yearbook, 64% of the total territory of Montenegro is covered by forests, 14% is arable land and 9% is pastures.

Data from the National Forest Inventory (NFI), prepared in 2010, shows that forests cover 60% of the territory of Montenegro, while forest soil covers an additional 9.7%, which represents a significant part of the country's territory. In its structure, high forests cover 51.1% of the country's territory and represent 48.9% of the total forest area. Most of the high-forest areas are in the northern part of Montenegro. Coppice forests are a characteristic of the central and coastal parts of the country, while on the coast there are substantial areas of forest underbrush and small areas occupied by wild scrubland and degraded forest formations.

Agricultural land in Montenegro covers an area of 309,241 hectares and represents 22.4% of the territory (95.2% is family farms and 4.8% is registered agricultural businesses) and is very fragmented.

More than 90% of the surface area in Montenegro is more than 200 metres above sea level (MASL), 45% is less than 1,000 MASL, and mountainous areas above 1,500 MASL cover about 15% of the state's territory. The geological structure of Montenegro is characterized by rocks of different ages. Limestone, dolomite, and igneous rocks account for almost two-thirds of its surface are. Hydrogeological characteristics are determined by the geological structure of the terrain. Due to the composition of the rocks, precipitation quickly penetrates into the ground, feeding both confined and unconfined karst aquifers that discharge into the zones of erosion bases, the sea, Lake Skadar, and along the rim of the Zeta-Bjelopavlići plain, Nikšić Field, and the area adjacent to the watercourse beds.

Figure 2.2 shows the percentage of land use in Montenegro.

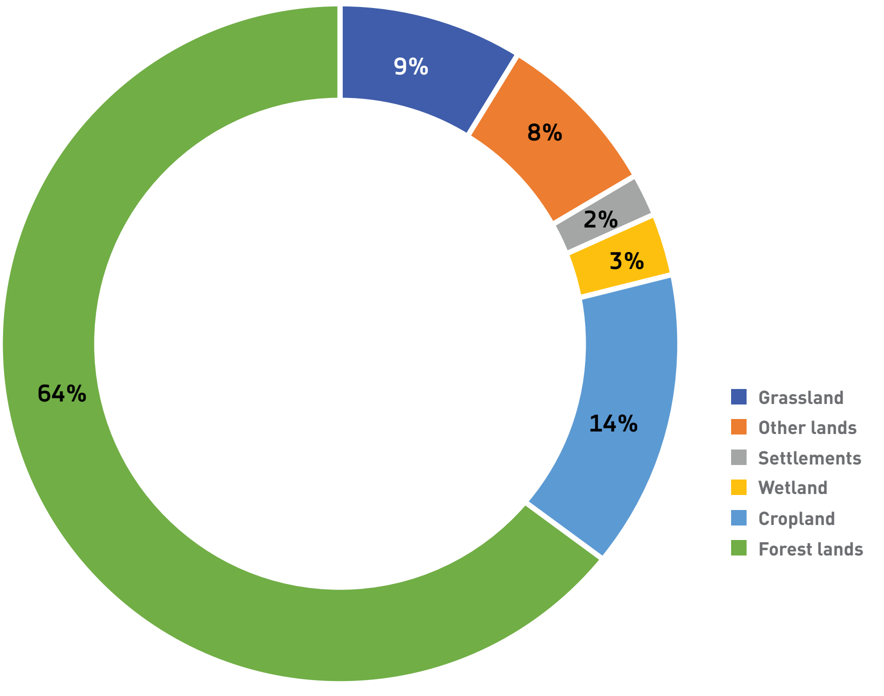


FIGURE 2.2 **Land use by category in Montenegro**

Source: MONSTAT

In Montenegro, 13.41% of the territory on land is located in a protected area (see the table below)[1].

TABLE 2.2
Protected Areas in Montenegro

TYPE OF PROTECTED AREA	NUMBER	AREA ON LAND/% OF MONTENEGRO
STRICT NATURE RESERVE	3	420.00 ha / 0.030%
NATIONAL PARK	5	100,427.00 ha / 7.271%
SPECIAL NATURE RESERVE	1	150.00 ha / 0.011%
NATURE RESERVE	6	79,583.10 ha / 5.762%
NATURAL MONUMENT	56	4493,54 ha / 0,325%
REGION OF EXCEPTIONAL VALUE	2	196,05 ha / 0,014%
TOTAL	73	185,269.69 ha / 13.414%

[1] Source: http://prirodainfo.me/Izvjestaji/PoVrstiZasticenogPodrucja.

2.4 Climate profile

Montenegro is located in the central part of a moderately warm zone in the Northern Hemisphere (latitudes 41° 52' to 43° 32' N and longitudes 18° 26' to 19° 22' E). Owing to its latitude, i.e. its proximity to the Adriatic and Mediterranean Seas, it has a Mediterranean climate with warm and somewhat dry summers, and mild and rather humid winters. The weather and climate in Montenegro are greatly influenced by the Genoese Cyclone, the Adriatic Cyclone, the Icelandic Depression, the Black Sea Depression, the Azores Anticyclone, the Siberian Anticyclone, the Central European Anticyclone, the cold frontal system from the north – the Arctic Cold Front, and the warm, tropical front from the south. Additionally, large bodies of water, its altitude and the position of its coastal mountains, along with the relief of its terrain, affect both its local and regional climates; thus within a small area there are large differences between the climates in the coastal and high mountain regions.

The dominant climate types in Montenegro are:

- Maritime
- Continental
- Mountainous

The large water surface, the height and direction of the coastal mountains, and the relief of the land locally and regionally affect its climate, creating, in a small area, large differences between the climate of the coastal region and the climate of the highland region, with numerous transitional forms of the local climate.

The mean annual air temperature has a range of 4.6°C in the Žabljak area at an altitude of 1,450 m, to 15.8°C on the coast. The average annual rainfall ranges from 800 mm in the far north to about 5,000 mm in the far southwest.

During the year, there are between 115 and 130 days of rainfall on average and 172 days of rainfall in the northern regions of Montenegro. The rainiest month on the coast is November, and the driest is July. Snow cover forms at altitudes above 400 metres, and with a depth of more than 50 cm it lasts on average from 10 days (in Kolašin) to 76 days (in Žabljak). In mountainous areas, snow falls much more frequently in the spring than in the autumn.

2.5 Natural resources

WATER RESOURCES

Surface water

The surface area of Montenegro is 13,812 km^2 and if its corresponding part of the Adriatic Sea (2,540 km) is also taken into account it totals 16,352 km^2. Water from the territory of Montenegro drains into two basins: the Adriatic Sea and the Black Sea.

The total surface area of the Black Sea Basin is 7,545 km^2 or 54.6% of Montenegrin territory. This part of Montenegro drains through the River Ibar and further on to the Western Morava River towards the Danube, as well as through the Rivers Tara, Piva, Lim, and Ćehotina towards the Rivers Drina and Danube. The Montenegrin part of the Adriatic Sea basin is about 6,560 km^2 in area or 45.4% of the territory. The biggest watercourses of this basin are the Rivers Zeta and Morača – that is, the River Morača after the confluence of these two rivers in Podgorica – and the River Bojana, which borders with Albania.

In Montenegro, there are significant differences in the distribution and abundance of water resources ranging from arid karst areas to areas rich in both surface and ground water. Generally speaking, with an average annual runoff of 624 m^3/s (i.e. a volume of 19.67 billion m^3), the territory of Montenegro is considered to be an area that is rich in water. The average specific runoff is about 43 litres/s/km. Of this total runoff, about 95% is from inland water, whilst the remaining 5% is from transit water.

The rivers drain into two basins: the Black Sea and the Adriatic Sea. The major rivers of the Black Sea Basin are the Lim (the longest river, 220 km long), the Tara (146 km), the Ćehotina (125 km) and the River Piva (78 km). The rivers that run into the Adriatic Sea basin are the Morača (99 km), the Zeta (65 km) and the Bojana (40 km). The water balance of the Adriatic Sea basin without the River Bojana is 256 m^3/s in total and together with the River Bojana is 670 m^3/s in total. The water balance of the Black Sea basin is 242 m^3/s in total.

Natural lakes are also an important water resource. The most significant of these are Lake Biogradsko (area of 0.23 km^2), Lake Plav (1.99 km^2), Black Lake (0.52 km^2), Lake Šasko (3.6 km^2) and Lake Skadar. The surface area of Lake Skadar, depending on its water level, varies from about 360 to over 500 km^2, while the volume of the lake ranges from 1.7 to 4.0 km^3. The largest artificial reservoir is Lake Piva with a total accumulation capacity of 880 million m^3. Other significant accumulations include Lakes Slano, Krupac, and Vrtac (225 million m^3) and Otilovići (18 million m^3). Wetlands can generally be found in the areas around the lakes and to a lesser extent in coastal areas. The most important wetland area is located in the vicinity of Lake Skadar and is listed as an internationally important area (based on the Ramsar Convention).

Ground water

Ground water in Montenegro is present in rocks of different ages, from the Palaeozoic Era to the Quaternary Period. It is a very important resource that represents the only practical source of water for the population. In addition to supplying water to the population, ground water is also used in industry, as well as in agriculture. Seventy-five sources are used to provide public water supplies to 40 urban settlements; 21 of these are municipal centres and there are also a large number of suburbs. Of the total number of sources, ground water from karst aquifers is abstracted from 64 of them and ground water from inter-granular aquifers is abstracted from 11 sources.

FORESTS

Montenegro has more than 60% of its territory covered by forests, which makes it among the top three most forested countries in Europe, falling close behind Finland (86%) and Sweden (67%). The forest cover is far above the average European (46%) and world (30%) level of forest cover. The high percentage of forest cover represents a big advantage in terms of environmental protection and improvement, and is also positive in terms of adapting ecosystems to meet future changes.

Orographic features and the refugial character of many habitats have made the abundance and diversity of wildlife (flora and fauna) a quality specific to Montenegro. The floristic diversity comprises 3,250 plant species and the index (S/A-species/area) of 0.837 makes Montenegro one of the most important biodiversity centres in Europe. The refugial character of habitats predominates; however, there is also evidence that species of flora and fauna that are endemic in Europe, Alpine, and in other Mediterranean regions are also present here.

Major diversity in terms of dendroflora is illustrated by the fact that the National Forest Inventory registered 68 species of trees (57 broadleaf and 11 coniferous species). Woody species form pure and mixed forests and cover 59.9% (832,900 ha), while forest land covers an additional 135,800 ha or 9.8%, which represents 69.7% of the territory of Montenegro.

Dominant species in the forest include beech, spruce, fir, black pine, etc. Figure 23 shows the distribution of high forests and coppice forests.

High forests cover 61%, shoots cover 12%, shrubs 13%, and forest land 14% of the total forest area. In the national parks (Lake Skadar, Lovćen, Biogradska Gora, Prokletije, and Durmitor), forests (37,125 ha) and forest land (2,825 ha) cover 40.5% of the area. Compared to the total area under forests in Montenegro, this is 53.7% of forests and 14.6% of forest land in the Emerald Network zone. In national parks, 66% of the area under forests is high forest (24,475 ha). Conifer forests cover 20.4% (7,575 ha), shrubs 13.6% (5,050 ha), while artificially raised communities cover 25 ha. The dominant share of self-renewing stands indicates a still high level of bioecological stability and productivity, especially in the national parks of Biogradska Gora, Prokletije, and Durmitor, in which forest ecosystems were one of the basic motives for declaring and establishing their status as national parks. The percentage of the area where the young trees is registered can be considered favourable in relation to the total forest structure.

The estimated biomass in the national parks of Montenegro is 10,717,149 m^3, while the forest ecosystem permanently captures 2,979,966 tonnes of carbon. The total amount of dead trees in deep condition and the stand is estimated at 258,079 m^3 and 238,967 trees of different tree species.

According to data from the Spatial Plan of Montenegro, 67% of the forests are state-owned. However, there are some indications that the balance of ownership has changed in favour of private forest owners, due to updates in the cadastre, and due to restitution, etc. and that 49% of forests and forest land are now privately owned.

Currently, 185,269.69 ha, or 13.41% of Montenegrin territory is protected. The national parks: Durmitor, Lake Skadar, Lovćen, Biogradska gora, and Prokletije occupy a total of 100,427 ha (7.27%), while nature reserves cover 79,583.10 ha, or 5.76% of the territory.

The factors that threaten forest ecosystems are primarily wildfires, abiotic factors (droughts, floods, frost, snow, high winds, etc.), and pests and diseases. The number of wildfires varies from year to year. Given the ecological and economical damage, wildfires are the biggest threat to forest ecosystems in Montenegro. Although currently their coverage is about 0.5% of the total forest area at the annual level, they could impose a serious threat in the future, especially in the southern forest region, where forests spread along the coast and in karst terrains. Here access to put out wildfires is difficult.

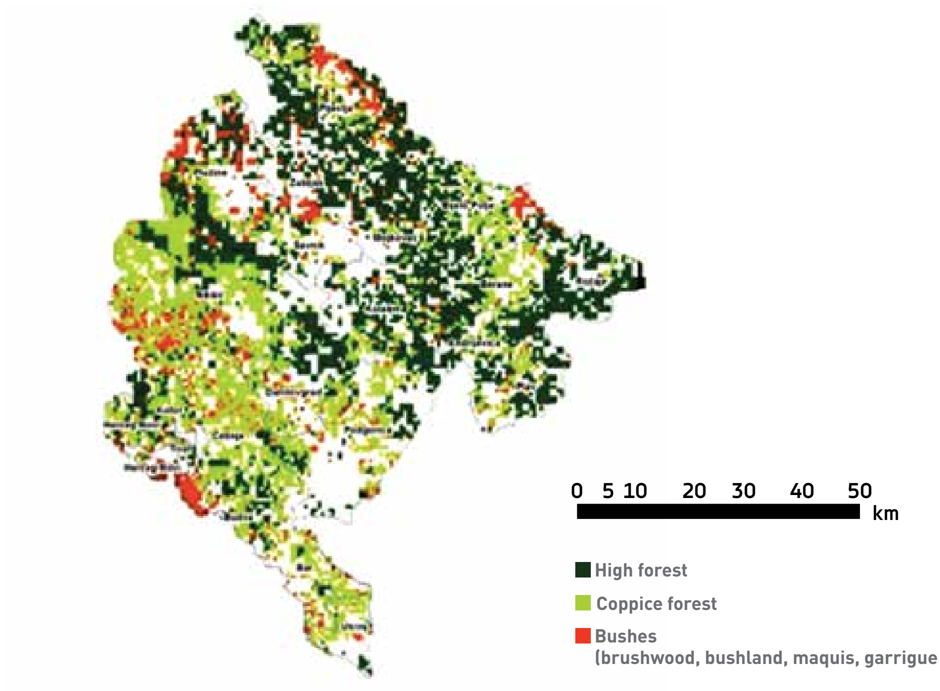


FIGURE 2.3 **Distribution of high and coppice forests**

Source: NFI (2012)

Unsustainable forest management practices have resulted in the deterioration of forest ecosystems. It has been observed that forests have become more susceptible to climate change, air pollution, and fires, as well as parasitic fungi, insects, and to a lesser extent rodents and parasitic flowering plants. The threats to forest ecosystems in Montenegro include:

- weakening of the immunity of certain tree species
- reduced productivity and bioecological stability
- intensive drying of forests, especially conifers: spruce and fir (larch on Mt. Lovćen), but also relatively poor defoliation
- occurrence of pathogenic fungal epiphytocia and/or gradation of harmful insects
- rodent damage
- the appearance of mistletoe
- occurrence of forest fires
- snowstorms, windbreaks and frost
- impact of air pollution
- illegal logging

According to available detailed information from Montenegro's national forest monitoring data, which is obtained from 49 locations and covers the entire territory of Montenegro, the average health and condition of forests is satisfactory. In most of the locations, the recorded degree of defoliation is within expected limits (0–25%). Of all the inspected trees (1,176 trees), 43% fell into the category of no defoliation (0–10% no defoliation), 37% showed signs of slight defoliation (10–25% slight (warning) defoliation), and major changes in defoliation were only recorded in 20% of trees (25–60% medium defoliation).

Common insects and fungi, causing tree degeneration, were identified during tree inspections. It should be stressed that, according to the ICP7 2011 Report, total damage caused by pests and fungi was found in 21% of trees (insects – 181 trees (15.39%) and plant diseases – 68 trees (5.78%)). Compared to 2010, this damage was identified in 26 additional trees or 2.21% more, which is an insignificant change.

Some of these phenomena are a direct consequence of climate change, i.e. increased air temperature, altered precipitation, more frequent droughts, storms, and generally extreme weather events. Climate change, as one of the major drivers of ecological change in forests, creates the need to review current forest management methods and reassess the plant and breeding methods used.

2.6 Economy and development priorities

The Montenegrin gross domestic product (GDP) in 2018 was €4,663 million, while for 2017 it was €4,299 million. GDP per capita in 2018 was €7,495 while in 2017 it was €6,908 (MONSTAT, 2018). Table 2.2 shows an overview of the important economic and social indicators in Montenegro for 2017 and 2018.

TABLE 2.3:
Gross domestic product (2017–2018)

	2017	2018
Gross domestic product at current prices, € million	4,299	4,663
Population (in thousands)	622.4	622.2
Gross domestic product per capita in € (3 = (1/2))	6,908	7,495
Gross domestic product at constant prices (at prices of previous year), € million	4,141	4,517
Real growth rate of GDP (%) ((GDP at constant prices in current year/GDP at current prices in previous year) × 100) – 100	4.7	5.1

Source: MONSTAT

Tourism remains one of the main drivers of the Montenegrin economy, contributing 7.5% to the GDP, and agriculture contributes 6.7% (MONSTAT, 2018). Figure 2.4 shows a disaggregation of Montenegro's GDP for 2018.

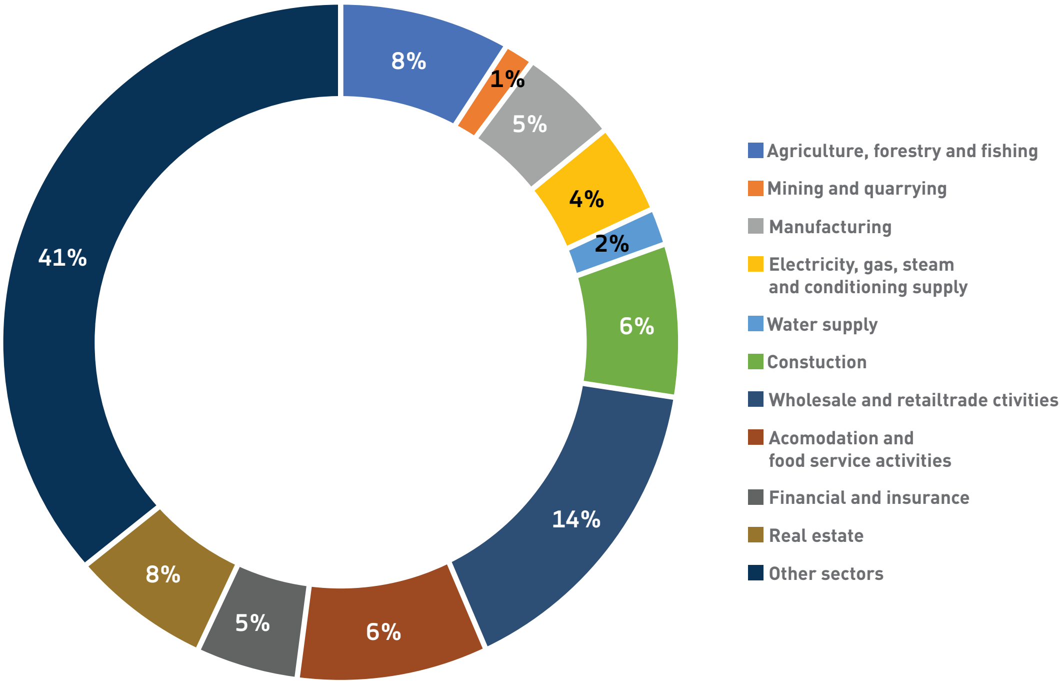


FIGURE 2.4 **Montenegro's GDP structure – 2018 (Other sectors includes: public administration; pro fessional, scientific, and technical activities; education; human health; and transportation)**

Source: MONSTAT

Montenegro's population is experiencing poverty and income inequality; however in the last few years the conditions have improved. The at-risk-of-poverty rate in Montenegro in 2017 was 23.6%, which was 1.6% lower compared to 2013. A decreasing trend is also recorded in the relative at-risk-of-poverty gap, since the value of this indicator in 2013 was 39.7%, and in 2017 it was 34.0%, which is a decrease of 5.7%. The permanent at-risk-of-poverty rate for the period 2013–2016 was 15.6%. Income distribution inequality reduced from the value of 8.5 recorded in 2013 to 7.6 recorded in 2017 (MONSTAT, 2018). Figure 2.5 shows a summary of the at-risk-of-poverty rate by age for the period 2012–2017.

The observation by gender does not show any significant difference in the risk of poverty between males and females for the years 2013–2017. In the observed period, females were less exposed to the risk of poverty, while exposure risk for males remained the same. In 2017, the risk of poverty of males was 24.2% and it is 1.2 percentage points higher than the risk of poverty of females (23.0%).

The population of northern region is the most exposed to the risk of poverty during the entire observed period, while the ranking of other regions by years was different. In 2017, 37.9% of the population of the northern region was at risk of poverty, while the population of the central region had the lowest risk of poverty (15.4%). Compared to 2013, the northern and central regions and the capital Podgorica recorded a decreased risk of poverty (Figure 2.6). The considerably lower income of the population in the northern region compared to other regions can be explained to a certain degree by the dominant share of agriculture.

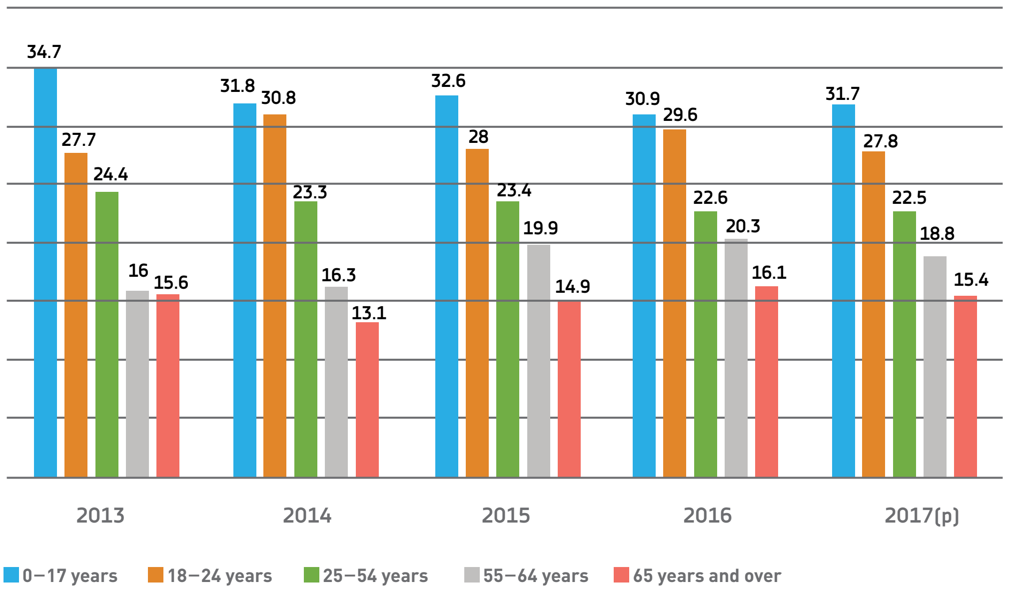


FIGURE 2.5 At-risk-of-poverty rate by age for 2013–2017 (%)

Source: MONSTAT (2018)

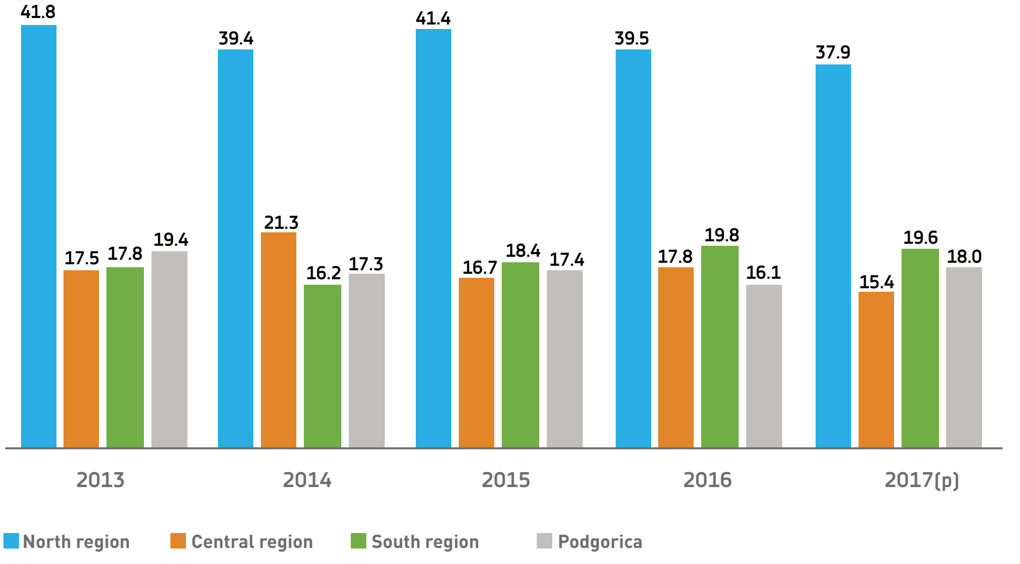


FIGURE 2.6 At-risk-of-poverty rate by regions for 2013–2017 (%)

Source: MONSTAT (2018)

2.7 Economic sectors

ENERGY SECTOR

Energy generation and consumption

The energy sector remains the most significant source of anthropogenic GHG emissions in Montenegro. The energy sector includes all activities related to the combustion of fuels (solid, liquid, gaseous, and biofuels) in stationary and mobile sources, as well as fugitive emissions from fuels. Fugitive emissions occur during the production, transmission, processing, storage, and distribution of fossil fuels. Activities related to electricity and heat production account for the largest share of total emissions from the energy sector. Emissions from the transport subsector recorded a slight, constant upward trend over the reporting period, in line with the increase in the number of motor vehicles in the country.

According to the electricity balance for 2017, Montenegro's primary electricity production in 2017 was 1,101 GWh, while electricity generation from transformations was 1,265 GWh. Imports of electricity amounted to 1,537 GWh, while exports amounted to 416.7 GWh. Power consumption was 119 GWh, and transmission and distribution losses were 512 GWh (Figure 2.7) (MONSTAT, 2017). The total available electricity for final consumption in 2017 was 2,855 GWh. The highest consumption of electricity was recorded in the household sector 45.1%, other sectors 29.3%, and industry activities 25.6% (MONSTAT, 2017)

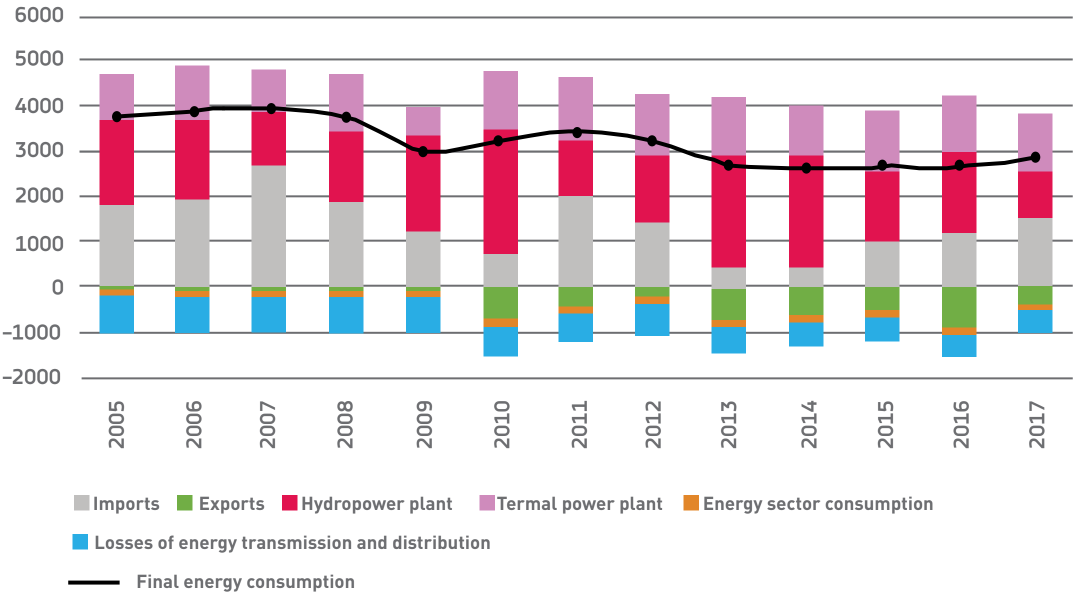


FIGURE 2.7 Energy balance for 2005 2017 (GWh)

Source: MONSTAT (2018)

Total electricity production in Montenegro in 2018 was expected to be 3,256 GWh, which is 36% higher than the estimate for 2017. An overview of the achieved electricity production by power plants and the total for 2016, an estimate of the realization for 2017, and the plan for 2018 are shown in Table 2.4.

TABLE 2.4:
Electricity production for 2016–2018

Power plant	Achieved	Estimate	Planned	%	%
	2016	2017	2018	(2/1)	(3/2)
	1	2	3		
"Perućica" hydroelectric plant	939	560	920	60	164
"Piva" hydroelectric plant	792	430	750	54	174
Small hydroelectric	25	19	19	74	102
Total hydroelectric	1, 756	1,009	1,689	57	167
Renewables – (small hydroelectric)	51	47	70	92	149
Wind		61	180		294
"Pljevlja" thermoelectric plant	1,216	1,280	1,317	105	103
TOTAL	**3,024**	**2,397**	**3,256**	**79**	**136**

Source: MONSTAT (2018) Energy balance for 2018

Based on the Energy Sector Status Report for Montenegro in 2018, issued by the Energy Regulatory Agency (RAE), the share of electricity produced in facilities using renewable energy sources out of total electricity generation in 2018 was 61.44%.

The share of electricity production by production facilities during 2018 is shown in Figure 2.8. The figure shows that in 2018 hydroelectric power plants produced 57.11% of the total electricity produced in Montenegro.

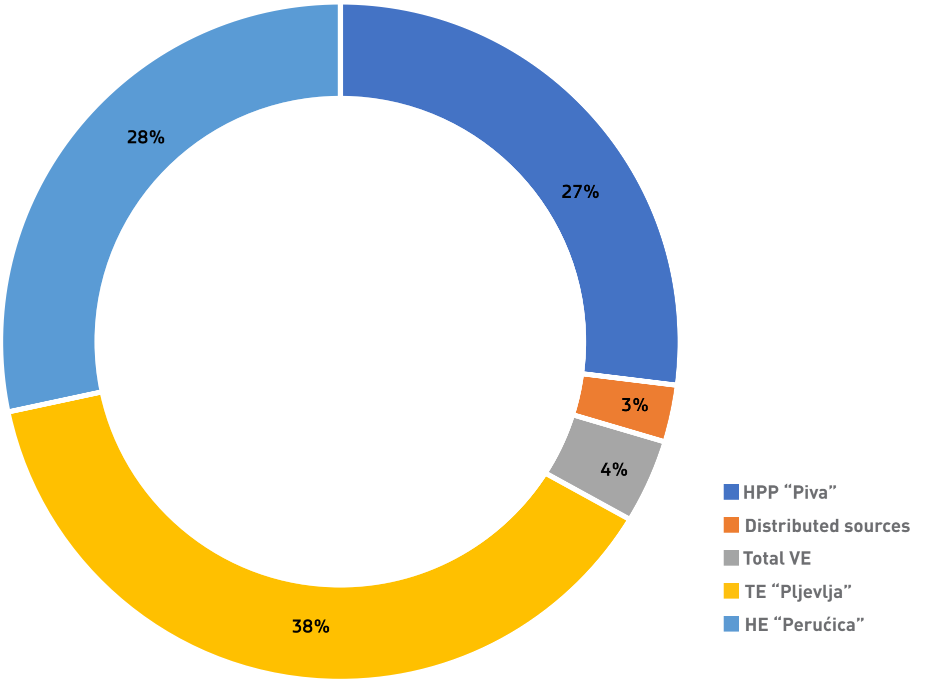


FIGURE 2.8 Share of production facilities out of total electricity production in Montenegro (2018)

The program for the development and use of renewable energy sources until 2020 defines the dynamics of natural resources use, as well as the planned use of technologies needed to meet national target of energy produced from renewable sources in total final energy consumption.

Energy efficiency

Montenegro's obligation under the Energy Community Agreement is to achieve the indicative energy efficiency target, which is 9% of the average final energy consumption in the country, or about 1% per year for the period 2010–2018. This trend of the indicative energy efficiency target has continued in the new Action Plan, which was adopted in July 2019 and covers the period 2019–2021, setting an indicative annual target for 4.16 ktoe of final energy (or 6.54 ktoe expressed in primary energy equivalent). A preliminary analysis shows that the energy savings achieved in the period 2010–2018, account for 49.76 ktoe, which represents 84.5% of the achievement of the indicative target.

In order to achieve the indicative target in the coming period, significant financial resources need to be mobilized. It is also necessary for the energy market to be further liberalized, especially with regard to the provision of energy services. In this regard, it is essential to further develop public–private partnerships in the field of energy efficiency.

The Action Plan envisages 27 measures in different sectors to introduce energy efficiency measures. Table 2.5 shows a list of the proposed measures, the necessary financial resources, an assessment of energy savings, and an overview of the entities responsible for their implementation. Many of these are also included within the mitigation section of this report – although they are grouped.

TABLE 2.5:
Overview of planned EE measures with an assessment of the savings and necessary financial assets

	NAME OF EE MEASURE	SOURCE OF FINANCING (€)				PLANNED ENERGY SAVINGS (ktoe)		RESPONSIBLE ENTITIES
		National budget	Donor funding	Credit	Other resources	2020	2021	
H1	Development of the basic legislative, regulatory and institutional framework for electricity in Montenegro	10,000	20,000					*Ministry of the Economy (MoE)*
H2	Adoption of planning documents for EE	10,000	110,000					*MoE, state administration bodies and local self-government units*
H3	Establishing a sustainable financing model for energy efficiency projects through the Eco Fund	10,000	50,000		1,150,000			*MoE, state administration bodies and local self-government units*
H4	Information campaign for EE promotion	30,000	30,000					*MoE, Chamber of Economy of Montenegro, donor community, NGO sector*
H5	Strengthening education and training in areas of EE	30,000						*MoE, University of Montenegro, Centre for Vocational Education*
H6	Introducing a regulatory framework for eco-design of products that affect energy consumption	10,000	20,000			7.27	13.83	*MoE, Inspection Directorate (Market Inspection)*
H7	Individual measurement and informative calculation							
B1	Development and implementation of a regulatory framework for the energy efficiency of buildings	10,000	550,000			16.10	24.15	*MoE, MSDT, local self-government units, participants in construction*

INDUSTRY AND MINING

The Industry Policy of Montenegro 2019–2023 (IP 2023) is a strategic document for the development of the competitiveness of the Montenegrin economy with a focus on the industrial sector. IP 2023 recognizes that the real drivers of change and development are companies that, with adequate support, should maximize their potential for growth, development and competitiveness. IP 2023 represents a continuation of the activities implemented under the Industrial Policy to 2020, adopted in June 2016.

Until 2023, industrial policy also recognizes the circular economy as one of the important directions for future development. According to the Strategy, in 2015 the European Commission adopted an action plan to help accelerate Europe's transition to a circular economy, to strengthen global competitiveness, to promote sustainable economic growth, and to create jobs. The Action Plan sets out 54 measures to "round out" the product life cycle: from production and consumption to waste management and the secondary raw materials market.

Managing the lifecycle of natural resources, from extraction, through design and production, to what is considered waste, is essential for green growth and is part of developing a cost-effective, resource-efficient, circular economy where nothing is lost. Smarter design, that allows products to be modified, reused, re-manufactured, and recycled, should become the norm.

Montenegro, which is significantly tourism-oriented, and has been declared an ecological state, must pay special attention to the valorisation of green growth and the circular economy, integrating the demographic, social, natural, and economic aspects of economic development, as stated in the National Development Strategy of Montenegro to 2030, which has taken the universal UN Sustainable Development Goals into the national context (Ministry of the Economy, 2019).

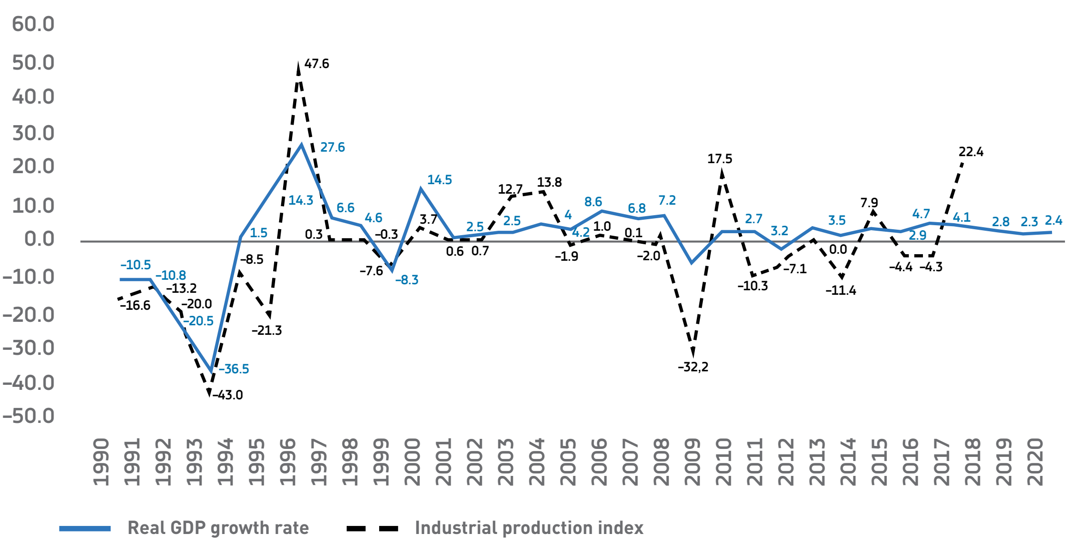


FIGURE 2.9 Industrial production index and real GDP growth rate in Montenegro for 1990–2018

Industrial production is an important economic indicator in economic policy making, in monitoring the trend of economic activity, and especially for the needs of national accounts. Table 2.6 shows the share of industrial production within GDP for the period 2010–2017.

TABLE 2.6:
The share of industrial production within GDP for 2010–2017

	2010	2011	2012	2013	2014	2015	2016	2017
Industrial production (€ million)		329.9	327.4	376.9	376.6	387.1	403.6	393.1
GDP (€ million)	3,103	3,234	3,148	3,327	3,457	3,624	3,954	4,299
Share of industry within GDP (%)	11.12	10.20	10.40	11.32	10.89	7.9	10.21	9.14

Source: MONSTAT (2017)

In absolute terms, industrial production in recent years has recorded uniform values, with some minor changes caused by movements within the industrial structure itself. The decrease in the share of industrial production in GDP in 2017 is a consequence of lower production activity in the electricity supply sector, while production activity in the manufacturing sector is at the level of previous years.

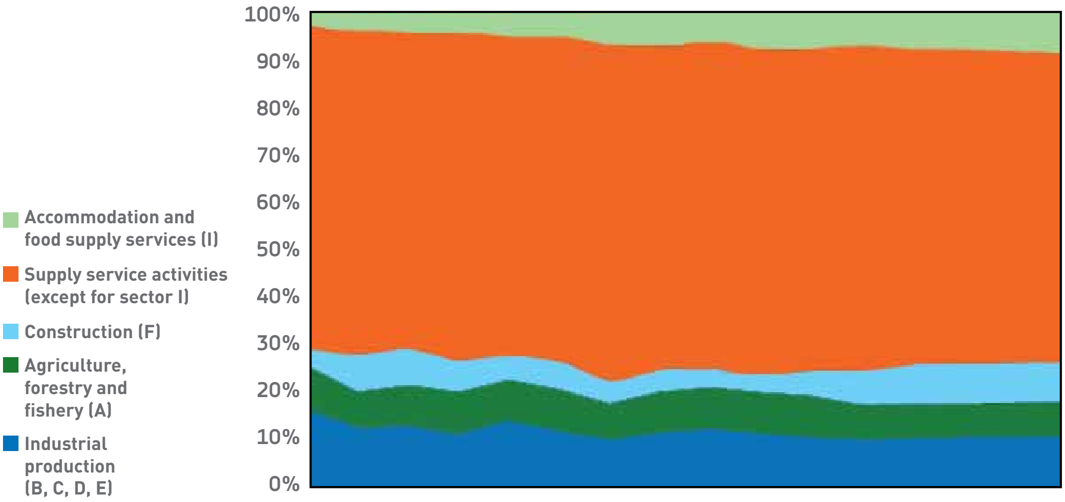
According to the United Nations Industrial Development Organization (UNIDO), gross value added in the manufacturing sector in the period 2010–2017 shows uniform values, with a very slight increasing trend, which is not, however, sufficient to significantly shift and increase industry within the GDP structure.

In the period 2011–2018 industrial production in Montenegro recorded growth in the years 2013, 2015, and 2018. The 2018 Industrial Production Index was recorded at a record level of 22.4%, primarily due to an increase in electricity production of over 62%, an increase in the manufacturing industry of 12%, but also a drop in mining and quarrying of 21% (Table 2.7).

TABLE 2.7:
Industrial Production Index in Montenegro 2011–2018 (average annual rates)

	Total Industry	Mining and quarrying (B)	Manufacturing (C)	Electricity Supply (D)
2011	–10.3%	6.3%	6.8%	–32.7%
2012	–7.1%	–21.0%	–10.1%	1.4%
2013	10.6%	–1.4%	–5.0%	38.7%
2014	–11.4%	14.4%	–6.7%	–19.6%
2015	7.9%	–8.1%	19.9%	–5.9%
2016	–4.4%	–18.1%	–7.8%	3.5%
2017	–4.2%	113.9%	–9.3%	–24.6%
2018	22.4%	–21.3%	12.1%	62.1%

Figure 2.10 shows the gradual change in the structure of the Montenegrin economy, from a "pre-industrialized" and "rigid" economy (economic structures) for the Yugoslav market to the gradual construction of an open and service-oriented economy, significantly dependent on external demand, with a growth-based development model.



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Accommodation and food supply services (I)		5.4%	5.3%	5.3%	6.5%	6.4%	8.3%	8.0%	7.9%	9.2%	9.1%	8.7%	9.3%	9.6%	9.9%	10.0%
Supply service activities (except for sector I)	68.3%	69.6%	67.9%	70.8%	69.0%	70.4%	74.5%	71.8%	71.7%	72.9%	72.1%	72.1%	70.5%	70.0%	69.9%	69.3%
Construction (F)	4.3%	8.2%	8.4%	7.0%	6.0%	6.6%	5.3%	5.4%	4.5%	4.2%	5.9%	7.9%	9.3%	9.3%	9.3%	9.3%
Agriculture, forestry and fishery (A)	10%	8%	9%	10%	10%	10%	9%	10%	10%	10%	10%	8%	8.2%	8.2%	8.2%	8.2%
Industrial production (B, C, D, E)	17.3%	13.8%	14.2%	12.3%	15.5%	13.1%	11.6%	13.1%	14.0%	13.1%	12.2%	11.6%	12.0%	12.2%	12.3%	12.5%

FIGURE 2.10 **Structure of gross value added with estimations for 2006–2017 and projections to 2021**

Source: MONSTAT (2019)

The participation of the sectors related to industrial production (B, C, D, E) continues to record a downward trend in gross values – from 17% in 2006 to 12% in 2018 (manufacturing reduced from 9% to 5% within that structure). Projections in the Economic Reform Programme indicate a slight increase in total industrial production in the medium term, up to 12.5% in the gross value structure by 2021. The service sector is steadily increasing until 2017, in particular accommodation and food services sectors are showing continued growth in medium term (up to 10% in gross value). Agriculture is consolidated at 8.2% of gross value share by 2021.

Within the framework of Industrial Policy, a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of the potential for industrial development was also carried out. The analysis showed that are the main weaknesses include the use of energy-intensive and often outdated technology and equipment. This results in industrial production characterized by high share of products of lower processing stages and high import dependency. There is lack of interaction between the industry sectors and scientific research institutions and other sectors of the economy.

To address these weaknesses, it is necessary to develop products and services with greater added value, fostering innovation and introducing new technologies through collaboration with the scientific research community, digital transformation. In addition, the gradual introduction of the principles of circular and low carbon economies can make a significant contribution in further developing a more resource efficient economy and good environmental management.

AGRICULTURE

Agriculture continues to be an important strategic sector within the economic development of Montenegro and has many economic activities that are linked to it, particularly in rural parts of the country. In 2018, the agriculture, forestry and fishing sector represented 6.7% within the GDP. Total number of actively employed persons in Montenegro interviewed in the farm structure survey in 2016 is 99,236.

Utilised agricultural land in 2018 is 256,808 ha, which has slightly increased with 0.2% compared to 2017. In total utilised agricultural land areas, perennial meadows and pastures areas prevail with the share of 94.3%, while arable land is present with 2.8%, permanent crops 2.1% and kitchen gardens 0.8%. In comparison with 2017, perennial meadows and pastures area increased by 0.2%, arable land increased by 0.5%, kitchen garden increased by 0.5% and permanent crops increased by 0.2%.

Of the total surface area of Montenegro, 515,740 ha or 37% is suitable for agriculture, but only 16% is actually used for agricultural purposes. There is 0.83 ha of agricultural land per capita. According to MONSTAT data, 515,740 ha of agricultural land in 2016 comprised the following (Figure 2.11):

- Arable land and gardens (45,748 ha)
- Orchards (12,007 ha) and vineyards (4,399 ha)
- Meadows (126,990 ha)
- Pastures (323,953 ha) and
- Other – wetlands (2,643 ha)

The farm structure survey in 2016 indicates a significant increase in utilised agricultural area under arable land, vineyards, orchards as well as meadows and pastures compared to the same areas from 2010 (MONSTAT, 2017).

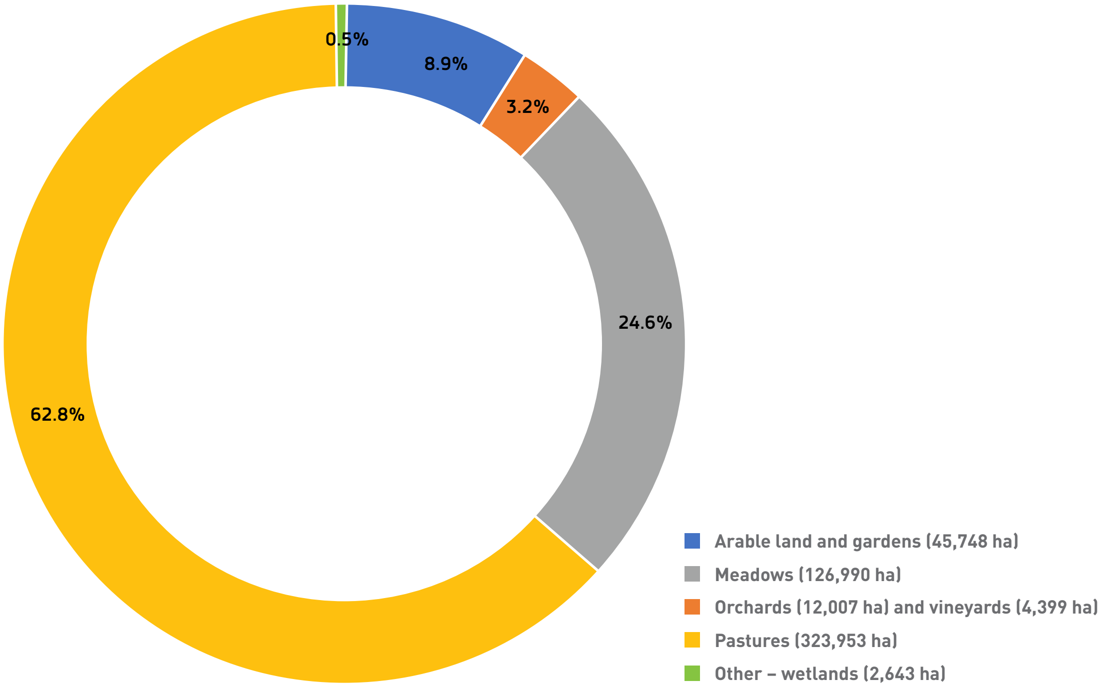


FIGURE 2.11 Agricultural land by usage category for 2016

Source: MONSTAT (2017)

The agricultural utilization structure remained approximately the same for the period 2015–2018, with a slight decrease in the usage of surface areas for arable land, gardens, and pastures, and a slight increase in the usage of surface areas for perennial plantations and meadows (Table 2.8).

TABLE 2.8:
Changes in the usage of agricultural land surface areas during the period 2015–2018 (×1,000 ha)

	Total agricultural utilized land	Utilized kitchen gardens and/ or gardens	Utilized arable land	Vineyards	Voćnjaci – plantažni	Orchards – plantations	Nurseries	Perennial meadows and pastures
2015	231,405	1,861	6,853	2,708	1,144	1,147	57.9	217,633
2016(p)	255,845	1,922	7,103	2,860	1,333	1,217	74.5	241,333
2017(p)	256,361	2,003	7,162	2,850	1,333	1,214	72.3	241,724
2018(p)	256,807	2,014	7,199	2,837	1,356	1,214	72.4	242,112

Source: MONSTAT

The most important crops are vegetables and fruits, while the commercial production of farm crops (cereals, maize, sugar beet, oilseed) is poorly represented. The main crops are potatoes and vegetable crops. The most commonly grown fruit crops are plums, apples, pears, peaches, and also oranges and tangerines in the south, and figs. There are about 495,200 fruit-bearing olive trees.

Achieved wheat production in 2018 was 2,466.9 t, which is a rise of 0.2% compared to 2017. An increase in production was also recorded in the following crops: rye (5.7%), maize grain (1.3%), tomatoes (2.1%), cucumbers (4.1%), watermelons (3.2%), and melons (5.4%). The total production of potatoes in 2018 fell by 4.8% (MONSTAT, 2018).

TOURISM

In Montenegro, tourism is one of the most important business activities which has the potential for economic growth and development. Tourism is of great importance, taking into consideration all of its direct and indirect multiplicative effects. It is one of the major revenue sources in Montenegro and the economic development of Montenegro is based primarily on the further development of this branch of the economy.

The tourist sector in general directly and indirectly affects the growth of gross domestic product, which is also the case in Montenegro. In the period 2010–2016, ***the share of the tourist sector within GDP in Montenegro recorded a constant growth trend***. When it comes to generating new jobs, analyses indicate that the tourist sector will directly or indirectly enable the creation of 40,000 jobs, which will represent 20.4% of the total number of employees in Montenegro (WTTC, 2017).

The importance of tourism for the Montenegrin economy can be seen from the Report of the World Tourism and Travel Council (WTTC), which analyses and ranks the impact of tourism on GDP, employment, exports, and investment, and covers 184 countries. In the mentioned report, Montenegro is recognized as one of the fastest-growing tourist destinations in the world. The Report estimates that the total contribution of tourism to Montenegro's GDP in 2017 was 23.7%, with a growth forecast of 8.9% in 2018 and a tendency towards generating 27.9% of GDP in 2028.

According to the latest report of the European Travel Commission (European Tourism in 2019: Trend & Prospects Q2/2019), Montenegro is recognized as the fastest-growing destination out of the 33 European countries that are members of this international organization. Montenegro was visited by 2.64 million tourists in 2019, which is 21% more than in 2018, and the income from tourism was €1.14 billion, which is €100 million more than in 2018 (Ministry of Sustainable Development and Tourism, February 2019).

Having in mind the importance of the development of tourism as a dominant branch of economic development, and then Montenegro's commitment to sustainable development and environmental protection, the concept of the development of green/responsible tourism on the principles of low-carbon development is beginning to represent an innovative approach that has its future in Montenegro.

The report on GHG emissions from the tourist sector indicates that total GHG emissions from the tourist sector in 2017 were 95.04 ktCO_2eq. The report has been prepared for the fifth year in a row, based on an internationally verified methodology, in accordance with ISO 14064-3: 2006. The report confirmed that the greatest potential for reducing emissions is in the area of accommodation (56.7% of total emissions in 2017), i.e. mainly through the application of energy efficiency measures in hotels and apartments.

TRANSPORT

The National Climate Change Strategy identifies transport as a priority sector for climate change actions and outlines a number of measures and targets related specifically to increasing the use of public transport and the promotion of more energy-efficient vehicles and electric vehicles for public and individual transportation. The strategy also stresses the need to increase the resilience of the transport sector to predicted climate impacts due to its vulnerability and the key role it plays in the country's economic and social development.

Based on the Action Plan for the Application of Renewable Energy Sources and Energy Efficiency Measures in the Transport Sector[1], the transport sector in Montenegro is based on oil derivatives (petrol, diesel fuel, and liquified petroleum gas – LPG) for road traffic and electricity for rail traffic, while road traffic makes up the most significant share. According to the structure of fuels used to power registered vehicles in the last 5 years, the highest-represented vehicles run on diesel and motor gasoline. The use of biofuels and other alternative fuels (except LPG) is not represented. Implementation of energy efficiency measures in the transport sector is still at its very beginning.

When it comes to the number of vehicles in Montenegro, in 2017 that number was 219,378. The share of vehicles with a diesel engine was 70%, with the existence of only 49 electric vehicles (official statistics do not differentiate hybrid vehicles as a special category). This figure consisted of 193,242 cars and 1,370 buses, as well as trucks, vans, motorcycles, and special-purpose vehicles. Overall, the vehicle fleet has made a significant step forward in terms of fuel efficiency, according to research conducted under the Global Initiative to Reduce Fuel Consumption (GFEI): between 2008 and 2014, resulting in a reduction in the CO_2 emissions per kilometre driven from 162.4 g to 147.7 g, with an average annual decrease of 1.8%. This came about due to the dominant reliance on the use of diesel vehicles, which in 2017 accounted for 71% of all vehicles in the country.

The largest share within road transport is occupied by passenger and commercial vehicles, while the other remaining categories are represented with a very low participation. In addition, there are many old vehicles (produced in the period 1980–1989 and 1990–1994), and the average age of all 39 registered vehicles in 2013 was 14.9 years. Considering the age structure, most of the vehicles do not meet the Euro-3 standard, while the number of vehicles that meet the Euro-5 standard is relatively small (9%).

The Strategy for the Development of Transport of Montenegro for the Period 2019–2035 was adopted in July 2019. For the purpose of drafting the Strategy, a regional traffic model for Montenegro was developed to estimate traffic flows under different scenarios. A significant increase in road traffic is expected in the future, which will have an impact on the efficiency of the state network and planned highways.

Table 2.9 shows that road traffic is expected to grow by at least 45% by 2025 and another 25% by 2035. Highways are expected to take on high average daily traffic volumes (over 22,000 vehicles daily in 2025 and 27,000 in 2035 for the smallest network segments' traffic volume).

[1] EU-funded project implemented by European Profile and Eptisa.

The total distance travelled (vehicle-km) will increase in the future, given that the total lengths of routes are not being radically shortened (the new highways run parallel to the existing network) and traffic volumes are increasing. On the other hand, the introduction of the highway contributes to the reduction of travel times and thus the total vehicle-hour ratio is reduced relative to the core network, at least for 2025, and is almost identical for 2035 (given that traffic will increase significantly by 2035).

The main factors behind the observed and projected increase in greenhouse gas emissions in traffic are:

- The total number of registered vehicles in Montenegro increased by 11%, from 187,913 to 209,098 in the period 2010–2016. Consequently, Montenegro has a relatively high and constantly growing rate of motorization (number of passenger cars per 1,000 inhabitants): it increased by over 40% in the period 2005–2015 and amounted to 265 passenger cars per 1,000 inhabitants in 2015 compared to the world average of 182 vehicles/1000 inhabitants.
- Aging of the vehicle fleet: the share of used (and less efficient) vehicles within the total vehicle fleet is growing.
- Road transport is the dominant mode of transport that accounts for 90% of all energy consumption in the transport sector in 2016. It is expected that travel will increase significantly in the future.
- Montenegro has a very low share of public transport – less than 5%.
- The Montenegrin transport sector is almost entirely dependent on fossil fuels, with a very small contribution from electricity used mainly in rail transport (0.74%): 99.6% of registered vehicles in Montenegro use diesel and oil.

TABLE 2.9:
Performance indicators for the road network (typical day)
(* includes trips with at least one end in Montenegro)

YEAR	Road passenger traffic			Road freight traffic		
	Trips*	Vehicle – km	Vehicle – hr	Trips	Vehicle – km	Vehicle – hr
2015	40,924	3,921,870	101,360	3,430	355,462	5,299
2025	59,752	5,020,369	75,742	4,397	399,972	4,321
2035	74,763	6,527,882	109,961	5,027	462,751	4,977

WASTE MANAGEMENT

Waste management[1] remains an area where Montenegro has to invest a lot of additional effort to obtain a functional system that ensures sustainable development, maximum protection of the environment, solutions to existing problems and creation of databases needed for both national level decision-making and international reporting.

Municipal waste

According to Monstat, Montenegro generated 330,839 tonnes of municipal waste in 2018 (2.1% more than in the previous year). Each inhabitant generated on average 531.7 kg of municipal waste per year, or 1.46 kg per day.

Out of the total quantity of waste generated in Montenegro, 303,107 tonnes of municipal waste were collected in 2018 (including the 1501 sub-group – Packaging), which gives 1.33 kg per capita per day. Total quantities of collected municipal waste included the municipal waste collected by the local utility companies (96.4% of the total quantity) and business entities (entered in the Register of Waste Collectors kept by the Agency for Nature and Environment Protection), which took waste directly from those who produced it, and all the waste brought to the landfill by individuals.

In 2018, most of the waste collected by the local utility companies in 2018 fell under "other municipal waste", which included: mixed municipal waste (84.3%); waste from gardens and parks (8.1%); separately collected fractions (7.6%), and waste packaging (0.04%).

Industrial waste

PAccording to Monstat's most recent official data on the quantities of industrial waste, 667,266.9 tonnes was generated in Montenegro in 2017. Out of that, the Mining and Quarrying sector generated 46.6% (2.6% less than in the previous year); the Processing Industry sector generated 6% (0.5% less than in the previous year); the Electricity, Gas and Steam Supply and Air Conditioning sector generated 46.4% (1.9% more than in the previous year), and the Water Supply, Wastewater Management, Waste Removal Control and Similar Activities 1% (0.2% more than in the previous year).

Almost the entire quantity of waste generated in industry in 2017 (298,196.8 tonnes) related to the Mining and Quarrying sector (99.5%) (296,520.5 tonnes), while almost all of the waste (99.9%) from the Electricity, Gas and Steam Supply and Air Conditioning consisted of non-hazardous waste from thermal processes.

Out of the total generated and stored waste, which amounted to 686,262.2 tonnes in 2017, industrial companies internally processed 3.4%; disposed 89.5% and temporarily stored 3.6%. They exported 7,297.5 tonnes (1.1%) of waste, while the remaining quantities (16,665.9 tonnes, or 2.4% of waste) were handed over to other companies in Montenegro.

[1] Taken from the State of the Environment Report for 2018, Agency for Nature and Environment Protection of Montenegro.

The most frequent operation under internal processing was backfilling (83%), followed by incineration (8.2%), recycling (6.4%), and other procedures (2.4%). Industrial companies disposed of 614,024.8 tonnes of waste in 2017; the most common operation was D12 – Underground storage, with a 50.2% share. Out of the 7,297.5 tonnes of industrial waste exported directly by the industrial companies in 2017, 75.7% was wood-processing waste, 10% was paper, cardboard and glass packaging, 9% were anodes and 5.3% mainly scrap metal.

Medical waste

According to the Ministry of Health data, a drop in the quantities of collected and treated medical waste was recorded in 2016-2018. The amount of waste from the public institutions providing medical services that was collected and treated in 2018 was 373.4 tonnes. That was 12% less than in 2016, and is attributed to improved selection of specific types of medical waste at the source. Contrary to this, private healthcare institutions collected and handed over for treatment 18.3 tonnes of medical waste in 2018.

Waste management infrastructure

Montenegro's waste management infrastructure includes the following:

- 2 regional non-hazardous waste landfills (in Podgorica and Bar);
- 3 recycling centres (in Podgorica, Herceg Novi and Zabljak);
- 5 end-of-life vehicles treatment plants (Podgorica (1), Berane (1) and Niksic (3));
- 2 transfer stations (in Kotor and Herceg Novi);
- 8 recycling yards (Podgorica (6), Herceg Novi (1) and Kotor (1)),
- 2 medical waste treatment plants (in Podgorica and Berane).

The "Livade" regional sanitary landfill in Podgorica expanded its capacities for non-hazardous waste disposal (with the construction of the third cell), and the leachate treatment plant began operation in mid-2018.

In addition to the primary recycling centres in Podgorica and Herceg Novi (where some types of waste are selected and prepared for transport/export for further treatment) and the small-scale facility in Kotor, Montenegro still has no recycling plants. Also, there are no incineration plants.

Montenegro still does not have the infrastructure for hazardous waste disposal that would comply, in technical and technological terms, with the European standards. In line with the Law on Waste Management (Official Gazette of MNE 64/11, 39/16) and the requirements under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, and on the basis of the licenses issued by the Agency for Nature and Environment Protection, hazardous waste is exported. In 2018, the Agency issued 9 licenses for the export of 4,615 tonnes of hazardous waste.

Clean-up of irregular dumpsites

Clean-up of irregular dumpsites undoubtedly constitutes a priority objective. Clean-up of the following dumpsites took place in the past year:

- "Vrtijeljka", in the Old Royal Capital of Cetinje (June 2018);
- "Vasove Vode", in Berane Municipality (late October 2018), and
- "Zauglina", in Savnik Municipality (late October 2018).

2.8 Policy and institutional framework for climate change in Montenegro

POLICY FRAMEWORK FOR CLIMATE CHANGE

Montenegro became a non-Annex-I party to the UN Framework Convention on Climate Change (UNFCCC) in 2006. Following this, the country adopted the Law on Ratification of the Paris Agreement in October 2017, confirming its INDC submitted to the UNFCCC in September 2015, with a goal of a 30% GHG emission reduction by 2030. Montenegro is a candidate country for EU accession, and as such it has undertaken to transpose the EU climate and energy package into its domestic legislation. Moreover, it is also a party to the treaty establishing the Energy Community (EnCT), undertaking to rapidly endorse EU rules on the monitoring, reporting, and inventorying of GHGs and the actions undertaken to address CC, and to develop integrated a National Energy and Climate Plan (NECP) in line with the European Commission (EC)[2] proposal.

The National Climate Change Strategy (NCCS) to 2030 is the key policy instrument for the management of climate change in Montenegro and establishes the commitment of the Government to act against climate change in an integrated and multisector manner, complying with the international commitments assumed by the country before the UNFCCC. The strategy sets out a vision to 2030 to enable Montenegro to adapt to the adverse effects and promote low-carbon sustainable development. The NCCS has a strong focus on harmonization with the EU climate change legislative framework.

The NCCS provides the necessary guidelines for climate mitigation and adaptation actions. The objectives of the strategy are also accompanied by different means of implementation: institutional strengthening and governance, education and training of actors, research on climate change and technological development, and financing.

[2] Recommendation of the Ministerial Council of the Energy Community 2018/01/MC-EnG on preparing for the development of integrated national energy and climate plans by the Contracting Parties of the Energy Community.

In order to give continuity and legitimacy to the efforts being developed within the framework of the NCCS and to ensure long-term commitments, a binding framework must be in place through legislative instruments. For this purpose, Montenegro adopted the Law on Protection against Climate Change in December 2019. The objective of the Law is the protection against the adverse effects of climate change, a reduction of greenhouse gas emissions, and protection of the ozone layer. The Government of Montenegro issued the new Decree on Issued Activities for GHG Emissions on 6 February 2020 and entered into force on 21 February 2020. This has brought Montenegro even closer to the EU climate change acquis. Adoption of the regulation was also one of the preconditions for negotiations under Chapter 27 – Environment and Climate Change – in the EU accession process.

The regulation establishes a regulatory framework to limit greenhouse gas emissions from industrial and energy plants in the country. In addition, it determines the operators participating in emission trading and determines the total amount and minimum price (€24/tCO_2) of the emission credits auctioned, the formation of a stabilization reserve, the method of recording the allocated emission credits, their transfer, and use, as well as the purpose of funds raised through the auction of emission credits. The funds will be transferred to the Eco Fund and used for environmental measures, support for renewable energy, and financing for innovation.

Montenegro also adopted the Law on Industrial Emissions in March 2019. Directive 2010/75/EU on industrial emissions (IED) is the main EU instrument regulating the emissions of pollutants from industrial plants. It has been fully transposed into the Montenegrin legislation, thanks to the adopted Law on Industrial Emissions, which was preceded by an analysis of compliance with national legislation.

The regulation establishes a regulatory framework to limit greenhouse gas emissions from industrial and energy plants in the country. In addition, it determines the operators participating in emission trading and determines the total amount and minimum price (€24/tCO_2) of the emission credits auctioned, the formation of a stabilization reserve, the method of recording the allocated emission credits, their transfer, and use, as well as the purpose of funds raised through the auction of emission credits. The funds will be transferred to the Eco Fund and used for environmental measures, support for renewable energy, and financing for innovation.

Montenegro also adopted the Law on Industrial Emissions in March 2019. Directive 2010/75/EU on industrial emissions (IED) is the main EU instrument regulating the emissions of pollutants from industrial plants. It has been fully transposed into the Montenegrin legislation, thanks to the adopted Law on Industrial Emissions, which was preceded by an analysis of compliance with national legislation.

Additional climate-related national policies and strategies in Montenegro include:

The National Strategy of Sustainable Development to 2030 (NSSD) was prepared in 2016. Based on the principles outlined above, the NSSD defines objectives that can be grouped into several priority areas such as: (1) better management of water resources and demand; (2) improved rational use of energy, increased use from renewable sources, and mitigation of adaptation to climate change; (3) sustainable mobility through appropriate transport measures; (4) sustainable tourism as a leading economic sector; (5) sustainable agriculture and rural development; (6) sustainable urban development; and (7) sustainable management of marine, coastal, and marina resources.

The National Strategy with Action Plan for Transposition Implementation and Enforcement of the EU Acquis on the Environment and Climate Change 2016–2020 (NEAS). As key strategic document, climate change issues are articulated throughout the NSSD. The NSSD also introduced the concept of resource efficiency and the need for a circular economy. These concepts are considered a significant contribution to the achievement of climate change policy goals. NEAS is a critical aspect of establishing the necessary actions to meet the EU's climate change requirements and the costs of full alignment with the EU's environmental and climate change requirements. It also provides a baseline against which the government determines its progress.

The National Forest Strategy (NSS) recognizes that forests can contribute to combating, mitigating, and adapting to climate change, as they generate about 4.6 million tonnes of CO2 per year from the atmosphere. The NSS recognizes climate change as an important factor affecting national forest protection measures. Accordingly, analysis estimates that climate change poses the greatest threat to Montenegrin forests that can increase the risk of droughts, fires, and biodiversity pests. The NSS recognizes an increase in such threats in the coming period and provides guidelines and actions to protect forests from extreme droughts and fires, forest management plans, and management programmes to increase the resilience of forest ecosystems.

The Smart Specialization Strategy (S3) (2019–2023) is a national innovation strategy that sets development priorities, aiming to build a competitive advantage by connecting its own strengths in research and innovation with the needs of the economy, responding coherently to growing opportunities and market development, thus avoiding overlapping and fragmenting policies.

The strategy's priorities are:

- energy and a sustainable environment
- sustainable agriculture and food value chain
- sustainable and health tourism
- ICT (information and communication technologies).

INSTITUTIONAL FRAMEWORK FOR CLIMATE CHANGE

The Ministry of Sustainable Development and Tourism (MSDT) is the main national entity responsible for national environmental and climate change policy and the National Focal Point to the UNFCCC.

Montenegro has also established a high-level multi-institutional council, chaired by the President of Montenegro, which focuses on sustainable development. The council was established by the Government in 2008, marking a positive development in inter-institutional coordination and cooperation. The council's 2013 reform strengthened its mandate in the field of climate change, as a strategic priority of the Government towards the creation of a low-carbon society. In 2016, this became the National Council for Sustainable Development, Climate Change, and Coastal Area Management (NCSDCCCAM).

Table 2.10 summarizes the key institutions and their responsibilities in climate change management in Montenegro. Additional details on the responsibilities for measurement, reporting, and verification (MRV) are included in an Annex.

TABLE 2.10:
Institutions responsible for climate change management in Montenegro

ORGANIZATION	ACRONYM	RESPONSIBILITIES
Ministry for Sustainable Development and Tourism (Climate Change Division of the Climate Change and Mediterranean Affairs Directorate)	**MSDT**	In charge of climate policy adoption, implementation and monitoring. The Climate Change Division is a focal point for the UNFCCC and the Green Climate Fund (GCF). It also deals with waste as a part of its remit.
Agency for Nature and Environmental Protection	**EPA**	Works under the MSDT and has an important role in inventorying GHG emissions.
Institute of Hydrometeorology and Seismology	**IHMS**	The Institute of Hydrometeorology and Seismology is a state administration body, with numerous competencies in the field of meteorology, climatology, hydrology, hydrography, oceanography, and seismology. The Institute takes care of the establishment, development, and work of the meteorological and hydrological observation and forecasting stations on the entire territory of Montenegro. The Institute is also the contact institution for the Intergovernmental Panel on Climate Change (IPCC).
Environment Protection Fund	**Eco Fund**	It was established by the Decision of the Government of Montenegro (22 November 2018) on the basis of Article 76 of the Law on Environment with the aim of providing funds for financing environmental protection and respect for the basic right of citizens to a clean and healthy environment.
Ministry of the Economy	**MoE**	In charge of energy and industrial policy. Additional possibilities in CC mitigation also exist.

Ministry of Agriculture and Rural Development	MARD	In charge of agricultural and forestry policy. Additional possibilities in CC mitigation also exist.
Ministry of Transport and Maritime Affairs	MTMA	Important role in CC policy making.
Ministry of Internal Affairs (Directorate for Emergencies)	MIA	Important role in CC policy making.
National Council for Sustainable Development, Climate Change and Integral Coastal Zone Management	NCSDCCICM	Responsible for monitoring development and implementing national sustainable development and CC policies. Also involved in planning, alignment of development policies for sustainable development and CC requirements, and the implementation of EU sustainable development frameworks under the Energy and Climate Package.
Mitigation and Adaptation Working Group	MAWG	Offers support and guidance for the national climate policy to implement mitigation, i.e. emissions reduction, and adaptation measures to adverse CC impacts. The working group is an inter- governmental body composed of the representatives of all relevant authorities, civil society, business alliances, and academia.

During the preparation of the Second Biennial Updated Report (SBUR), a concept was developed to establish a National Monitoring, Reporting, and Verification System (MRV). Figure 2.12 highlights the key institutional arrangements for the MRV system being developed by Montenegro.

The structure of the national MRV system includes:

- **A steering committee** contributing to the prioritization of activities within the MRV system and its outputs. The proposed steering committee will be linked with or will form part of the NCSDCCICM (National Council).
- **The management and coordination of the MRV system** will be led by the Directorate for Climate Change (DCC) within the MSDT.
- **Defined focal points coordinating data gathering, analysis, and reporting** across adaptation, mitigation, and climate finance/support.
- **Specific data gathering and compilation expertise** within a range of specialist organizations. Expert organizations and experts are engaged in the relevant sectors according to their areas of existing expertise (e.g. energy systems, buildings and infrastructure, industry and manufacturing, transport, land use and forestry, and agriculture) and cross-cutting activities, such as the GHG inventory and projections, disaster-risk reduction, climate monitoring and the tracking of climate data, and support for climate action. These experts will be trained in the gathering, processing, and preparation of reports and datasets for the MRV system for the MSDT.

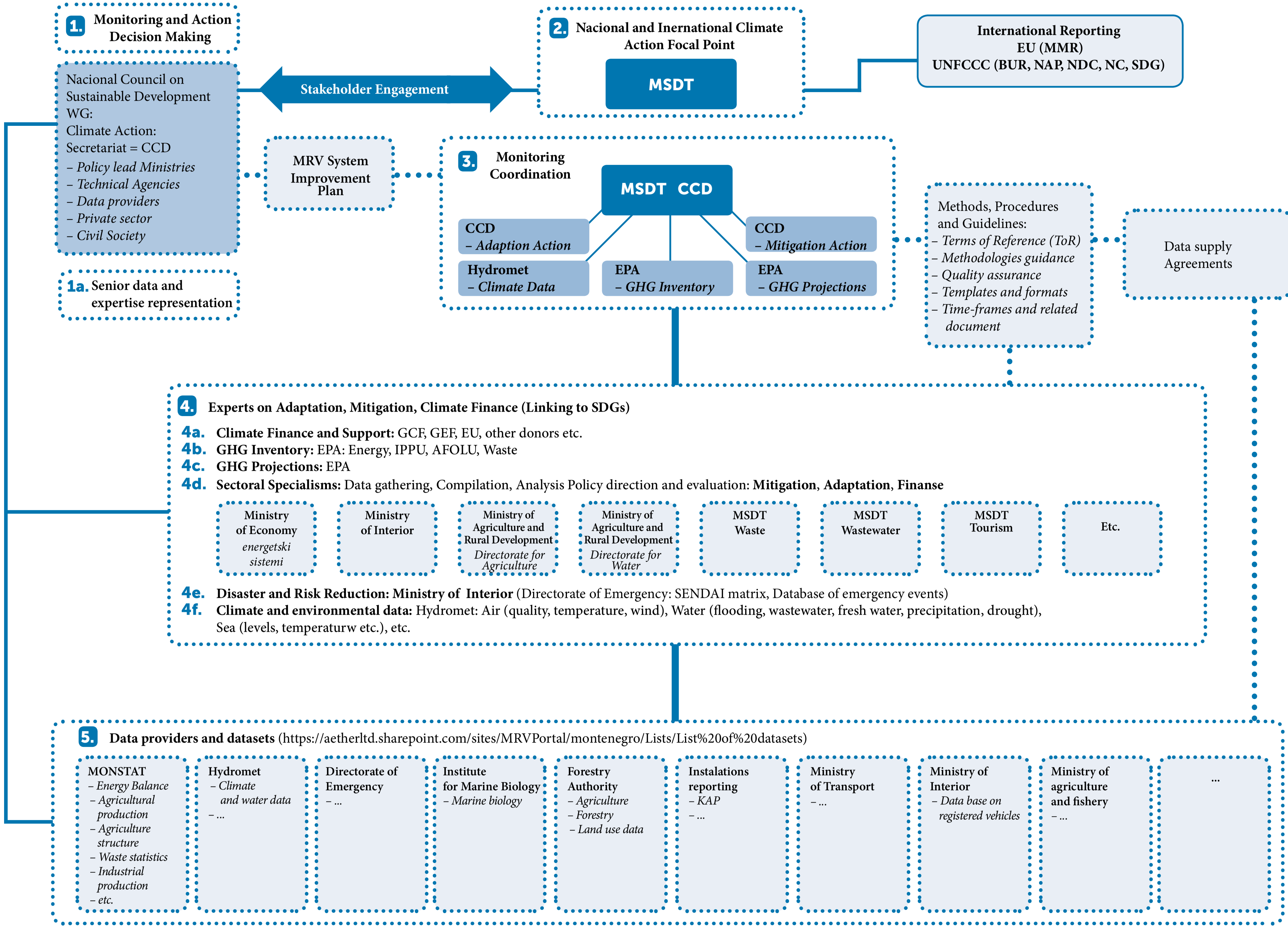


FIGURE 2.12 Proposed institutional arrangements for an MRV system in Montenegro

2.9 Gender equality and climate change

Women and men are affected differently by climate change and are differently prepared to adapt to climate change. This is due to underlying inequality in socio-economic status, influenced by three factors: 1) The degree of equality of rights of women and men in national legislation; 2) The degree of law enforcement; 3) The tradition and customs that define the role of men and women in society (so-called "gender roles").

Countries can successfully address climate change risks only if they recognize the different perspectives, impacts, and interests of women and men in sector-level policies relevant to climate change (e.g. energy, transport, agriculture, tourism, and forestry). Additionally, so-called "horizontal policies" concerning human rights and gender equality are of key importance.

CURRENT SITUATION

In 2017, UNDP, in collaboration with the Ministry of Sustainable Development and Tourism, began organizing activities to prepare the Second Biennial National Report (SBUR) and the Third National Communication (TNC). Within the SBUR, a study entitled "Women and Climate Change in Montenegro" was prepared, presenting the existing gender-disaggregated statistics.

The results of the analysis show that there is a substantial gender gap in local and national decision making across the government. In the Parliament of Montenegro, 19 out of 81 MPs are women (23.5%), while in local parliaments, women make up 25.5% of the councillors. Men tend to hold the key positions at the both national and local levels (speaker of the parliament, the deputy speakers, the presidents of local councils and their deputies). In the working bodies of the National Parliament currently 13.79% of the members are women[3]. Three committees are chaired by women – the Legislative Committee, the Gender Equality Committee, and the Anti-Corruption Committee[4]. When it comes to the executive branch, in the national government, men currently occupy the positions of prime minister and all three deputy prime ministers, and only four out of 21 ministers are women (21%)[5]. At the local level, three out of the 23 mayors (13%) are women[6]. In general, there is also a substantial gender gap among the occupations of legislators, officials, and managers. Accordingly, only 22.0% of legislators, officials, and managers are women.[7]

[3] The Parliament has 15 working bodies, of which 14 are committees and one is a commission.
[4] Report on Implementation of the Action Plan for Chapter 23 for 2016, Parliament of Montenegro, 2017, http://www.skupstina. me/images/dokumenti/plan-zakonodavnog rada/Izvje%C5%A1taj_o_sprovodjenju_Akcionog_plana_za_2016._godinu.pdf.
[5] The Minister of Science, Minister of the Economy, Minister of Public Administration, and Minister without Portfolio. This is for the government that was established after the parliamentary elections held on October 2016.
[6] The Municipalities of Gusinje, Kolašin, Tivat, and Šavnik.
[7] Women and Men in Montenegro, 2016, page 98, MONSTAT and Ministry of Human and Minority Rights http://www. monstat.org/userfiles/file/publikacije/ZENE%20I%20MUSKARCI%20U%20CRNOJ%20GORI%20-%202016%20 za%20STAMPU.pdf (accessed on 19 July 2017).

INTERNATIONAL AND NATIONAL POLICIES ON GENDER AND CLIMATE CHANGE

Montenegro has ratified international treaties, such as the UN Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) and the United Nations' Framework Convention on Climate Change (UNFCC), which promote a gender-sensitive approach and encourage the signatory countries to mainstream gender into national sustainable development and climate change policies.

Montenegro is a parliamentary democracy where gender equality is recognized in its legal and policy framework as one of the main principles.

The **Constitution of Montenegro** (2007) proclaims the equality of all citizens as one of its main principles and provides the opportunity for the introduction of special measures for achieving overall equality, including equality between women and men.

The **Anti-Discrimination Law** (adopted in 2010, amended in 2011, 2014, and 2017) and the **Law on Gender Equality** (adopted in 2007 and amended in 2010, 2011, and 2015), which is accompanied by the **Action Plan for Gender Equality** (2007–2010, 2011–2016, and 2017–2021), lay the foundation for legal and institutional protection from gender-based discrimination. The national laws and strategies that recognize the importance of gender equality in policies related to climate change include the following:

- National Strategy for Sustainable Development until 2030, which includes the measure related to Sustainable Development Goal No. 5 – "Eliminate gender discrimination";
- Strategy for Development of Agriculture and Rural Areas 2015–2020;
- National Strategy on Women's Entrepreneurship (2015–2020), which could be fully implemented in all climate change policies that are related to economic activities, entrepreneurship, and equal distribution of economic power and resources,
- A gender-sensitive approach is declared as one of the leading principles of the National Climate Change Strategy to 2030, but gender sensitivity is not integrated into the objectives and measures of the Strategy and its Action Plan.

In Montenegro, gender equality is recognized as an important aspect of the Sustainable Development Strategy and two sectoral policies - agriculture and entrepreneurship, so additional efforts are needed to integrate gender equality into other sectoral policies relevant to climate change (such as energy, water management, forestry, tourism, transport, etc).

The National Strategy for Climate Change to 2030 considers a gender-sensitive approach important for addressing climate change but has not elaborated it further in the objectives or the Action Plan. In December 2019, the Law on Protection against Climate Change was adopted, which did not highlight the gender aspect. This law envisages the adoption of two strategic documents that will practically replace the current National Strategy on Climate Change. It is of utmost importance that in the process of drafting these two strategic documents, the gender aspect is taken into account and incorporated horizontally across all objectives. Article 9 of the Law on Protection against Climate Change (2019) calls for the adoption of a 10-year Climate Change Adaptation Plan. This plan provides an opportunity for integrating gender aspects.

Gender mainstreaming in climate change actions in Montenegro

Gender mainstreaming in Montenegro's climate-related policies and actions is an important prerequisite for ensuring effective outcomes. Gender mainstreaming can be achieved through awareness-raising and gender-sensitive reporting on climate change.

When it comes to reporting, the process of developing the Second Biennial Climate Change Report (SBUR) has involved the development of the concept of a national monitoring, reporting, and verification (MRV) system. An MRV portal has also been set up to share the most important information on current climate change activities and projects, which will include up-to-date information on gender equality.

In 2017, Montenegro was included in a regional programme to support gender mainstreaming in the MRV, implemented by the United Nations Global Programme for Support, along with Albania, Bosnia and Herzegovina, Lebanon, North Macedonia, and Serbia. Under the programme, which lasted until February 2020, three regional workshops were held, attended by representatives of national gender equality and climate change institutions, as well as representatives of the UNFCCC and UNDP national offices. The workshops discussed various aspects of the impact of climate change on women and men, as well as vulnerable social groups, and exchanged experiences and good practices between participating countries. The Global Programme has also provided expert support to countries to incorporate gender into the MRV.

In Montenegro, this programme raised the level of knowledge and understanding of the correlation between gender and climate change, and fostered the development of closer cooperation between the Ministry of Human and Minority Rights (which coordinates gender equality policies) and the Ministry of Sustainable Development and Tourism, which resulted in the drafting of the Action Plan for the gender mainstreaming agenda. Also, in collaboration with UNDP, the Ministry of Sustainable Development and Tourism organized meetings, presentations, and national consultations with relevant stakeholders (civil society institutions and organizations) to exchange information and improve understanding of the gender perspective in the national climate change context.

The draft Action Plan is a working document that has not been formally adopted. Its value is that it has been done in collaboration with two relevant institutions, which could usefully serve as a basis for future strategic planning on the gender dimension of climate change.

Montenegro should consider the enabling factors for enhancing the efforts on mainstreaming gender in climate change. Enabling factors and potential actions include:

- **Gender equality in policy making:** Engagement of an equal number of women and men in policy making, decision making, and the implementation of climate change measures, considering differentiated vulnerability and adaptive capacity;

- **Gender-differentiated statistics:** Collect and document gender-disaggregated statistics, as a basis for planning of gender-sensitive programmes and projects, and as an instrument for monitoring their implementation

- **Institutional capacities:** Build the capacities of institutions as well as the capacities of civil society organizations to create and implement gender-sensitive programmes and projects at all levels

- **Conduct public outreach and education campaigns:** Raise awareness of the impact of climate change on different social groups and encourage action to help develop civic awareness and solidarity in adapting to and mitigating climate change.

- **Strengthen institutional mechanisms**: Enhance gender-sensitive mechanisms through the National Council for Sustainable Development, Climate Change and Coastal Zone Management, to mainstream gender into all climate change policies.

INVENTORY OF GREENHOUSE GASES

3

Montenegro is a non-Annex-B country for the Kyoto Protocol (2007) and a signatory country to the Paris Agreement (2017), pledging to contribute to reducing greenhouse gas emissions globally. Montenegro has pledged to reduce GHG emissions by at least 1,572 kt CO_2eq, to 3,667 kt CO_2eq or less. Montenegro's contribution to the efforts of the international community in the fight against climate change, expressed through the Intended Nationally Determined Contribution to GHG Reduction, is at least 30% by 2030 compared to the 1990 baseline level.

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

Results of National Inventory report are used for the purpose of this report. The report provides data on the preparation of the inventory of GHGs for the years 2016 and 2017 and the recalculation of the inventory time series for the period 1990–2015. It was implemented using the 2006 Intergovernmental Panel on Climate Change (IPCC) methodology[8], while the Intergovernmental Panel on Climate Change (Ver. 2.69) software was used to calculate emissions.

The plan for ensuring and quality control in the preparation of the inventory of greenhouse gases is prescribed by the Rulebook on the Manner of Preparation and Content of the Inventory of Greenhouse Gas Emissions (Official Gazette of Montenegro, No. 66/17). This ordinance provides for an outline of data quality control procedures, as well as methods for archiving the inventory and the supporting material and documentation.

In accordance with the Regulation on the Monitoring of Greenhouse Gases No. 525/2013, of the European Union, whose transposition into the national legislation is in progress, regulates the quality control procedures. In the future, it is envisaged to define the Reliability Control Plan as well as the Quality Control.

For the purpose of quality assurance (QA) of the report, an auditor for national GHG inventories was commissioned, with the support of the UNDP–UNEP Global Support Programme (GSP). The compliance of the NIR with the recommendations of UNFCCC Decisions 17/CP.8

[8] 2006 IPCC Guidelines for National Greenhouse Gas Inventories with Vol. 1 GGR, Vol. 2 Energy, Vol. 3 IPPU, Vol.4 AFOLU, Vol. 5 Waste, 11th Corrigenda for the 2006 IPCC Guidelines.

Annex, UNFCCC Decisions 2/CP.17 Annex III and the advice of the IPCC Guidelines for GHG Inventory Design, which will be an integral part of the National Communications and Biennial Reports for non-Annex Members, has been examined.

All recommendations of the audit report have been taken into account and, in accordance with the real circumstances, have been applied in the final version of this report. This activity has contributed to a significant improvement in the knowledge of the inventory and NIR team as well as the quality of this report.

Following the recommendations of the IPCC Guidelines, inventory verification was performed through a series of simple completeness and accuracy checks, including arithmetical errors, comparisons of national statistics with international statistics, and verification of estimated carbon dioxide emissions from the energy sector, comparing the results obtained using the Sector and Reference approaches.

The GHG emissions inventory included the calculation of emissions of the following direct greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrogen suboxide (N_2O), and synthetic gases (PFC, HFCs and SF_6).

The sources and sinks of emissions of direct and indirect GHG are divided into six main categories:

1. Energy
2. Industrial processes
3. Use of solvents
4. Agriculture
5. Land use change and forestry
6. Waste

This report has been prepared in accordance with the guidelines of the UNFCCC for the reporting of annual inventories, as adopted by Decision 18/CP.8COP (Conference of Parties). In line with the IPCC guidelines, national emission factors were used where possible (in certain activities of the energy, industry, agriculture, and forestry sectors), thereby increasing the accuracy of the calculated emissions. For other activities representing sources of GHG emissions, the recommended (default) emission factor values were used.

3.2 Greenhouse gas emissions by gases

TOTAL CO_2eq EMISSIONS

This section describes total GHG emissions expressed as carbon dioxide equivalents (CO_2eq). GHG emissions are expressed as CO_2eq in line with the guidance provided in the Intergovernmental Panel for Climate Change – Fourth Assessment Report (IPCC AR4).

TABLE 3.1:
GHG emissions expressed as CO_2eq.

	CO_2	CH_4	N_2O	CF_4	C_2F_6	SF_6	HFC23
CO_2eq	1	25	298	7,390	12,200	22,800	14,800
	HFC125	HFC134	HFC134a	HFC152a	HFC227ea	HFC236fa	HFC4310mee
CO_2eq	3,500	1,430	4,470	124	3,220	63,009,810	1,640

Table 3.2 shows the total GHG emissions, expressed as CO_2eq for the period 1990–2017. Table 3.3 shows the GHG emissions sinks for the same period. The total sink emissions range from 1,581.97 Gg CO_2eq in 2009 to 8,738.24 Gg in 2011 due to large burned areas. According to the latest data on logging and fires in the forest area, a recalculation of the entire time series with additional years for 2016 and 2017 has been made and the results indicate a much lower sink potential than is shown in previous calculations.

The total GHG emissions (excluding emission sinks) reported as CO_2eq were highest in 2011 accounting for 8,738.24 Gg, however they were estimated at almost half this in 2017 – 4,936.81 Gg.

TABLE 3.2:
Total GHG emissions expressed in CO_2eq by sector, 1990–2017 (Gg)

YEAR	Energy (Gg CO_2eq)	Industrial processes (Gg CO_2eq)	Agriculture and land use emission sinks (Gg CO_2eq)	Waste (Gg CO_2eq)	Total emissions with sinks (Gg CO_2eq)	Total emissions without sinks (Gg CO_2eq)
1990	2339.68	1701.52	2472.79	171.19	6685.19	6685.19
1991	2444.46	2201.73	1453.88	175.82	6275.89	6275.89
1992	1794.19	1419.86	2303.05	180.52	5697.62	5697.62
1993	1584.79	533.21	1203.55	185.31	3506.87	3506.87
1994	1419.06	132.40	1330.46	190.15	3072.07	3072.07
1995	814.48	446.86	1834.27	195.70	3291.31	3291.31
1996	1832.32	996.14	1338.93	201.84	4369.22	4369.22
1997	1843.21	1530.39	–266.26	208.52	2392.62	3315.85
1998	2254.84	1165.56	–583.71	215.36	1821.33	3052.04

1999	2327.80	1220.72	–426.59	222.32	2261.88	3344.24
2000	2421.79	1576.60	1588.02	234.18	5820.60	5820.60
2001	2010.31	1657.07	–533.44	240.40	2206.27	3374.33
2002	2537.18	1609.65	–212.44	245.77	3326.45	4180.16
2003	2412.51	1378.58	179.33	250.43	3752.91	4220.86
2004	2399.89	1271.25	149.94	254.33	3606.49	4075.40
2005	2189.64	1165.84	192.25	257.36	3559.30	3805.09
2006	2335.91	1284.09	788.63	259.59	4668.21	4668.21
2007	2278.46	1400.69	1618.05	264.46	5561.65	5561.65
2008	2891.20	1547.25	586.02	268.10	5292.57	5292.57
2009	1958.93	585.63	–456.42	269.16	1581.97	2357.30
2010	2711.73	776.97	129.80	271.83	3703.46	3890.33
2011	2752.40	734.21	4975.69	275.94	8738.24	8738.24
2012	2667.07	522.11	1584.27	271.67	5045.13	5045.13
2013	2400.73	385.11	635.48	269.46	3690.79	3690.79
2014	2304.51	364.24	353.71	268.24	3290.70	3290.70
2015	2455.69	355.35	720.21	266.40	3797.65	3797.65
2016	2265.80	335.13	664.42	264.86	3530.22	3530.22
2017	2370.32	351.42	1961.18	253.89	4936.81	4936.81

TABLE 3.3:
GHG emission sinks in CO_2eq, 1990–2017 (Gg)

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Sink emissions (Gg)	/	/	/	/	/	/	/	923.23	1230.71	1082.37	/
YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sink emissions (Gg)	/	1168.06	853.71	467.94	468.91	245.79	/	/	/	775.34	186.87
YEAR	2011	2012	2013	2014	2015	2016	2017				
Sink emissions (Gg)	/	/	/	/	/	/					

Figure 3.1 and Figure 3.2 show the net GHG emissions expressed as CO_2eq over the period 1990–2017. Figure 3.1 shows the total emissions with sinks, while Figure 3.2 shows the emissions without sinks.

The total sink emissions range from 1,581.97 Gg CO_2eq in 2009 to 8,738.24 Gg in 2011 due to large burned areas. According to the latest data on logging and fires in the forest areas, a recalculation of the entire time series with additional years for 2016 and 2017 has been made and the results indicate a much lower sink potential than shown in previous calculations.

Figure 3.3 shows CO_2eq emissions by sector for the period 1990–2017.

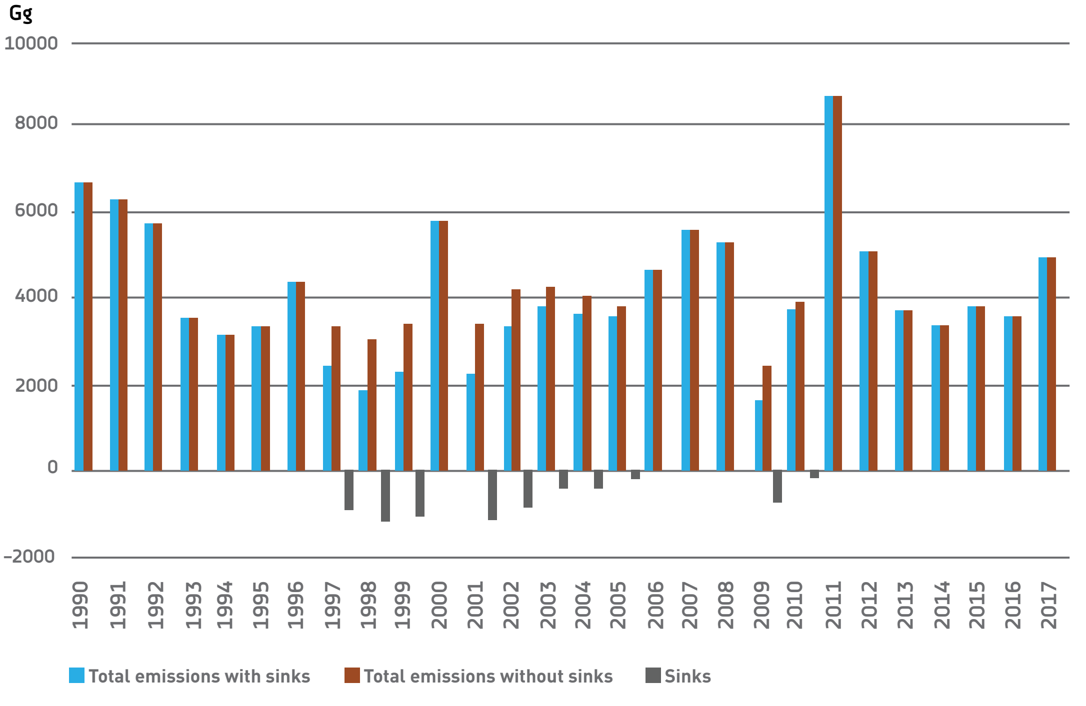


FIGURE 3.1 Total GHG emissions expressed as CO_2eq with sinks for 1990–2017

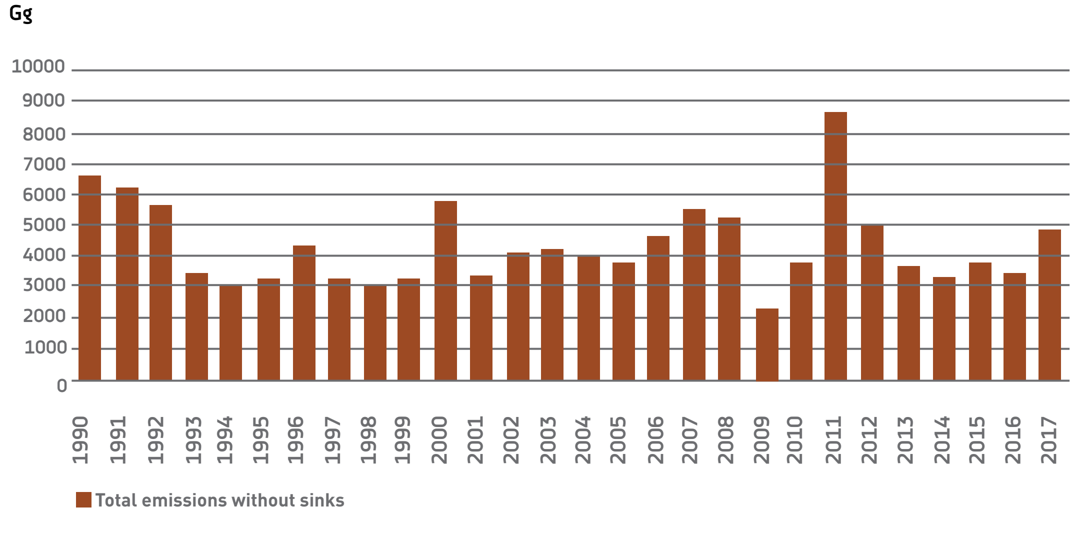


FIGURE 3.2 Total GHG emissions expressed as CO_2eq without sinks for 1990–2017

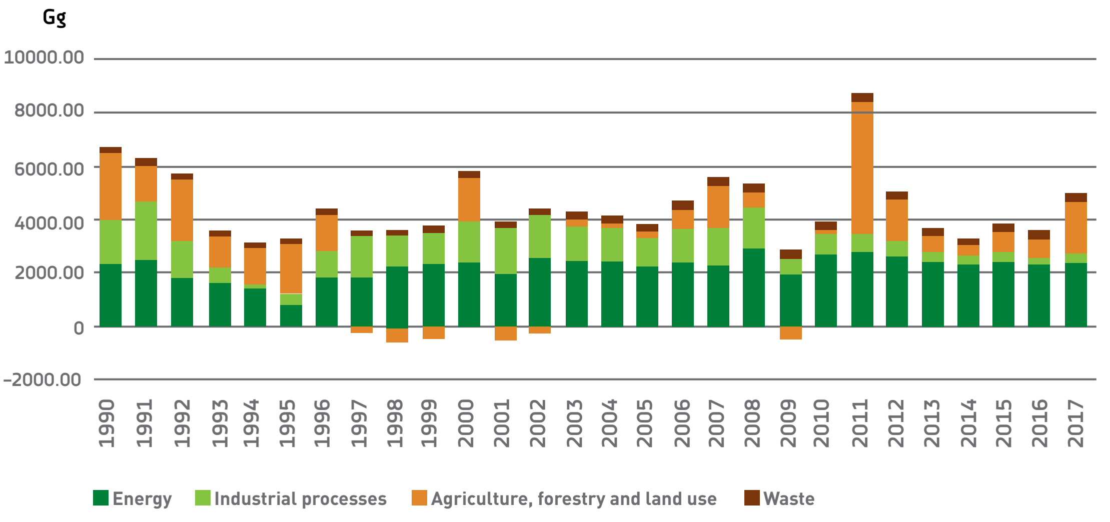


FIGURE 3.3 GHG emissions expressed as CO_2eq by sectors for 1990–2017

As shown in Figure 3.4, the energy and industrial sectors account for the largest share of total CO_2eq emissions for the observed period, with the exception of 2011, when high emissions from the forestry and land use sectors are recorded due to forest fires over a large area.

The share of emissions from the energy sector ranges from 24% in 1995 to 70% in 2014 and for 2017 it is 48.1%. The share of industrial process emissions ranges from 4.3% in 1994 to 46% in 1997 and in 2017 it is 7%. CO_2eq emissions from the agricultural sector range from 6.2% in 2004 to 57% in 2011 and in 2017 it is 39%. The waste sector has the lowest share of total emissions and ranges from 2% in 1991 to 11% in 2009 and for 2017 it is 5%.

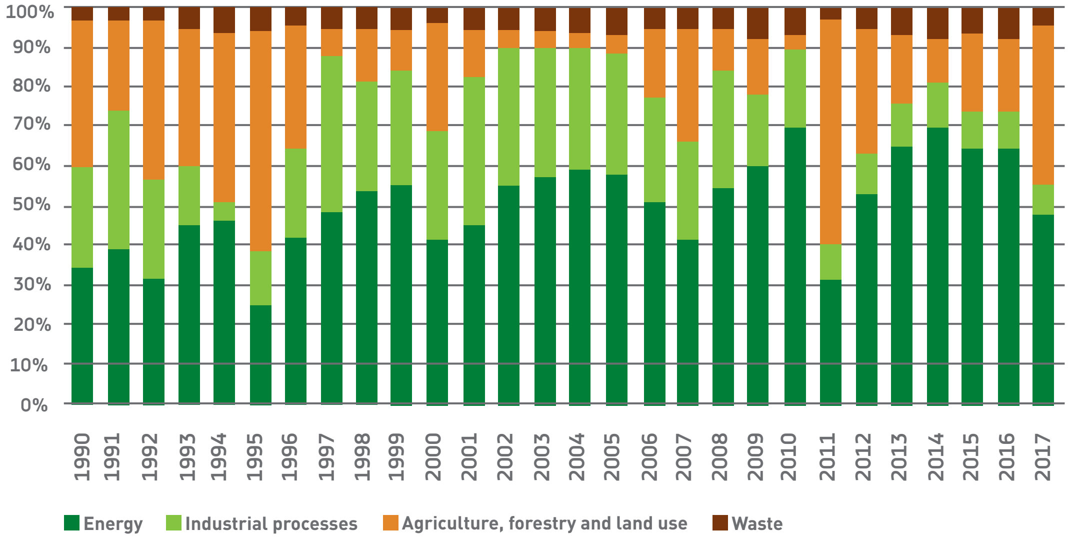


FIGURE 3.4 Sector-based share of GHG emissions in CO_2eq, 1990–2017 (%)

As shown in Table 3.4 and Figure 3.5, the largest share of total GHG emissions is CO_2 (28%–84%), followed by PFC (CF_4 and C_2F_6) with less than 3% to 42%, the share of CH_4 ranged from 7.80% to 26% and N_2O content ranged from 2% to 5%. SF_6 had the lowest share within total emissions, ranging from 0.01% to 0.07%. Based on the data available during the inventory recalculation, HFC emissions (2011, 2012, 2013, 2014, and 2015) and automatic updating of the 2006 IPCC tool for the 1990–2010 series were estimated for use of products from the subsector 2F as substitutes for ozone-depleting substances only (2F1 – refrigeration and air-conditioning).

TABLE 3.4:
Total GHG emissions expressed as CO_2eq, 1990–2015 (Gg)

YEAR	CO_2	CH_4 CO_2eq	N_2O-CO_2eq	PFC – CO_2eq	SF_6 CO_2eq	HFC – CO_2eq	TOTAL
1990	4183.85	835.80	176.85	1487.90	0.78	0.00	6685.19
1991	3280.41	823.27	176.06	1994.03	0.78	1.33	6275.89
1992	3487.20	796.29	167.01	1242.55	0.78	3.79	5697.62
1993	2093.29	794.79	157.13	453.66	0.78	7.22	3506.87
1994	2027.06	784.82	156.81	91.12	0.78	11.48	3072.07
1995	1945.52	818.19	165.94	344.41	0.78	16.46	3291.31
1996	2484.40	814.93	167.79	879.26	0.78	22.06	4369.22
1997	974.90	798.15	160.15	1353.69	0.78	28.19	3315.85
1998	1073.63	799.06	155.93	987.79	0.84	34.79	3052.04
1999	1293.62	810.55	164.31	1033.13	0.84	41.79	3344.24
2000	3419.58	816.03	175.91	1359.01	0.92	49.15	5820.60
2001	954.91	792.96	163.53	1405.18	0.92	56.82	3374.33
2002	1760.54	850.97	162.68	1340.23	0.97	64.78	4180.16
2003	2043.91	831.87	172.23	1098.73	1.15	72.98	4220.86
2004	2037.93	818.18	163.87	972.68	1.33	81.40	4075.40
2005	2050.42	672.11	123.16	867.59	1.43	90.37	3805.09
2006	2798.25	671.07	131.25	966.34	1.49	99.82	4668.21
2007	3565.55	667.79	146.93	1070.21	1.49	109.68	5561.65
2008	3162.05	657.32	128.90	1222.86	1.52	119.92	5292.57
2009	1198.97	578.61	108.21	339.50	1.54	130.48	2357.30
2010	2539.19	599.75	111.97	496.54	1.55	141.32	3890.33
2011	7307.61	678.14	175.97	422.51	1.60	152.42	8738.24
2012	3906.89	617.00	121.43	223.03	2.00	174.77	5045.13
2013	2658.82	612.04	114.76	115.26	2.19	187.74	3690.79
2014	2270.43	620.98	109.63	86.60	2.23	200.85	3290.70
2015	2780.03	620.28	118.05	71.80	2.23	205.27	3797.65
2016	2515.29	619.51	122.42	45.40	2.52	225.08	3530.22
2017	3922.01	625.28	105.40	45.22	2.99	235.91	4936.81

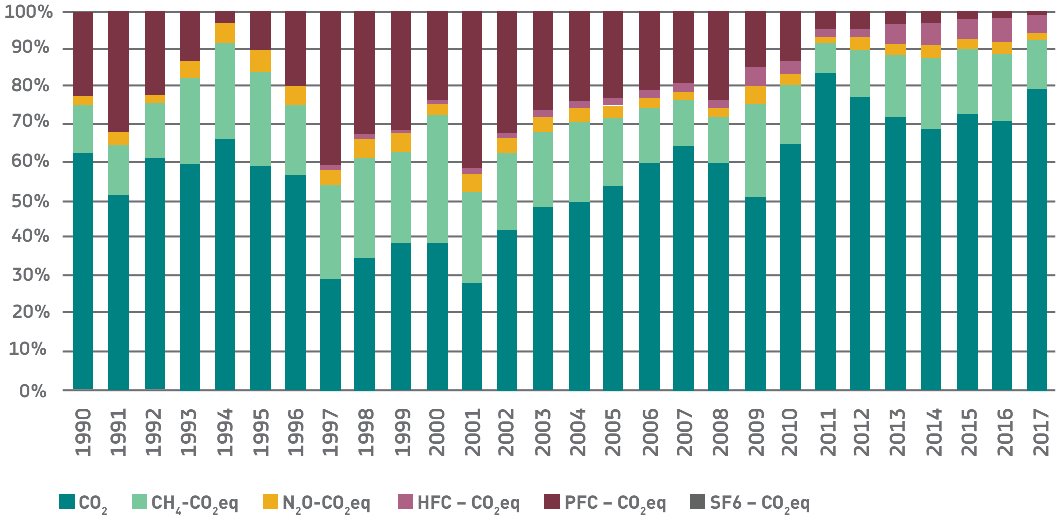


FIGURE 3.5 **Share of GHG emissions within total CO_2eq emissions, 1990–2017**

TOTAL CO_2 EMISSIONS

Figure 3.6 shows the total CO_2 emissions. In the observed period, the largest share of total CO_2 emissions was in the energy sector (37%–97%), the industrial sector participated with 3%–20%, while the agriculture sector, i.e. the forestry and land use sector, contributed with 0.2%–47%.

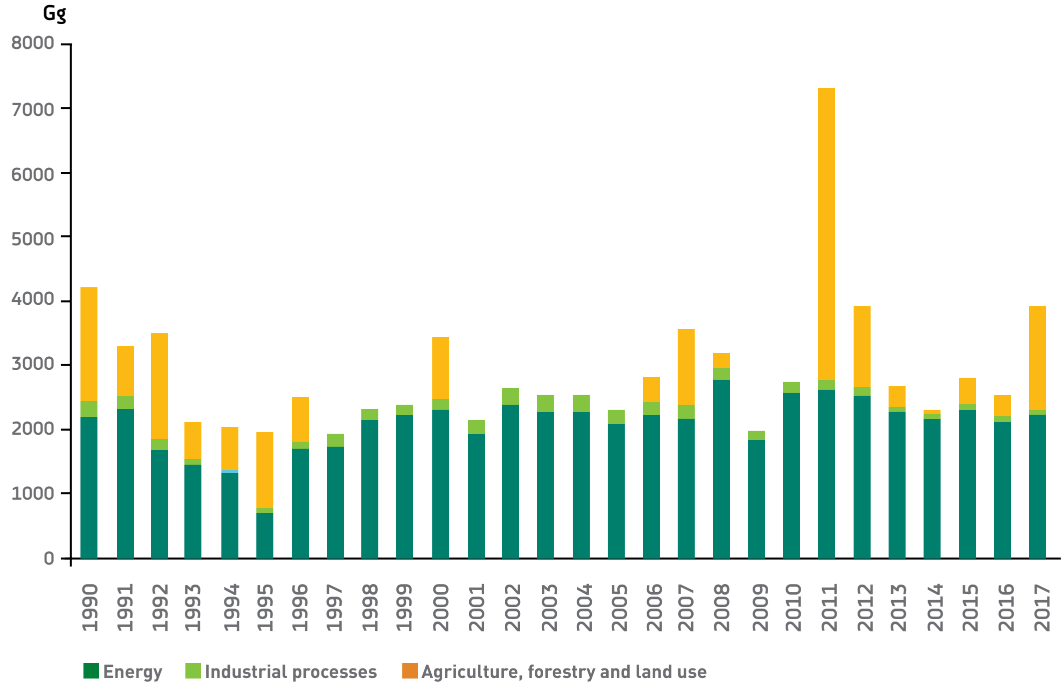


FIGURE 3.6 **Total CO_2 emissions by sector, 1990–2017**

TOTAL CH_4 EMISSIONS

Figure 3.7 shows the total CH_4 emissions. Over the reporting period, the largest share of CH_4 emissions stems from the agricultural sector (40%–69%), with energy accounting for 8%–17%, and waste for 19%–44%.

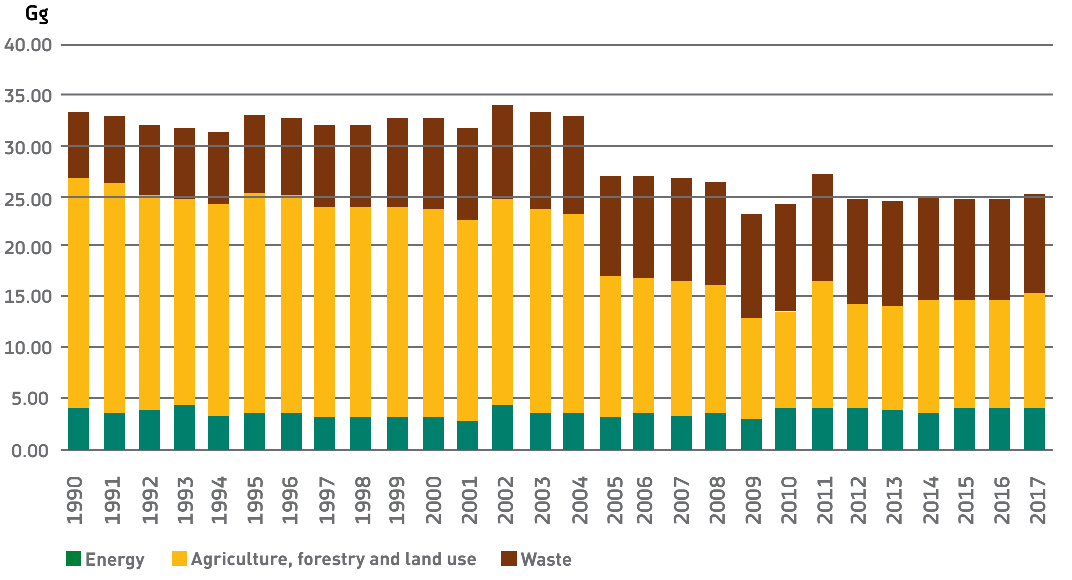


FIGURE 3.7 Total CH_4 emissions by sector for 1990–2017

TOTAL N_2O EMISSIONS

Figure 3 8 shows total N_2O emissions. In the observed period, the largest share of total N_2O emissions was in the agricultural sector (63%–87%), followed by the energy sector with 7%–24%, and the waste sector with 5.5%–13%.

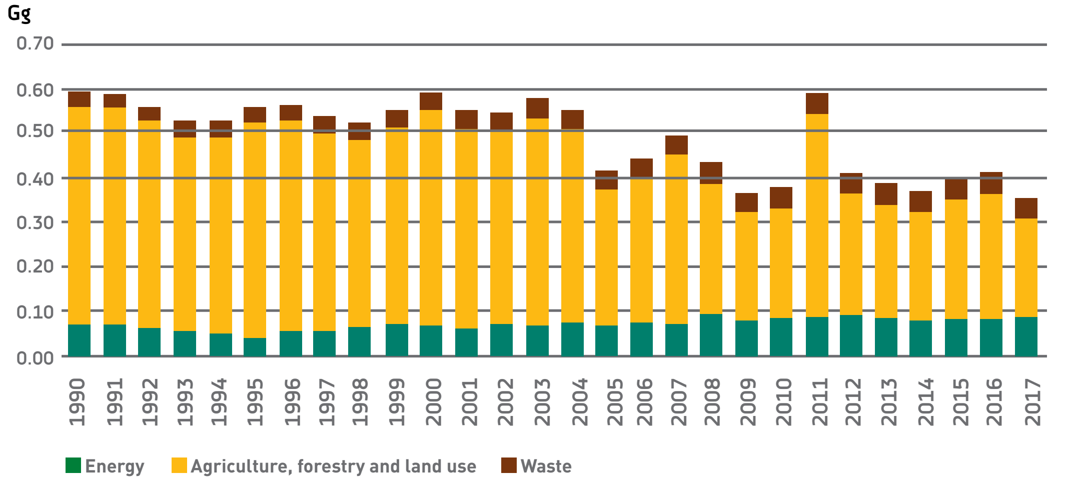


FIGURE 3.8 Total N_2O emissions by sector for 1990–2017

TOTAL PFC EMISSIONS

According to the data available for the reporting period, the emissions of PFCs (CF_4 and C_2F_6) from industrial processes, i.e. aluminium production and electrolysis plants, were estimated (Figure 3.9). For 2017 the emissions were 45 Gg.

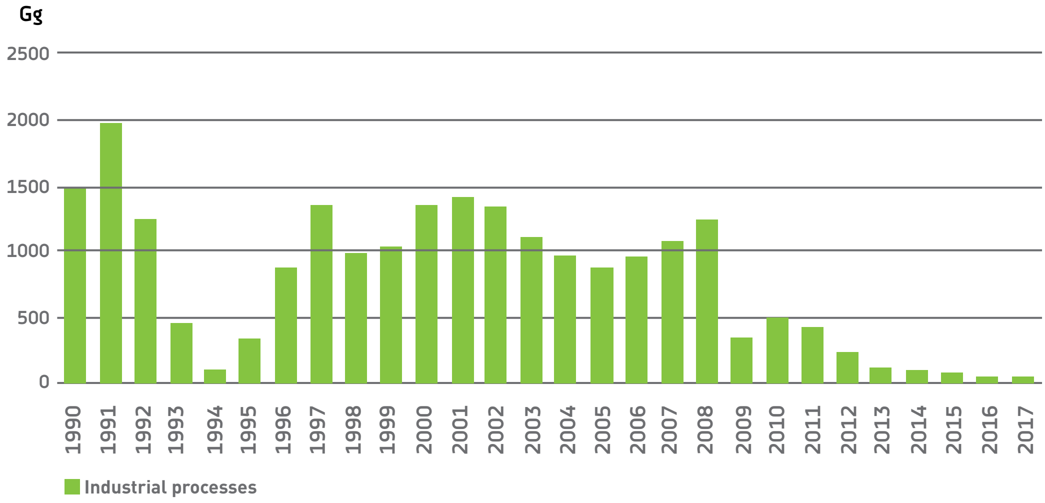


FIGURE 3.9 Total PFC emissions from industrial processes for 1990–2017

TOTAL SF_6 EMISSIONS

According to the data available for the reporting period, SF_6 emissions from the subsector 2G – manufacture and use of other products (2G1 – electrical equipment) were calculated (Figure 3.10).

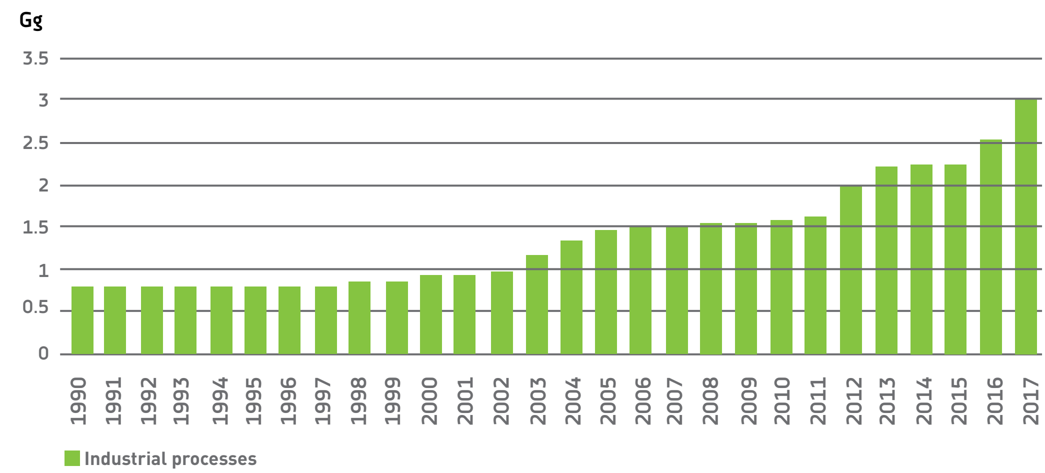


FIGURE 3.10 Total SF_6 emissions from industrial processes for 1990–2017

TOTAL HFC EMISSIONS

Data to assess the total emissions of HFCs was available for the period 2011–2013. Estimates were made for the use of products in the subsector 2F, substitutes for ozone-depleting substances, i.e. activity 2F1 – refrigeration and air-conditioning (Figure 3.11).

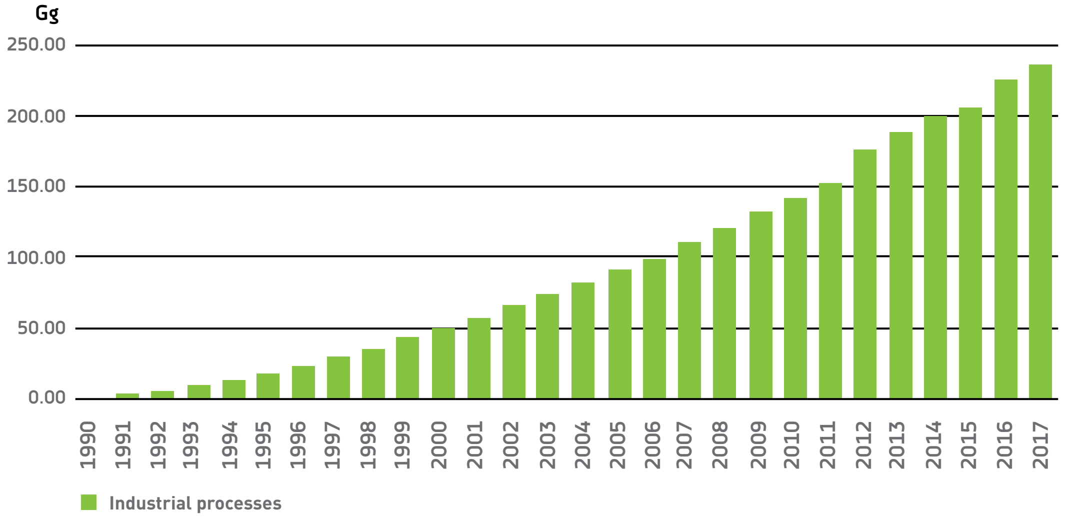


FIGURE 3.11 Total HFC emissions from industrial processes for 2005–2017

3.3 Analysis of key categories and inventory completeness

The analysis of key sources and completeness of the inventory was done on the basis of the Intergovernmental Panel on Climate Change methodology, using the *Tier-1* approach – Trend assessment and *Tier-2* approach – Level assessment. Table 3.5 gives an assessment of the trends for key emission sources for 1990 and 2017 and the levels of key categories for 2017.

TABLE 3.5:
Analysis of key emission sources – trends in 1990 and 2017

Category	GHG	Estimated CO_2eq emissions in 1990 (Gg)	Estimated CO_2eq emissions in 2017 (Gg)	Trend	Share of the trend	Aggregate share in total emissions (%)
2C3 – Metal industry – Aluminium production	PFC (PFC)	1487.90	45.22	0.15	0.31	0.31
1A3b – Fuel combustion – Transport – Road transportation	CO_2	330.30	713.14	0.07	0.14	0.44
1A1 – Fuel combustion – Energy (solid fuels)	CO_2	1088.79	1259.48	0.07	0.13	0.57
3B1a – Forestry and forest land	CO_2	1865.98	1637.44	0.04	0.08	0.65
2F1 – Use of alternative substances – refrigerators and air conditioners	HFC, PFC	0.00	235.91	0.03	0.07	0.72
1A1 – Fuel combustion – Energy (liquid fuels)	CO_2	317.44	0.00	0.03	0.07	0.79
3A1 – Enteric fermentation	CH_4	483.90	216.94	0.02	0.04	0.83
3B2 – Land for crops	CO_2	–109.79	–24.86	0.02	0.03	0.86
4A – Solid waste disposal	CH_4	151.07	221.76	0.02	0.03	0.89
2C3 – Metal industry – Aluminium production	CO_2	168.67	62.95	0.01	0.02	0.91
1A4 – Other sectors (Liquid fuels)	CO_2	116.25	41.87	0.01	0.01	0.92
1A2 Fuel combustion – Manufacturing and construction	CO_2	215.97	187.94	0.00	0.01	0.93
1A4 – Other sectors (Solid fuels)	CO_2	60.19	16.08	0.00	0.01	0.94
3C1 – Biomass combustion emissions	CH_4	1.84	24.22	0.00	0.01	0.94
3A2 – Manure management	CH_4	83.92	40.68	0.00	0.01	0.95
3B1a – Forestry and forest land	CO_2		1637.44	0.33		0.33
1A1 – Fuel combustion – Energy (solid fuels)	CO_2		1259.48	0.25		0.58
1A3b – Combustion of fuels – Traffic – Road traffic	CO_2		713.14	0.14		0.72
2F1 – Use of alternative substances – refrigerators and air conditioners	HFC, PFC		235.91	0.05		0.77

4A – Solid waste disposal	CH_4		221.76	0.04		0.82
3A1 – Enteric fermentation	CH_4		216.94	0.04		0.86
1A2 – Fuel combustion – Manufacturing and construction	CH_4		187.94	0.04		0.90
2C3 – Metal industry – Aluminium production	CO_2		62.95	0.01		0.91
1B1 – Solid fuel	CH_4		49.87	0.01		0.92
1A4 – Other sectors – biomass	CH_4		48.69	0.01		0.93
2C3 – Metal industry – Aluminium production	PFC (PFC)		45.22	0.01		0.94
1A4 – Other sectors – liquid fuels	CO_2		41.87	0.01		0.95
3A2 – Manure management	CH_4		40.68	0.01		0.95

3.4 Greenhouse gas emissions by sector

ENERGY SECTOR

The energy sector is the primary source of anthropogenic GHG emissions. The energy sector includes all activities referring to the combustion of fuels (solid, liquid, gaseous, and biofuels) in stationary and mobile sources, as well as fugitive emissions from fuels. Fugitive emissions occur during the production, transmission, processing, storage, and distribution of fossil fuels.

In Montenegro, energy accounted for 64.18% of total GHG emissions in 2016 and 48.01% in 2017. In the period between 1990–2017, the highest share of emissions from Energy within total emissions was recorded in 2014 (70.03%). Details on the estimated GHG emissions for the energy sector are included in Annex 4.

Data sources for the estimation of the GHG emissions inventory for the energy sector

Data related to the consumption, import, and distribution of fuels in Montenegro is reported by the National Statistics Office – MONSTAT. The data is processed and systematized as an energy balance, which is the basis for calculating GHG emissions from the energy sector. For the purpose of developing the inventory, MONSTAT has updated the energy balances for 2016 and 2017.

According to the recommendations of the expert visit of the UNFCCC Secretariat, natural gas consumption at Toščelik Nikšić Steel Plant for 2016 and 2017 is included in the energy balance. Data on the consumption of this fuel in energy units were used to estimate emissions from combustion of firewood. Recalculation of estimates for the whole period between 1990–2017 was made. According to the expert recommendation, an oxidation factor of 0.98 was used in the estimation.

For most of the liquid fuels distributed and consumed in Montenegro, MONSTAT provided information on lower calorific values that are close to the recommended values from the IPCCC 2006 methodology. For lignite, a lower calorific value was used in accordance with the IPCC 2006 recommendations.

For verification of the inventory, the records of fossil fuel consumption in large industrial facilities were used, which were made available to the Environment Protection Agency (EPA).

Emission trends

The estimation of direct GHG emissions from the energy sector was carried out according to the IPCC 2006 Methodology. In accordance with the available national data (lower calorific values and specific fossil carbon emissions), a combined *Tier-1* and *Tier-2* approach was used to estimate emissions from solid and liquid fuels in energy production (1A1, 1A4, and 1A2). The estimated emissions from different energy subsectors over the reporting period are shown in Table 3.6.

GHG emissions expressed as CO_2eq

The largest share within the total energy sector emissions is accounted for by activities related to power and heat generation. The reported drop in emissions from 1992 to 1995 and in 2009 was a result of reduced output from the Thermoelectric Power Plant (TPP) in Pljevlja, reduced production at the energy facility of the Podgorica Aluminium Plant (KAP), as well as an overall economic downturn in the country.

Emissions from the transport subsector record slowed but saw a steady increase commensurate with the increase in the number of motor vehicles in the country. The need to align the methodology for developing planned and effectuated energy balances with reporting requirements to EUROSTAT (European Statistics) and International Energy Agency (IEA) encouraged MONSTAT to create a new reporting format. The most prominent difference relates to biomass consumption. It includes the consumption of firewood and woodchips, pellet, charcoal, and other primary solid biomass types. It is also noteworthy that the definition “jet kerosene” was introduced into aviation fuel, whereas until 2013 the term “jet fuel” had been used.

TABLE 3.6:
CO_2eq emissions from energy sectors and subsectors for 1990–2017 (Gg)

Category	1990	1991	1992	1993	1994	1995	1996
1 – Energy	2339.68	2444.46	1794.19	1584.79	1419.06	814.48	1832.32
1A – Fuel combustion	2293.47	2405.37	1755.71	1536.79	1378.29	767.07	1791.55
1A1 – Energy industries	1412.45	1371.35	1074.03	978.21	812.57	165.22	1099.76
1A2 – Manufacturing industries & construction	276.72	394.07	257.15	194.28	205.21	200.80	239.88
1A3 – Transport	345.54	398.81	251.38	194.77	217.10	233.09	287.35
1A4 – Other sectors	239.95	219.11	163.55	163.12	136.99	158.22	154.99
1A5 – Non-specified	18.81	22.02	9.60	6.41	6.43	9.74	9.58
1B – Fugitive emissions from fuels	46.21	39.09	38.48	48.00	40.76	47.41	40.76
1B1 – Solid fuels	46.21	39.09	38.48	48.00	40.76	47.41	40.76
Category	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1 – Energy	1843.21	2254.84	2327.80	2421.79	2010.31	2537.18	2412.51
1A – Fuel combustion	1807.94	2220.00	2292.42	2387.72	1981.23	2480.17	2377.28
1A1 – Energy industries	1097.09	1392.56	1373.67	1496.42	1161.95	1695.09	1604.19
1A2 – Manufacturing industries & construction	199.61	181.55	178.20	174.95	187.62	188.71	160.68
1A3 – Transport	303.20	426.00	519.26	519.36	451.55	368.14	384.94
1A4 – Other sectors	186.66	190.47	196.21	168.42	160.94	198.63	198.73
1A5 – Non-specified	21.38	29.42	25.07	28.57	19.17	29.60	28.74
1B – Fugitive emissions from fuels	35.27	34.84	35.39	34.07	29.08	57.01	35.23
1B1 – Solid fuels	35.27	34.84	35.39	34.07	29.08	57.01	35.23
Category	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1 – Energy	2399.89	2189.64	2335.91	2278.46	2891.20	1958.93	2711.73
1A – Fuel combustion	2363.48	2158.31	2299.87	2250.02	2853.31	1938.09	2669.53
1A1 – Energy industries	1537.73	1122.91	1273.04	1005.03	1530.37	824.79	1732.19
1A2 – Manufacturing industries & construction	170.16	438.89	427.76	458.09	454.47	170.18	83.44
1A3 – Transport	436.52	409.32	434.53	530.82	605.76	706.50	618.87
1A4 – Other sectors	196.98	158.37	139.50	224.93	232.08	205.60	202.85
1A5 – Non-specified	22.10	28.83	25.05	31.14	30.64	31.02	32.17
1B – Fugitive emissions from fuels	36.41	31.33	36.04	28.44	37.89	20.84	42.20
1B1 – Solid fuels	36.41	31.33	36.04	28.44	37.89	20.84	42.20

Category	2011	2012	2013	2014	2015	2016	2017
1 – Energy	2752.40	2667.07	2400.73	2304.51	2455.69	2265.80	2370.32
1A – Fuel combustion	2709.45	2628.20	2363.87	2268.47	2411.77	2220.00	2320.46
1A1 – Energy industries	1771.83	1771.54	1512.47	1465.66	1531.55	1230.22	1265.49
1A2 – Manufacturing industries & construction	52.53	43.55	75.49	147.10	179.74	189.85	213.17
1A3 – Transport	665.66	643.04	614.68	535.66	573.25	675.89	726.43
1A4 – Other sectors	213.12	163.77	89.08	120.05	127.22	124.03	115.37
1A5 – Non-specified	6.31	6.30	72.16	0.00	0.00	0.00	0.00
1B – Fugitive emissions from fuels	42.96	38.87	36.85	36.04	43.92	45.80	49.87
1B1 – Solid fuels	42.96	38.87	36.85	36.04	43.92	45.80	49.87

Total GHG emissions expressed as CO_2eq. from the energy sector for the period 1990–2017 are shown in Figure 3.12, while Figure 3.13 shows CO_2eq emissions by energy subsector.

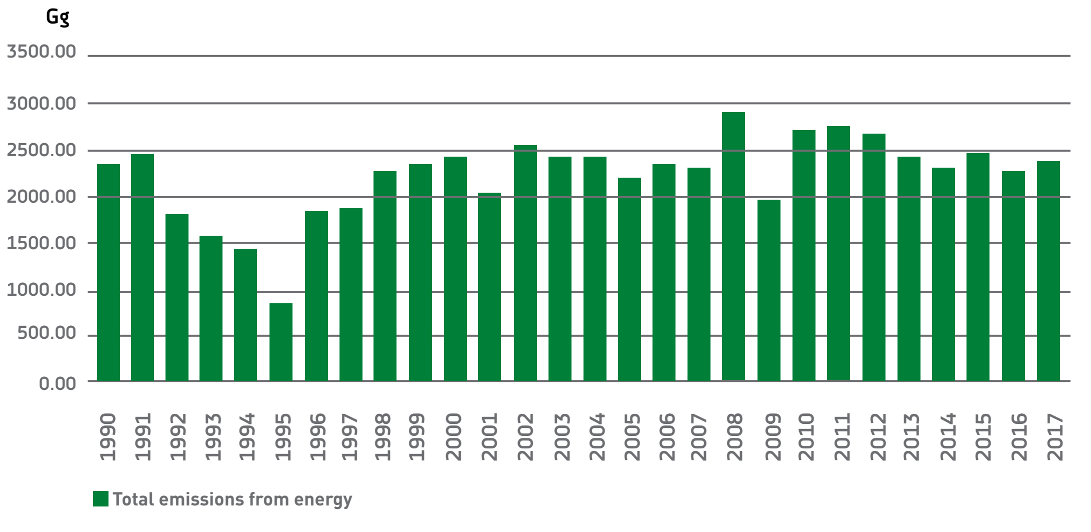


FIGURE 3.12 Total CO_2eq emissions from the energy sector for 1990–2017

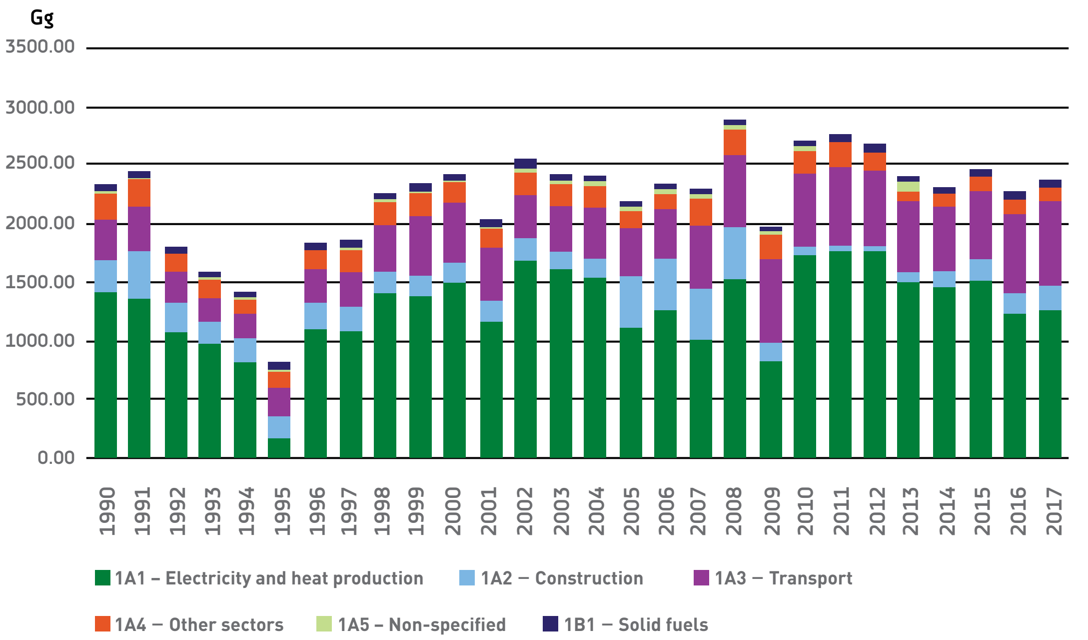


FIGURE 3.13 Emissions CO_2eq from energy subsectors for 1990–2017

CO_2 emissions

Due to the burning of lignite in the "Pljevlja" TPP, activity 1A1a – Electricity and Heat Production accounts for the largest share of CO_2 emissions from the energy sector. In accordance with the IPCC Methodology, emissions from biomass combustion are not included in the total estimates of CO_2 emissions. Table 3.7 shows the CO_2 emissions (2017) from biomass combustion. Figure 3.14 Total CO_2 emissions from the energy sector for 1990–2017.

TABLE 3.7:
CO_2 emissions from biomass combustion for 2017 (Gg)

Sectors with biomass combustion	CO_2 emissions (Gg)
1A2c – Manufacture of chemicals	37.74
1A2e – Manufacture of food and beverages	26.88
1A2f – Manufacture of non-metallic minerals	0.1
1A2h – Construction machinery	2.13
1A2j – Manufacture of wood and wood products	0.75
1A2l – Manufacture of textiles and leather	0.49
1A2m – Non-specified industry	0.9
1A4a – Commercial-institutional sector	29.22
1A4b – Residential sector	667.06

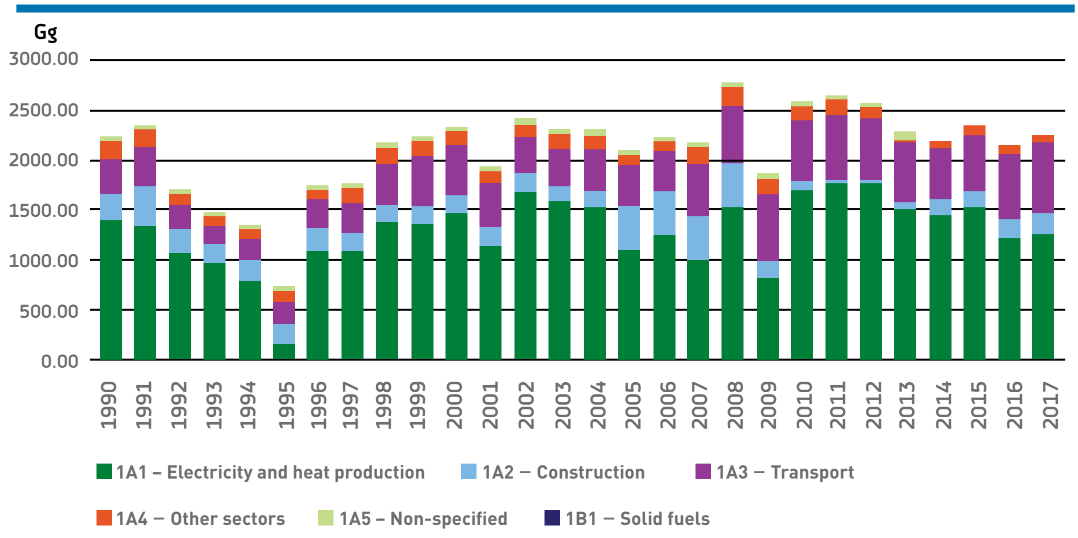


FIGURE 3.14 Total CO_2 emissions from the energy sector for 1990–2017

CH_4 emissions

Comparing CH_4 emissions with CO_2 emissions, it is concluded that the level of methane emissions from the energy sector is rather low and relates to combustion in other energy activities (1A4) and fugitive fuel emissions (1B), involving fugitive emissions from the Pljevlja coal mine (Figure 3.15). There has been an increase in CH_4 emissions over the last 7 years (2010–2017). The analysis of energy balances shows that the observed increase in emissions was caused by biomass consumption since 2011.

FIGURE 3.15 Total CH_4 emissions from the energy sector for 1990–2017

N_2O *emissions*

Over the reporting period a low level of N_2O emissions from the energy sector is recorded, with the highest share from 1A4 – Other sectors, related to fuel combustion, with a negligible share from the transport sector (Figure 3.16).

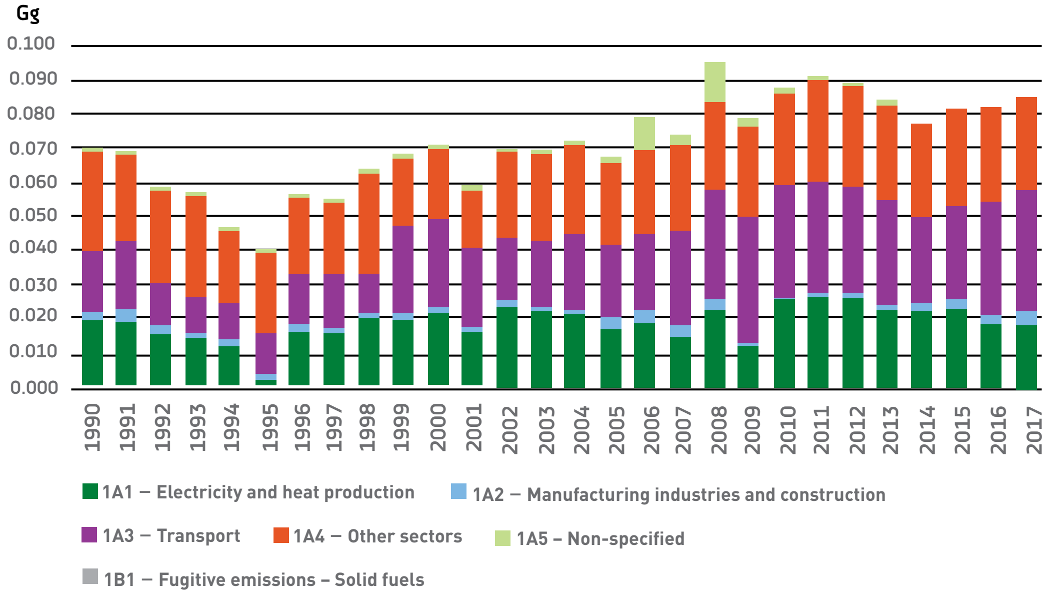


FIGURE 3.16 Total N_2O emissions from the energy sector for 1990–2017

Emissions from transport

Emissions from the transport sector recorded an increase over the reporting period 1990–2017 (except for the period during the 1990s), in line with the increase in the number of vehicles in road transport. Road transport has the largest contribution to total traffic emissions, given the fact that there is no intra-state air traffic, non-scheduled nautical traffic, and low GHG emissions from rail transport, which was refocused from diesel to electric locomotives during 2011 (Table 3.8 and Figure 3.17). The overall share of transport emissions is dominated by the share of CO_2 emissions from road transport (Figure 3.18). CH_4 and N_2O emissions from the transport are presented in Figure 3.19 and Figure 3.20.

TABLE 3.8:
CO_2eq emissions from transport for 1990–2017 (Gg)

Category	1990	1991	1992	1993	1994	1995	1996
1A3 – Traffic	345.54	398.81	251.38	194.77	217.10	233.09	287.35
1A3b – Road traffic	337.75	392.08	244.65	188.05	210.37	226.36	280.63
1A3c – Rail transport	4.59	3.53	3.53	3.53	3.53	3.53	3.53
1A3d.ii – Domestic aviation	3.20	3.20	3.20	3.20	3.20	3.20	3.20
Category	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1A3 – Traffic	303.20	426.00	519.26	519.36	451.55	368.14	384.94
1A3b – Road traffic	296.12	417.03	512.94	509.72	436.64	345.67	360.59
1A3c – Rail transport	3.88	3.88	2.83	4.24	3.88	3.53	3.53
1A3d.ii – Domestic aviation	3.20	3.20	2.56	4.16	5.11	5.75	6.07
Category	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1A3 – Traffic	436.52	409.32	434.53	530.82	605.76	706.50	618.87
1A3b – Road traffic	426.53	385.13	412.02	512.89	586.80	688.18	595.49
1A3c – Rail transport	4.24	7.06	7.35	7.06	7.77	7.77	10.60
1A3d.ii – Domestic aviation	5.75	9.59	10.44	10.87	11.19	10.55	12.79
Category	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
1A3 – Traffic	665.66	643.04	614.68	535.66	573.25	675.89	726.43
1A3b – Road traffic	656.21	627.31	602.06	526.45	564.35	667.88	726.43
1A3d.ii – Domestic aviation	9.45	15.73	12.62	9.21	8.90	8.01	0.00

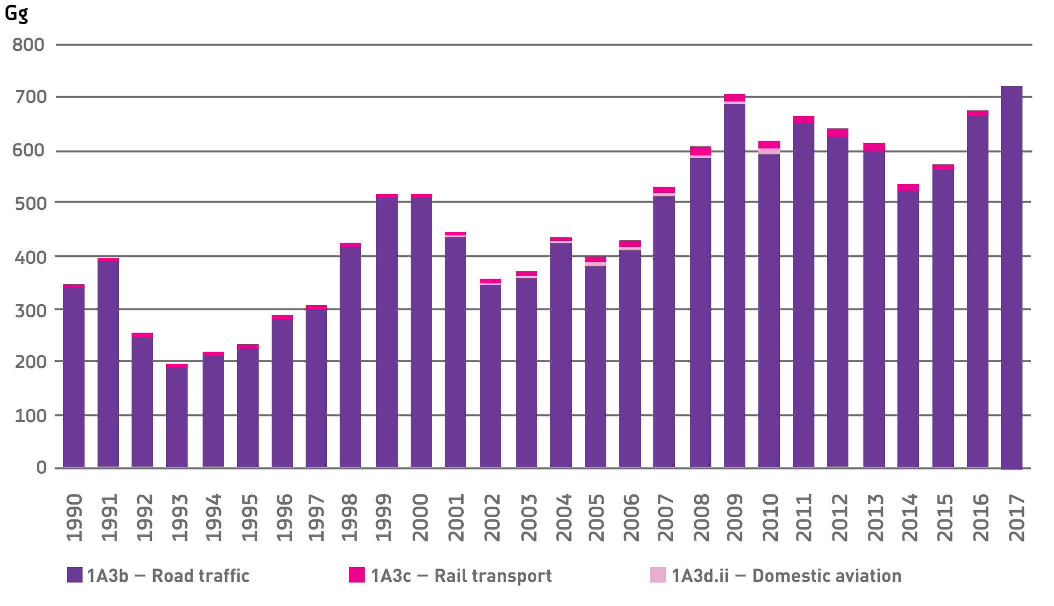


FIGURE 3.17 CO_2eq emissions from transport for 1990–2017

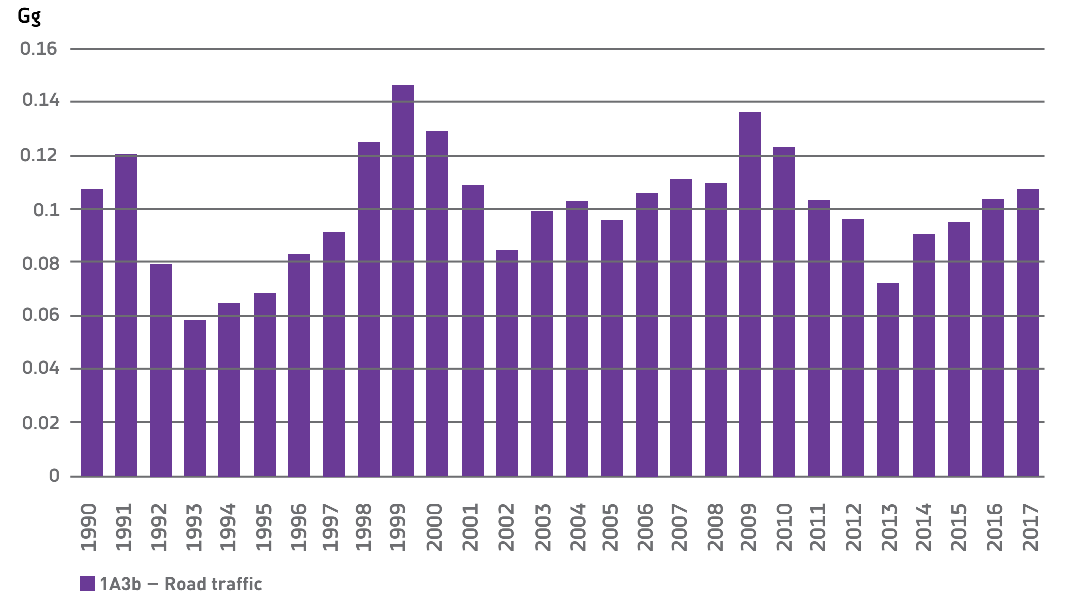


FIGURE 3.18 CO_2 emissions from transport for 1990–2017

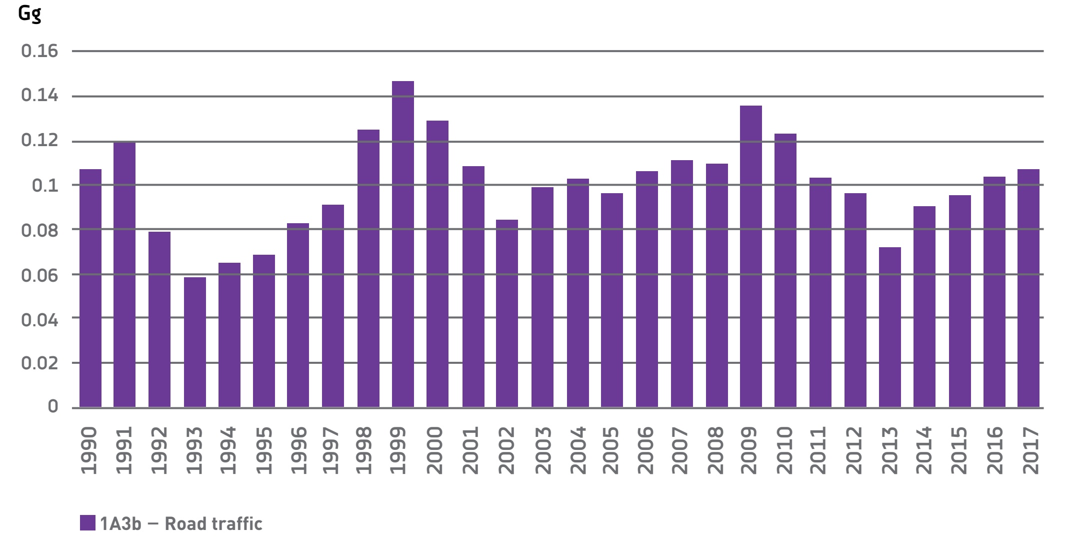


FIGURE 3.19 CH_4 emissions from transport for 1990–2017

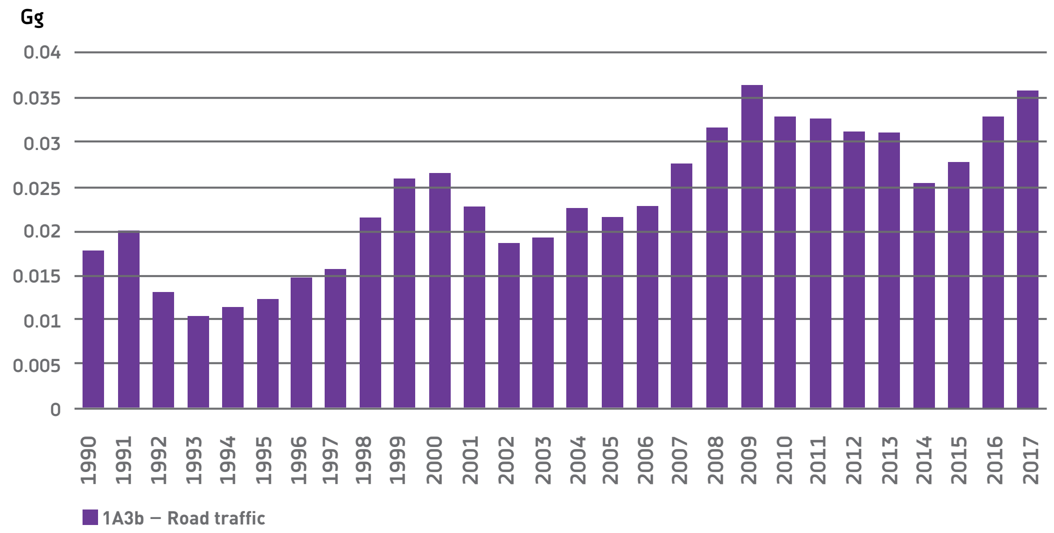


FIGURE 3.20 N_2O emissions from transport for 1990–2017

INDUSTRY SECTOR

The main industrial processes in Montenegro are in the mining and metal industry. In the metal industry sector, the most prominent processes are aluminium and steel production. Other industrial facilities involve the processing of food, beverages, tobacco, textiles, agricultural lime, leather products, paper, medications, and rubber and plastic products. Details on the estimated GHG emissions for the industry sector are included in Annex 4.

Economic development of Montenegro in the period until 1991 was characterized by intensive industrial production, so the share of GHG emissions from industry within the total emissions in the early 1990s was about 49.6%. After this period there was a continuous decline in industrial production and in 2016 the share of emissions was 9.49%, and in 2017 only 7.12%.

Data source for the GHG emissions inventory in the industry sector

Data related to industrial production was reported by: MONSTAT, the Electric Power Industry of Montenegro, the Electricity Transmission System of Montenegro, the Agency for Nature and Environmental Protection, Podgorica Aluminium Plant, Nikšić Steel Factory and Pljevlja Coal Mine.

Official MONSTAT statistics were used to estimate emissions from this sector, while industrial inventory records were used to verify the inventory.

GHG emissions expressed as CO_2eq

The estimated CO_2eq emissions from industrial processes for the reporting period are shown in Table 3.9 and Figure 3.21. In all the industrial subsectors, it is observed that the GHG emission level strictly monitors the level of production volume during the period 1990–2017, as well as technological improvements in the electrolysis plant in Podgorica Aluminium Plant.

TABLE 3.9:
CO_2eq emissions from industrial processes, 1990–2017 (Gg)

Category	1990	1991	1992	1993	1994	1995	1996	1997
2 – Industrial processes and product use	1701.52	2201.73	1419.86	533.21	132.40	446.86	996.14	1530.39
2A – Minerals industry	24.75	23.25	16.50	0.00	0.00	24.75	3.00	6.00
2A2 – Production of lime	24.75	23.25	16.50	0.00	0.00	24.75	3.00	6.00
2C – Metal industry	1673.23	2173.52	1396.68	523.90	118.51	402.79	968.13	1493.27
2C1 – Manufacture of iron and steel	16.66	15.76	11.47	9.28	9.00	16.66	7.14	10.62
2C3 – Manufacture of aluminium	1656.56	2157.76	1385.21	514.63	109.52	386.13	960.99	1482.65
2D – Non-energy fuel consumption and solvent use	2.21	2.21	1.62	0.98	1.18	1.52	1.67	1.67
2D1– Use of lubricants	2.21	2.21	1.62	0.98	1.18	1.52	1.67	1.67
2F – Use of substances to replace ozone-depleting substances	0.00	1.33	3.79	7.22	11.48	16.46	22.06	28.19
2F1 – Refrigerators and air conditioners	0.00	1.33	3.79	7.22	11.48	16.46	22.06	28.19
2G – Manufacture and use of other products	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
2G1 – Electrical equipment	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
2H – Others	0.56	0.64	0.49	0.32	0.45	0.56	0.50	0.48
2H2 – Food and beverage industry	0.56	0.64	0.49	0.32	0.45	0.56	0.50	0.48

Category	1998	1999	2000	2001	2002	2003	2004
2 – Industrial processes and product use	1165.56	1220.72	1576.60	1657.07	1609.65	1378.58	1271.25
2A – Minerals industry	6.00	6.00	5.33	9.74	8.34	6.10	7.94
2A2 – Production of lime	6.00	6.00	5.33	9.74	8.34	6.10	7.94
2C – Metal industry	1121.63	1169.66	1518.65	1586.99	1533.24	1295.81	1178.01
2C1 – Manufacture of iron and steel	11.35	7.06	6.80	8.81	6.65	4.74	12.05
2C3 - Manufacture of aluminium	1110.28	1162.60	1511.85	1578.18	1526.60	1291.07	1165.96

2D – Non-energy fuel consumption and solvent use	1.77	1.77	1.82	1.87	1.87	1.92	1.97
2D1 – Use of lubricants	1.77	1.77	1.82	1.87	1.87	1.92	1.97
2F – Use of substances to replace ozone-depleting substances	34.79	41.79	49.15	56.82	64.78	72.98	81.40
2F1 – Refrigerators and air conditioners	34.79	41.79	49.15	56.82	64.78	72.98	81.40
2G – Manufacture and use of other products	0.84	0.84	0.92	0.92	0.97	1.15	1.33
2G1 – Electrical equipment	0.84	0.84	0.92	0.92	0.97	1.15	1.33
2H – Others	0.53	0.65	0.72	0.72	0.45	0.63	0.60
2H2 – Food and beverage industry	0.53	0.65	0.72	0.72	0.45	0.63	0.60

Category	2005	2006	2007	2008	2009	2010	2011
2 – Industrial processes and product use	1165.84	1284.09	1400.69	1547.25	585.63	776.97	734.21
2A – Minerals industry	4.51	6.09	5.32	7.38	3.37	0.63	2.59
2A2 – Production of lime	4.51	6.09	5.32	7.38	3.37	0.63	2.59
2C – Metal industry	1068.41	1174.17	1282.93	1417.19	449.21	632.51	576.60
2C1 – Manufacture of iron and steel	8.21	12.95	13.96	16.19	8.30	3.87	4.91
2C3 – Manufacture of aluminium	1060.20	1161.22	1268.98	1401.01	440.90	628.64	571.70
2D – Non-energy fuel consumption and solvent use	0.49	1.87	0.59	0.54	0.44	0.39	0.49
2D1– Use of lubricants	0.49	1.87	0.59	0.54	0.44	0.39	0.49
2F – Use of substances to replace ozone-depleting substances	90.37	99.82	109.68	119.92	130.48	141.32	152.42
2F1 – Refrigerators and air conditioners	90.37	99.82	109.68	119.92	130.48	141.32	152.42
2G – Manufacture and use of other products	1.43	1.49	1.49	1.52	1.54	1.55	1.60
2G1 – Electrical equipment	1.43	1.49	1.49	1.52	1.54	1.55	1.60
2H – Others	0.64	0.66	0.67	0.69	0.59	0.56	0.52
2H2 – Food and beverage industry	0.64	0.66	0.67	0.69	0.59	0.56	0.52

Category	2012	2013	2014	2015	2016	2017
2 – Industrial processes and product use	522.11	385.11	364.24	355.35	335.13	351.42
2A – Minerals industry	344.32	194.20	156.17	142.71	106.90	111.80
2A2 – Production of lime	2.27	1.63	1.15	2.91	3.62	3.63
2C – Metal industry	342.05	192.57	155.02	139.80	103.27	108.17
2C1 – Manufacture of iron and steel	0.49	0.49	4.52	4.67	0.15	0.15
2C3 – Manufacture of aluminium	0.49	0.49	4.52	4.67	0.15	0.15
2D – Non-energy fuel consumption and solvent use	174.77	187.74	200.85	205.27	225.08	235.91
2D1– Use of lubricants	174.77	187.74	200.85	205.27	225.08	235.91
2F – Use of substances to replace ozone-depleting substances	2.00	2.19	2.23	2.23	2.52	2.99
2F1 – Refrigerators and air conditioners	2.00	2.19	2.23	2.23	2.52	2.99
2G – Manufacture and use of other products	0.53	0.49	0.48	0.48	0.48	0.57
2G1 – Electrical equipment	0.53	0.49	0.48	0.48	0.48	0.57

The share of CO_2eq emissions from aluminium production in the total emissions from the industry sector in the reporting period ranges from about 30% (in 2017) to over 90% (1991). Starting from 2009, due to a significant reduction in the volume of aluminium production, but also due to technological improvements in the Electrolysis Plant, PFC emissions have fallen and thus the dominant share of the aluminium industry within total CO_2eq has also reduced. With the increase in the number of refrigeration units, especially air conditioners in households, the PFC emissions from these activities are increasing, and thus the share of total emissions from the industry sector is also increasing. However, the value of this emission is low compared to the total value of emissions from all sectors.

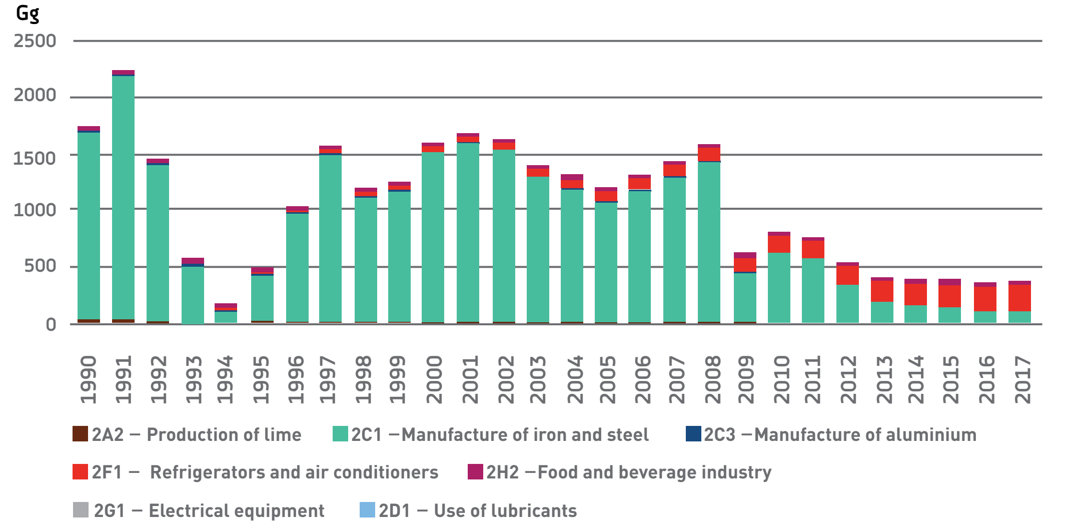


FIGURE 3.21 Total CO_2eq emissions from industrial processes, 1990–2017

CO_2 emissions

For the reporting period, 1990–2017, the estimated CO_2 emissions from the industrial subsectors are shown in Figure 3.22.

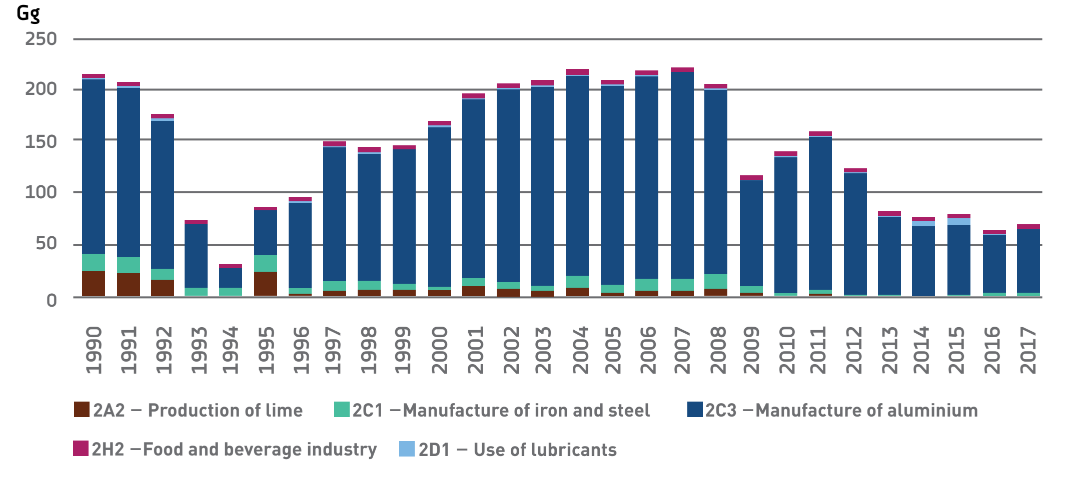


FIGURE 3.22 Total CO_2 emissions from the industrial processes and product use, 1990–2017 (Gg)

CH_4 emissions

For the observed period, the estimated CH_4 emissions from the industrial subsectors are shown in Figure 3.23. The total estimated methane emissions from this sector come from the iron and steel industry.

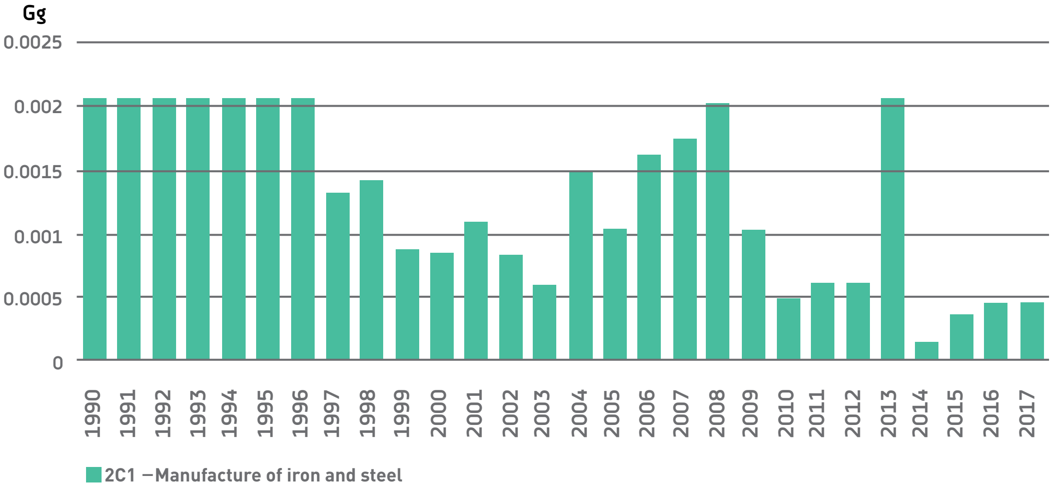


FIGURE 3.23 Total CH4 emissions from the industrial processes and product use, 1990–2017 (Gg)

PFC, SF_6, and HFC emissions

For the reporting period 1990–2017, the estimated PFCs, SF_6, and HFCs emissions from industrial subsectors are shown in Figure 3.24. The total estimated emissions of PFC substances from this sector come from the aluminium industry (electrolysis plants). The entire PFC emissions time series have been recalculated from the SBUR (2019) in accordance with the findings and recommendations of the UNFCCC Secretariat Expert Mission. The recalculated emissions show a significantly lower level due to the information being thoroughly analysed regarding the number and duration of anode effects and consequently the application of the *Tier-2* approach in the calculation. The decline in PFC emissions in the 1990s is related solely to the fall in production volume, while in the period 2009–2017, the fall in emission levels is related not only to the evident decline in the volume of aluminium produced, but also to technological improvements in terms of reducing the number and duration of anode effects in electrolytic cells.

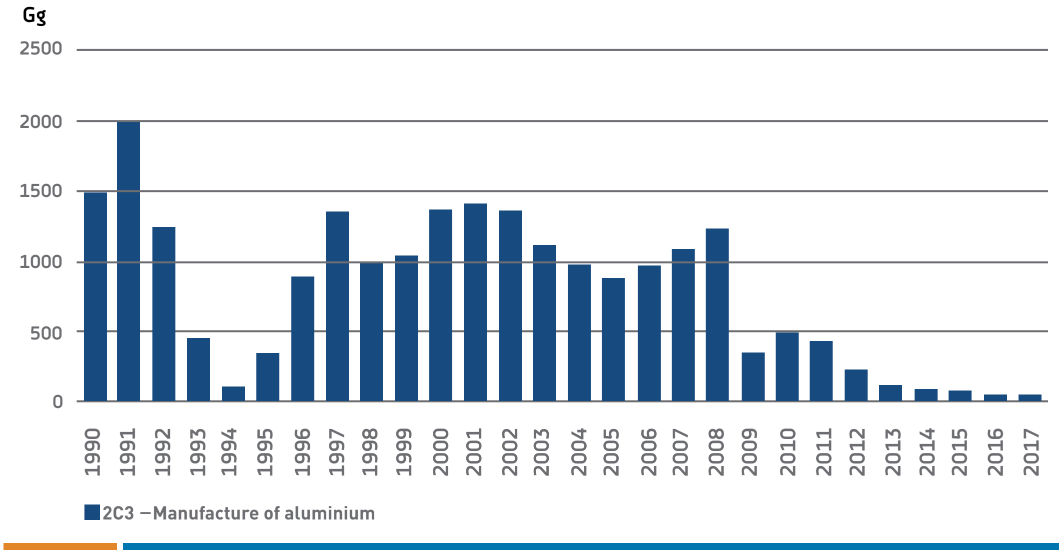


FIGURE 3.24 Total PFC (CO_2eq) emissions from industrial processes and product use, 1990–2017 (Gg)

AGRICULTURE, FORESTRY AND LAND USE

In 2016, there were 43,791 agricultural holdings, of which 43 are agricultural enterprises or business entities. Statistics from 2016 indicate a significant increase in the utilized agricultural area under arable land, vineyards, orchards, as well as meadows and pastures, compared to the same areas in 2010 (MONSTAT, 2017). Details on the estimated GHG emissions for the agriculture sector are included in Annex 4.

Data sources for the GHG Emission Inventory for the agricultural sector

To assess the GHG emissions from agriculture, data from MONSTAT and Corine Land Cover was used, following the 2006 IPCC Guidelines. Data on the area of grassland, wetlands, populated areas, and other land for individual years (CLC1990, 2000, 2006, 2012, and 2018) were obtained on the basis of interpolation and extrapolation of data from Corine Land Cover (CLC) for the years in question. The category of Other land is given in accordance with the IPCC methodology as the difference between all the other categories and the total area of Montenegro. Also arable land data was derived for the period 1990–2017 from the Statistical Yearbooks (MONSTAT) and the Corine Land Cover database. Data from Corine Land Cover 1990 – 2000 – 2006 – 2012 – 2018 and extrapolation, as well as NIS data, were used for this report to cover the entire land area of 1,381,200 ha.

At the end of 2012, work on developing a new methodology and templates for data collection and statistical processing began at MONSTAT. The new methodology brought about significant changes in the data for 2012 and 2013, while recalculation of the data for the time series on the database since the 2010 Census of Agriculture is planned in the forthcoming period.

The data used comes from Statistical Yearbooks (MONSTAT), the records of the Directorate for Forests of Montenegro, data from the National Forest Inventory of Montenegro (2013), as well as the data from "Analysis and Projection of Climate Change Impacts Using the Regional Climate Model on Future Spreading and the growth of the main tree species in Montenegro" (UNDP, 2013).

Data for animal populations has been subdivided into subcategories (MONSTAT data has been used since 2009, while extrapolation was performed for the series backwards). Classified inputs are useful in applying the *Tier-2* emission estimation approach because they are useful if a higher methodology is used.

Sources and sinks of GHG emission expressed as CO_2eq

The total sink emissions from the land use sector range from 2,472.79 Gg CO_2eq in 1990 to 1,961.80 Gg in 2017 (Table 3.10). The significant difference between CO_2eq sources and sinks in the land category is the result of the new updated data (deforestation, forests affected by fires, and firewood) used for the TNC.

During the reporting period (1990–2017), GHG emissions from the agricultural sector in almost all segments decreased, due to reduced crop and livestock production (by about 60%) and the total animal population. Table 3.10 and Figure 3.25 show the sources and sinks of GHG emissions from the agriculture and land use sectors, expressed as CO_2eq.

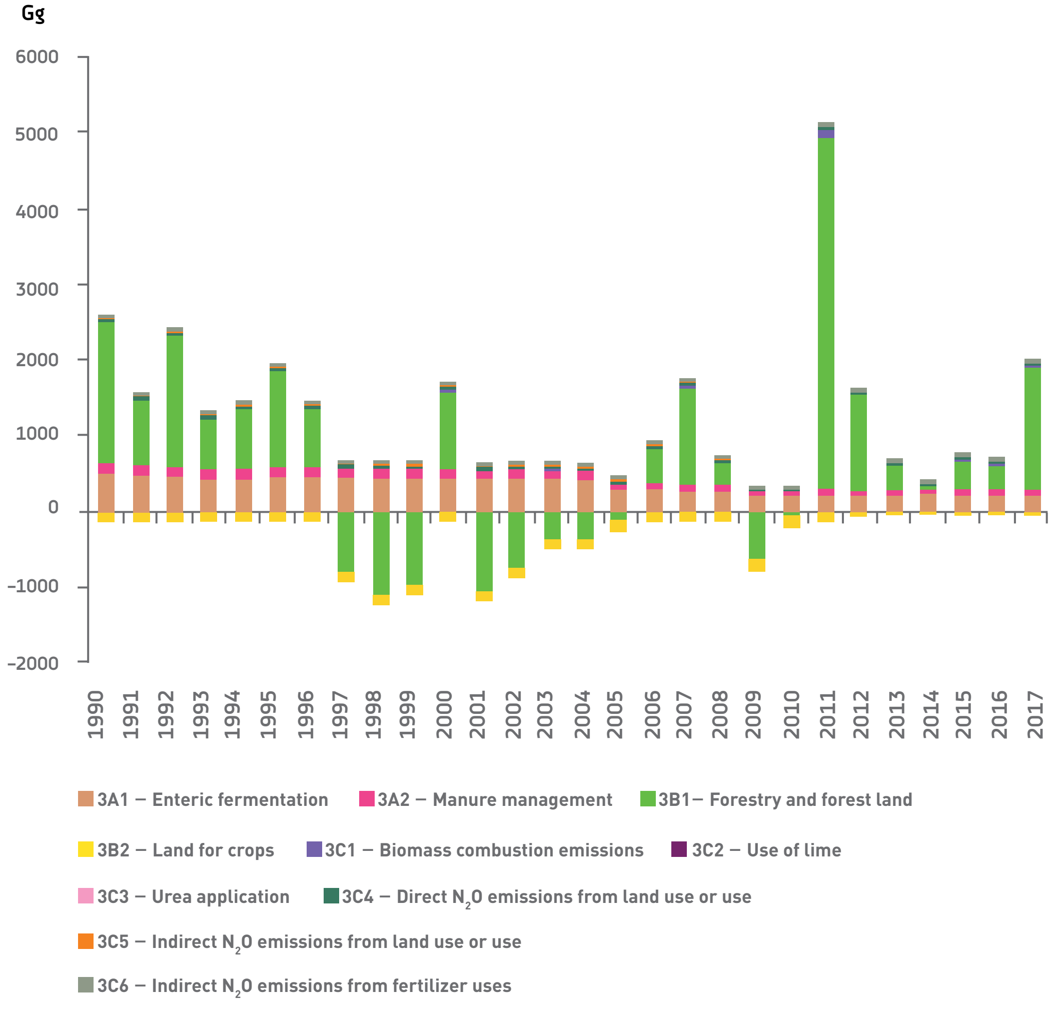


FIGURE 3.25 Sources and sinks of GHG emissions, expressed as CO_2eq from agriculture and land use, 1990–2017 (Gg)

TABLE 3.10:
Sources and sinks of GHG emissions, expressed as CO_2eq from agriculture and land use, 1990–2017 (Gg)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3 – Agriculture, forestry and other land use	2472.79	1453.88	2303.05	1203.55	1330.46	1834.27	1338.93	−266.26	−583.71	−426.59
3A – Livestock	625.75	623.72	587.78	565.76	576.60	593.93	592.39	577.83	574.02	578.34
3A1 – Enteric fermentation	483.90	482.47	453.10	436.16	444.24	457.87	456.34	443.86	439.22	441.70
3A2 – Fertilizer management	141.85	141.25	134.68	129.60	132.36	136.06	136.06	133.98	134.81	136.64
3B – Land	1756.19	740.37	1628.66	558.51	673.78	1150.55	659.71	−923.23	−1230.71	−1082.37
3B1 – Forest land	1865.98	850.17	1738.45	668.61	783.88	1261.01	770.00	−811.33	−1118.67	−969.64
3B2 – Areas under crops	−109.79	−109.80	−109.79	−110.10	−110.10	−110.46	−110.29	−111.90	−112.04	−112.73
3C – Cumulative and other sources of gas from the soil	23.47	22.80	21.21	18.35	17.80	25.71	22.71	15.93	15.16	12.68
3C1 – Biomass burning emissions	3.05	1.83	3.98	3.74	2.28	3.71	4.01	1.55	4.31	0.76
3C2 – Use of lime	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05
3C3 – Urea application	0.43	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
3C4 – Direct N_2O emissions from land use or use	46.25	46.47	42.38	38.46	39.76	45.45	42.97	39.34	32.75	38.32
3C5 – Indirect N_2O emissions from land use or use	17.90	17.96	16.61	15.12	15.61	17.55	16.75	15.52	12.98	15.17
3C6 – Indirect N_2O emissions from fertilizer uses	23.17	23.06	23.15	21.48	21.94	22.61	22.61	22.25	22.46	22.72

Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3 – Agriculture, forestry and other land use	1588.02	−533.44	−212.44	179.33	149.94	192.25	788.63	1618.05	586.02	−456.42
3A – Livestock	564.28	554.24	565.50	558.14	540.02	383.10	371.77	348.10	340.69	272.90
3A1 – Enteric fermentation	430.92	421.42	430.77	423.75	409.91	294.29	285.40	266.70	260.82	208.64
3A2 – Fertilizer management	133.36	132.81	134.73	134.39	130.11	88.81	86.37	81.40	79.87	64.26

3B – Land	926.42	-1168.06	-853.71	-467.94	-468.91	-245.79	355.58	1169.88	185.98	-775.34
3B1 – Forest land	1039.22	-1064.95	-750.53	-364.42	-364.06	-128.85	479.61	1294.63	310.79	-649.94
3B2 – Areas under crops	-112.80	-103.12	-103.19	-103.52	-104.85	-116.94	-124.02	-124.75	-124.82	-125.39
3C – Cumulative and other sources of gas from the soil	34.13	17.46	11.18	24.14	17.17	12.85	20.09	61.55	21.44	15.69
3C1 – Biomass burning emissions	18.29	1.51	1.28	9.80	3.55	0.49	0.74	43.78	4.37	0.46
3C2 – Use of lime	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
3C3 – Urea application	0.42	0.41	0.41	0.41	0.39	0.38	0.37	0.37	0.37	0..37
3C4 – Direct N_2O emissions from land use or use	40.35	40.30	37.00	40.47	38.14	28.37	33.38	30.73	30.02	25.18
3C5 – Indirect N_2O emissions from land use or use	15.85	15.82	14.76	16.04	15.05	10.88	12.44	11.47	11.21	9.25
3C6 – Indirect N_2O emissions from fertilizer uses	22.37	22.29	22.27	22.37	21.65	14.77	14.29	13.66	13.35	10.72

Category	2010	2011	2012	2013	2014	2015	2016	2017		
3 – Agriculture, forestry and other land use	129.80	4975.69	1584.27	635.48	353.71	720.21	664.42	1961.80		
3A – Livestock	268.25	286.45	282.15	291.20	304.89	292.11	297.24	286.24		
3A1 – Enteric fermentation	205.21	218.82	215.30	222.78	233.53	222.88	221.62	216.94		
3A2 – Fertilizer management	63.04	67.63	66.86	68.43	71.36	69.22	75.62	69.30		
3B – Land	-186.87	4524.80	1240.67	294.63	3.83	370.98	311.28	1612.57		
3B1 – Forest land	-60.89	4651.13	1271.97	330.63	38.84	403.08	341.77	1637.44		
3B2 – Areas under crops	-125.98	-126.33	-31.31	-36.01	-35.01	-32.09	-30.49	-24.86		
3C – Cumulative and other sources of gas from the soil	18.81	132.64	30.33	17.08	10.93	24.17	19.43	35.60		
3C1 – Biomass burning emissions	1.89	116.77	13.39	0.68	0.71	8.55	3.53	24.22		
3C2 – Use of lime	0.05	0.05	0.04	0.06	0.06	0.04	0.03	0.03		

3C3 – Urea application	0.36	0.35	0.28	0.31	0.31	0.34	0.34	0.34		
3C4 – Direct N_2O emissions from land use or use	26.15	26.30	26.72	27.39	23.04	26.99	28.85	27.38		
3C5 – Indirect N_2O emissions from land use or use	9.54	9.70	9.82	10.04	9.17	9.93	10.71	0.00		
3C6 – Indirect N_2O emissions from fertilizer uses	10.44	11.27	11.19	11.16	11.69	11.28	12.45	11.01		

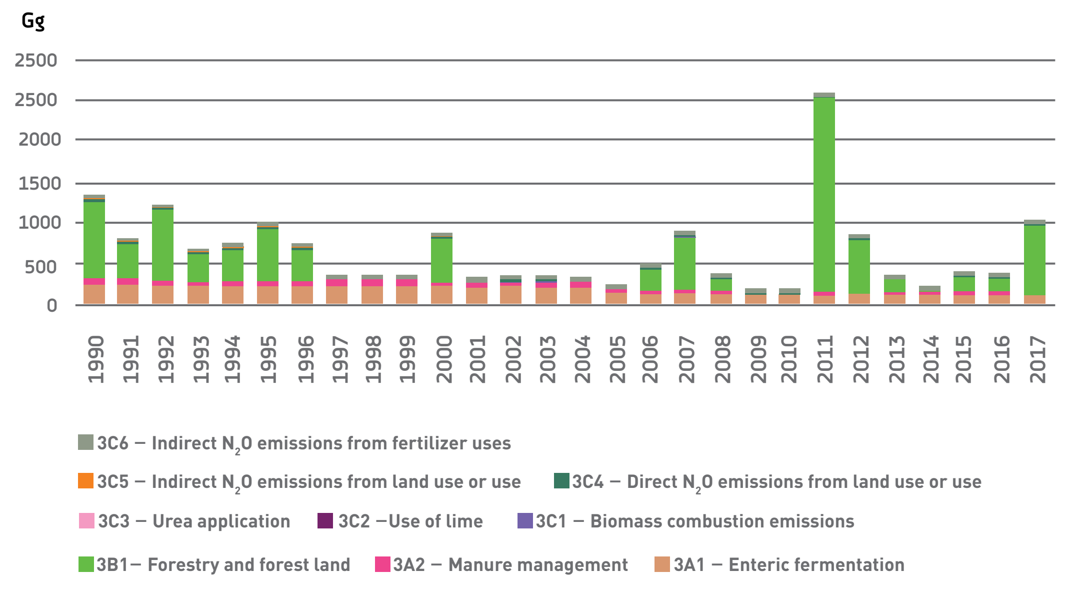


FIGURE 3.26 CO_2eq emissions from agriculture and land use sectors, 1990–2017 (Gg)

The largest share of total emissions from the agriculture and land use sectors is that of forest land (3B1), for which a hybrid approach is used, i.e. a combination of *Tier-1* and *Tier-2*, according to data on changes in carbon stocks in biomass (National Forest Inventory, 2013). This was compounded by total logging, use of firewood, and uncontrolled fires. Due to the fire, sink, and emissions from forest land vary from –1,064.95Gg CO_2eq in 2001 to as much as 4,561.13 Gg CO_2eq in 2011. Other significant emissions from Enteric fermentation were used to calculate emissions and sinks from the Forestry subsector (3A1) and Manure Management (3A2).

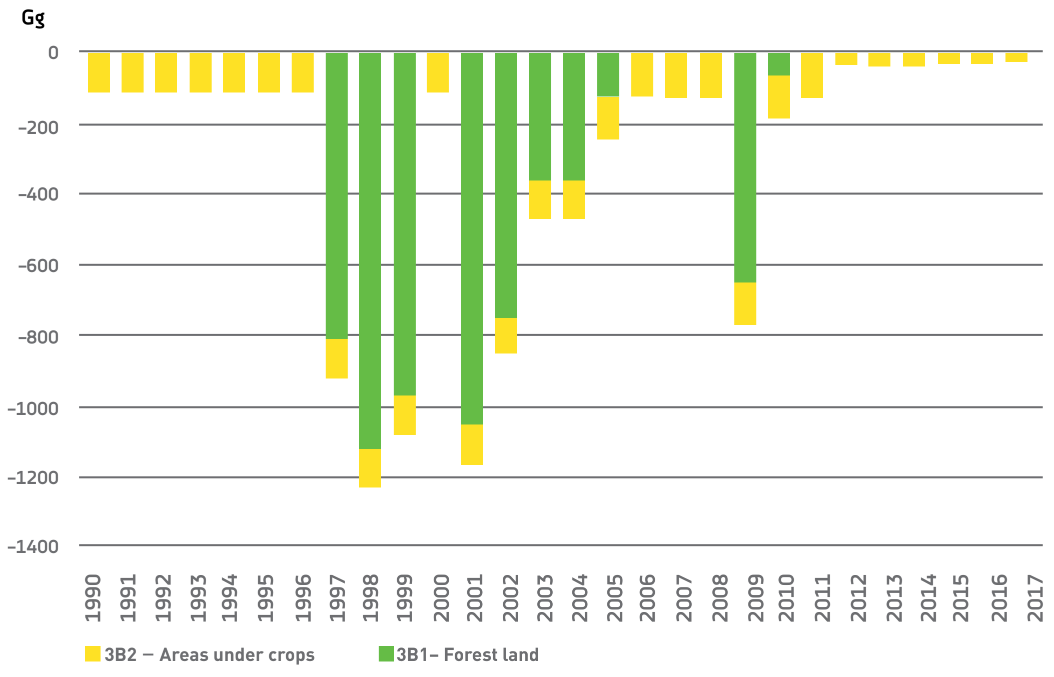


FIGURE 3.27 CO_2eq sinks from agriculture and land use sectors, 1990–2017 (Gg)

CH_4 emissions

Figure 3.28 shows CH_4 emissions from the agriculture and land use subsectors. The share of emissions from enteric fermentation in the livestock subsector is the most significant, ranging from 72% to 84.8% of the total CH_4 emissions, with the largest contribution from dairy cow emissions, followed by manure management, where dairy cow emissions have the largest contribution contributing between 12.9% and 15.5% and burning biomass with a share of 0.2% to 15.1%.

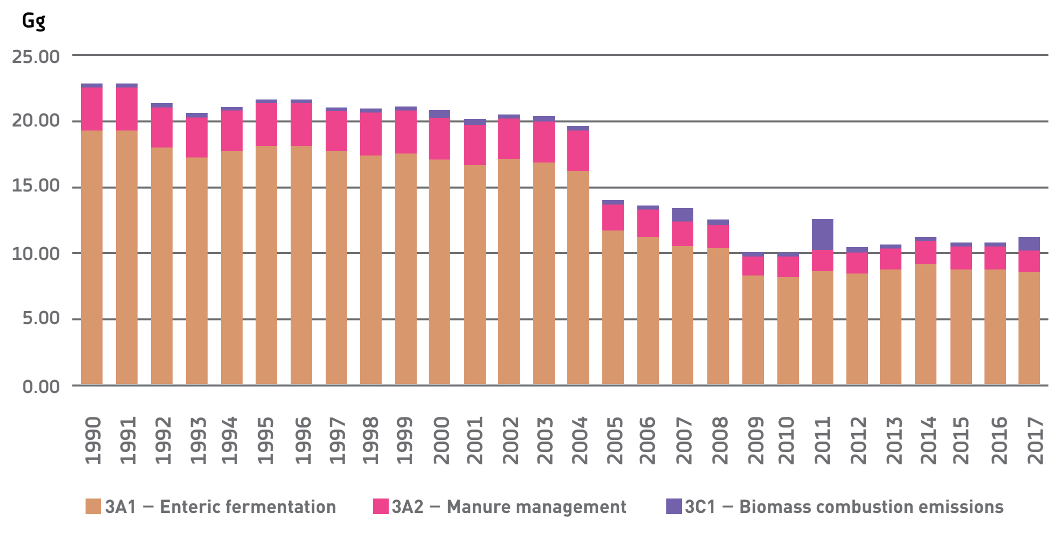


FIGURE 3.28 CH_4 emissions from agriculture and land use, 1990–2017 (Gg)

N_2O emissions

Figure 3.29 shows the N_2O emissions from the agriculture and land use subsectors. The share of emissions from direct land emissions is the most significant and ranges from 27.8% to 32.3% within total N_2O emissions.

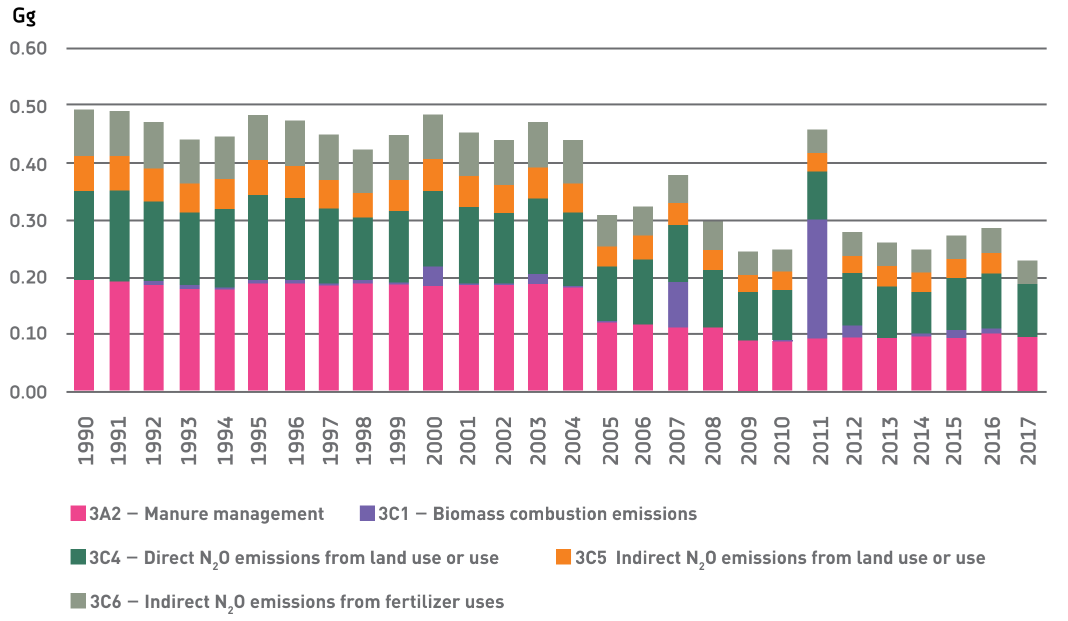


FIGURE 3.29 N_2O emissions from agriculture and land use, 1990–2017 (Gg)

WASTE

GHG emissions from the waste sector result from the disposal and treatment of solid municipal waste, wastewater management, and waste incineration. Solid Waste Disposal and Wastewater Management are included in the GHG inventory. The inventory included the methane (CH4) emissions resulting from the disposal and treatment of solid municipal waste and the emissions of nitrogen sulphide (N_2O) from wastewater management.

Montenegro does not carry out activities such as the biological treatment of solid waste, waste incineration, and waste incineration outdoors.

The methodology used to calculate CH_4 emissions according to the 2006 IPCC Guidelines is a first-order decay (FOD) kinetic model that incorporates a time factor into the calculation, allowing for the monitoring of emissions over a long period of time, during which organic carbon decomposes in waste. The proposed *Tier-2* methodology was used because national data on the quantities of waste produced and disposed of and the waste composition were included in the budget, while all other model parameters were recommended in accordance with the 2006 IPCC Guidelines, Volume 5, Chapter 3, Figure 3.

CH_4 emissions from household wastewater (especially in rural areas where septic tanks are used) are calculated using the IPCC *Tier-1* methodology recommended by the 2006 IPCC Guidelines.

Indirect N_2O emissions from wastewater management are calculated using the IPCC *Tier-1* methodology recommended by the 2006 IPCC Guidelines. Due to the application of the kinetic model, the amount of solid municipal waste produced and disposed of and its composition were included in the budget from 1950 to 2015.

GHG emissions expressed in CO_2eq

Table 3.11 and Figure 3.30 show an estimation of the annual GHG emissions from the activities of waste management are estimated CO_2eq for the period 1990–2017. The emissions from the solid waste disposal make up to 90%, while emissions from wastewater management are 10%–13%.

TABLE 3.11:
Total GHG emissions from waste sector for 1990–2017 (Gg CO_2eq)

	Solid waste disposal (Gg CO_2eq)	Wastewater management (Gg CO_2eq)	Waste – total (Gg CO_2eq)
1990	151.07	20.12	171.19
1991	155.48	20.34	175.82
1992	159.99	20.53	180.52
1993	164.59	20.72	185.31
1994	169.23	20.92	190.15
1995	174.58	21.12	195.70
1996	180.53	21.31	201.84
1997	187.01	21.51	208.52
1998	193.65	21.71	215.36
1999	200.41	21.91	222.32
2000	207.32	26.85	234.18
2001	213.29	27.11	240.40
2002	218.37	27.40	245.77
2003	222.70	27.73	250.43
2004	226.21	28.12	254.33
2005	228.86	28.50	257.36
2006	230.89	28.70	259.59
2007	234.71	29.75	264.46
2008	237.32	30.78	268.10
2009	238.77	30.39	269.16
2010	241.06	30.77	271.83
2011	244.93	31.01	275.94
2012	241.35	30.33	271.67
2013	238.23	31.23	269.46
2014	236.76	31.48	268.24
2015	234.53	31.86	266.40
2016	232.66	32.20	264.86
2017	221.76	32.12	253.89

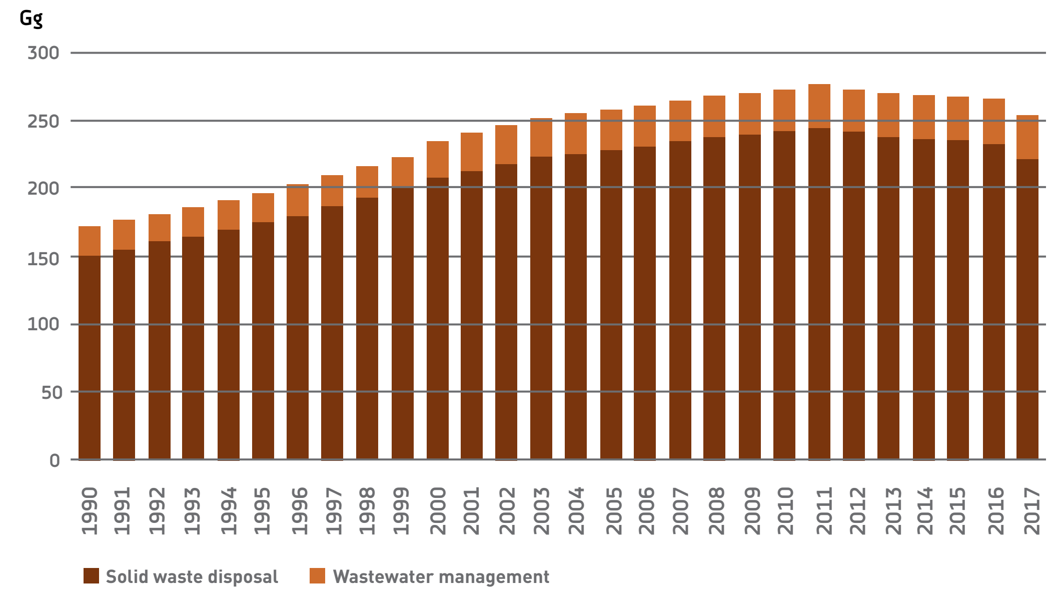


FIGURE 3.30 Total GHG emissions from the waste sector for 1990–2017 (Gg CO_2eq)

CH_4 emissions

In total, CH_4 emissions of solid waste disposal make up between 92% and 95% of the total emissions from the sector, while emissions from category wastewater management are between 5% and 8%. Figure 3.31 shows the annual CH_4 emissions from the activities of the waste sector expressed in Gg for the period 1990–2017.

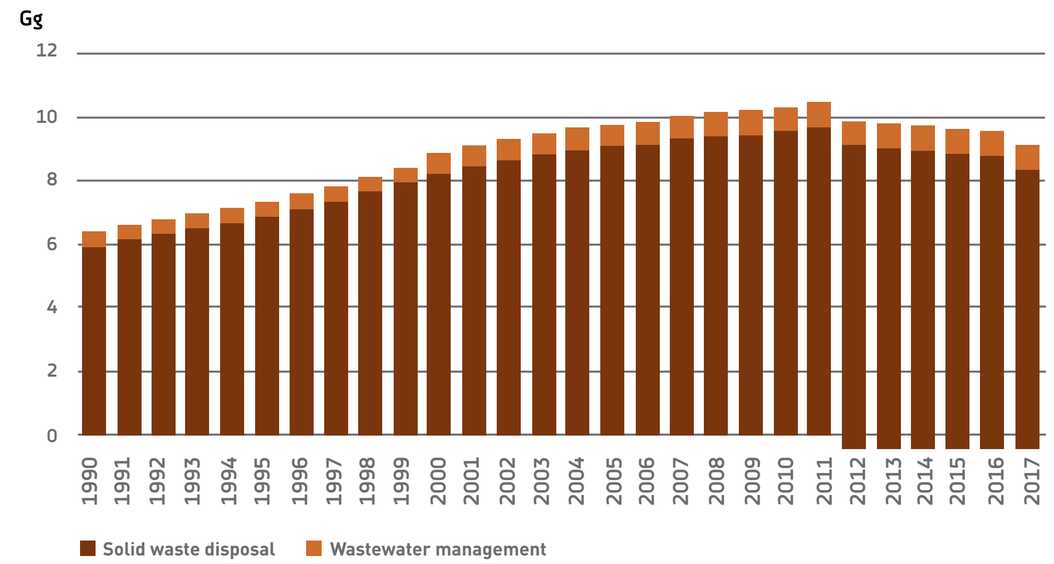


FIGURE 3.31 CH_4 emissions from the waste sector for 1990–2017 (Gg CH_4)

N_2O *emissions*

Figure 3.32 shows the N_2O emissions from the agriculture and land use subsectors. The share of emissions from direct land emissions is the most significant and ranges from 27.8% to 32.3% within total N_2O emissions.

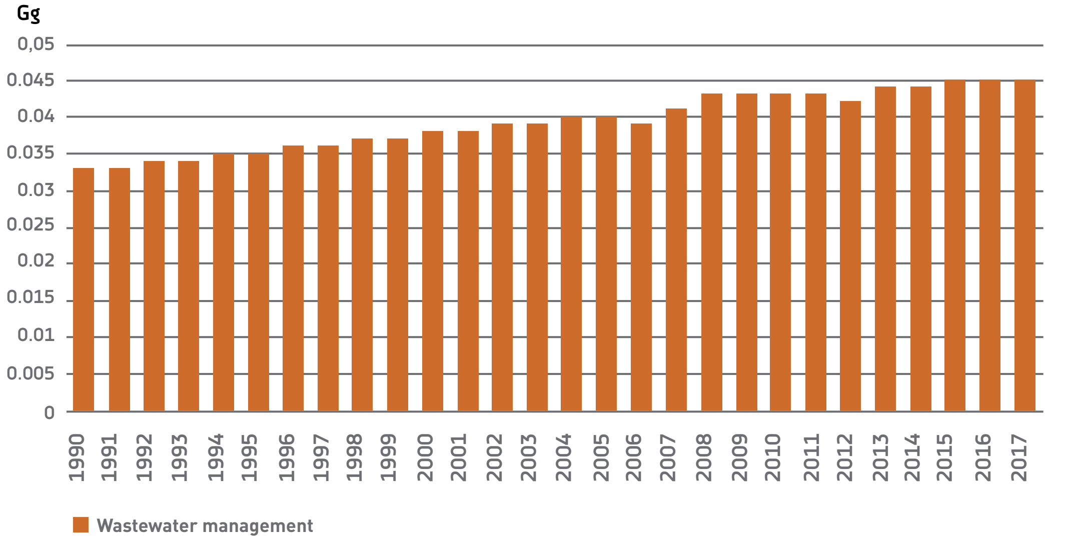


FIGURE 3.32 N_2O emissions from waste for 1990–2017 (Gg N_2O)

3.5 Uncertainty calculations for the period 1990–2017

The uncertainties associated with the annual estimates of emissions and emission trends over time (1990–2017) are reported according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The uncertainties are estimated using the *Tier-1* method described in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and in Good Practice Guidance and Uncertainty Management in the National Greenhouse Gas Inventories. Table 3.12 shows estimates of the measurement uncertainties for key categories for the period 1990–2017. In summary, the key measurement uncertainties include:

- The combined measurement uncertainty of CO_2 emission from road transport is 50.25%
- The combined measurement uncertainty of CO_2 emissions from liquid fuel combustion for electricity production is 26.21%
- The combined measurement uncertainty of CF_4 emissions from aluminium production is 30.7% and for CO_2 emissions it is 10.20%
- The combined measurement uncertainty of CH_4 emissions from enteric fermentation is 109.54%

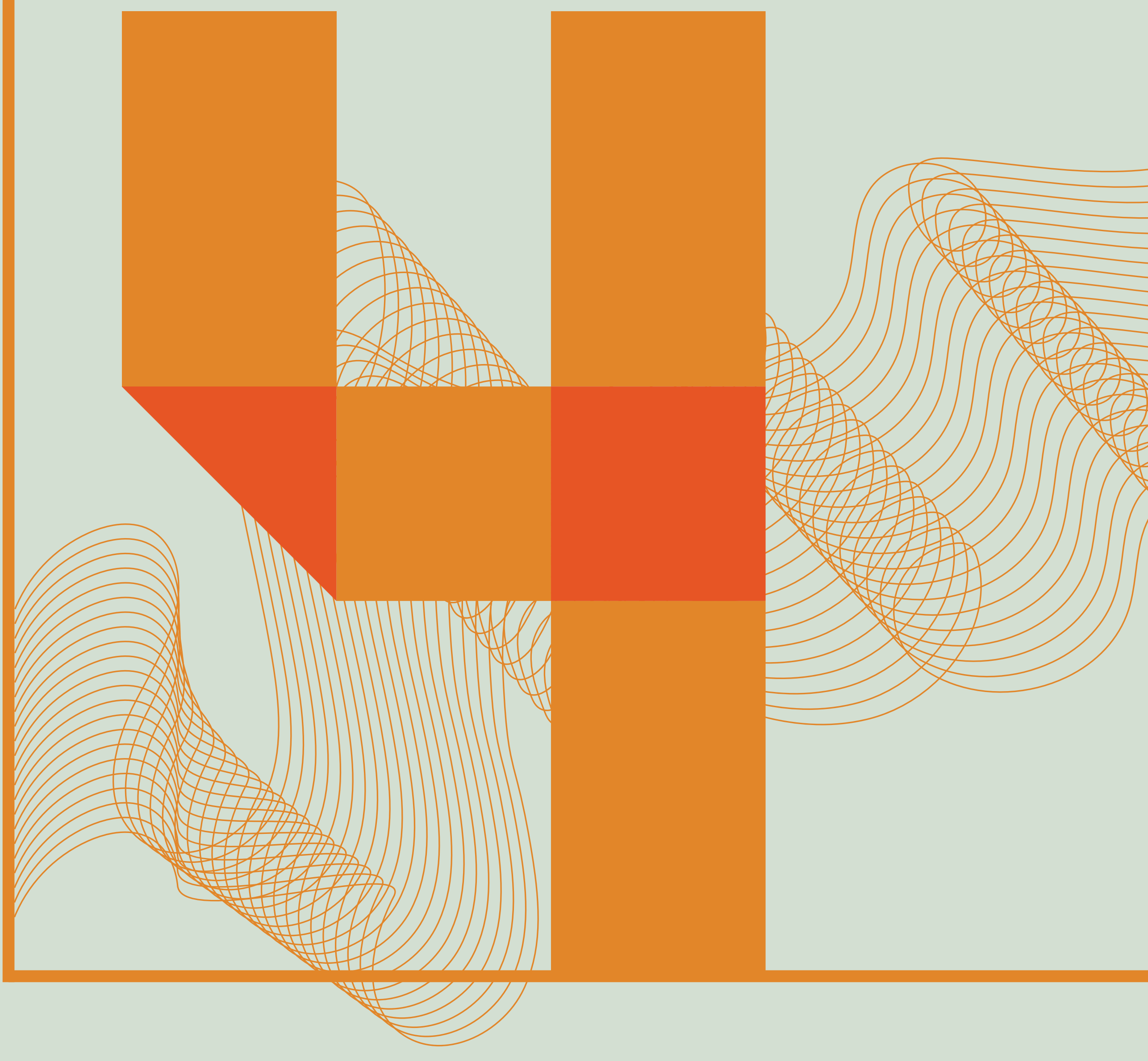
- The combined measurement uncertainty of CH_4 emissions from manure management is 95.39%

Detailed information on uncertainty calculations per sector and per gas is included in Annex 4.

TABLE 3.12:
Estimates of measurement uncertainties for key categories of GHG emissions (1990–2017)

Category	Gas	Estimated CO_2eq (Gg) emissions for 1990	Estimated CO_2eq (Gg) emissions for 2019	Estimated uncertainty of activity (%)	Estimated uncertainty of emission factors (%)	Combined measurement uncertainty (%)
Aluminium production	CF_4	1240.16	37.69	2	30	30.7
Road transport	CO_2	2.67	2.67	5	50.00	50.25
Electricity production – liquid fuel combustion	CO_2	1088.79	1259.48	12.25	23.18	26.21
Enteric fermentation	CH_4	483.90	216.94	48.99	97.98	109.54
Manufacturing and construction – Liquid fuel combustion	CO_2	215.97	187.94	18.03	18.03	25.749
Manure management	CH_4	83.92	40.68	52.92	79.37	95.39
Aluminium production	CO_2	168.67	62.95	2	10.00	10.20

CLIMATE CHANGE MITIGATION



Montenegro is a non-Annex-I party to the UNFCCC and a party to the Kyoto Protocol. Montenegro also ratified the Paris Agreement in December 2017. Therefore, the Government has a clear and ambitious commitment to join the international efforts to combat climate change by actively reducing GHG emissions. With a view to this ratification, Montenegro previously submitted its INDC to the UNFCCC Secretariat, in which the country outlined a national goal of a 30% GHG emission reduction by 2030 (excluding the land use change sector) against a 1990 baseline. The Ministry of Sustainable Development and Tourism, through its Directorate for Climate Change, officially coordinates climate-change-related policies in the country. Some policies which impact climate change are under the responsibility of other ministries; these include the Ministry of the Economy, the Ministry of Transport and Maritime Affairs, and the Ministry of Agriculture and Rural Development. The National Climate Change Strategy (NCCS) 2030 is the key strategic overview in the area of climate change in Montenegro. It provides guidance and direction for climate change policies until 2030, as well as analysis of the mitigation policies measures and actions that will be implemented during this period to reduce GHG emissions.

4.1 Greenhouse projections and scenarios

All the sectors recognized by the IPCC methodology (Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry, and Other Land Use (AFOLU); and Waste) have been assessed to estimate the mitigation potential of certain measures and policies. The GHG projections have been produced under low, medium, and high economic growth scenarios for business as usual (BAU)/with existing measures (WEM), and with additional measure (WAM) scenarios:

1. **The without measures (WOM)** reference scenario, which could also be considered as a business-as-usual (BAU) or "do-nothing" scenario
2. **The with existing measures (WEM)** mitigation scenario which includes targeted actions to reduce GHG emissions that are underway and have been agreed by relevant stakeholders; and
3. **With additional measures (WAM),** a more ambitious mitigation scenario, where the measures are being discussed but are not guaranteed to happen and/or require investments that have not yet been found.

The starting point of the assessment was Montenegro's 2015 greenhouse gas inventory. A spreadsheet tool was developed to calculate the baseline GHG projections and mitigation savings covering the time period from 2020 to 2030. Where possible, internationally recognized methodologies have been applied to generate GHG emissions projections and Policies and Measures (PaMs) savings. This is often supplemented and underpinned by information and assumptions using national expertise. The baseline for all projections is the historical emissions inventory, which has been compiled and recalculated for several years based on the IPCC Guidelines.[1] The historical inventory has formed part of Montenegro's Biennial Update Reports (BUR) and National Communications (NC) submissions to the UNFCCC. The inventory has therefore been assessed and verified through subsequent international review processes. There is an improvement programme to ensure that methodologies, datasets, and QA/QC procedures are effective and in line with best practice.

The economic growth scenarios are derived from recent World Bank and IMF reports (see Table 4.1). These will affect the emissions projections (as growth scenarios, in some areas of the economy, are expected to be correlated with emission trends).

TABLE 4.1:
GDP growth scenarios

Growth scenario	2018	2019	2020	2021	2022	2023	2024	2025	2030
GDP growth – high case	4.9	2.9	2.5	2.5	2.5	2.5	2.5	2.5	2
GDP growth – low case	4.9	2.9	2.4	2	1	1	0.5	0	−0.5
GDP growth – medium case	4.9	2.9	2.4	2.3	2	1.75	1.5	1.25	0.75

The three economic growth scenarios are:

- **High case** – this is based initially on recent World Bank projections, and then uses the IMF high scenario figures from 2021.
- **Low case** – this is based on a recent IMF low-growth scenario.
- **Medium case** – this profile converges on the IMF central projection for Montenegro.

The medium case growth scenario is deemed the most reasonable one and is selected as the default basis for BAU projections (and therefore the basis for further analysis) in the mitigation tool.[2] In order to determine the GHG emissions impact and savings for WEM and WAM measures, specific activity data or emissions projections have been obtained from relevant national experts/facilities where available. Alternatively, assumptions have been applied to create drivers for projections. This may be based on expected impacts on activity data e.g. fuel consumption, industrial production, or fuel switching.

Finally, simple indicator datasets may have been applied to drive emissions projections; typically these will be commonly available indicators of projected population or economic development, such as GDP. For each individual measure, the costs of implementation were also estimated.

[1] https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

[2] The high and low options provided are not at this time intended as fully defined economic limits. For example, it is noted that selection of the low case GDP growth scenario produces a negative growth outlook beyond 2026. Under existing national circumstances this is not considered a likely outcome but is included to provide tool users with a wider understanding of how GDP growth scenarios may impact GHG mitigation needs. As with all the baseline data in the tool, the scenarios may be updated as alternative data becomes available at the national level.

In line with GHG inventory compilation reporting requirements (known as 'common reporting format' (CRF) codes), the following sectors are covered:

- Energy (stationary energy combustion, including fuel combustion in the power generation sector, industry and the residential/commercial/public sectors, and mobile energy combustion, i.e. transport);
- Industrial processes and product use (IPPU);
- Agriculture;
- Land use, land use change, and forestry (LULUCF); and
- Waste.

Methodology: Mitigation tool

A mitigation tool has been developed to accompany this report. The tool enables users to view and control the selection of scenarios in order to consider the alternative resultant GHG projections.

The starting point of the assessment was Montenegro's 2015 greenhouse gas inventory. A spreadsheet tool was developed to calculate the baseline GHG projections and mitigation savings covering the time period from 2020 to 2030. The tool takes into account a number of assumptions on the underlying economy and economic activities in Montenegro during this time period including:

- That domestic economic growth is the main driver of WOM final demand for energy services (i.e. demand for heating, lighting, transport and the services of electrical plant/appliances). The relationships between recent economic growth (2014 to 2017) and trends in sector-level energy demand have been analysed and then projected forward to 2030, according to economic growth assumptions (see below).

- However, for energy combustion and industrial processes, the majority of emissions is driven by other factors. Therefore, for three plants (the large coal-fired thermoelectric power plant (TPP) in Pljevlja, the aluminium smelter, and the iron and steel works) projected energy and emissions use to 2030 have been individually tailored. An eco-upgrade of Pljevlja TPP will be performed.

- In 2020–2021, for four months during each year, the plant will not be operating. Emissions are therefore predicted to be much lower in these years. It is also anticipated that there will be a minor reduction in annual generation, starting from 2023 and then a more significant decrease in generation will take place starting from 2025, due to the introduction of the EU Emissions Trading Scheme (ETS). For iron and steel, it has been assumed that demand and hence emissions will stay constant through to 2030. Further information is provided in the WEM section (Section 1.5).

– Montenegro is heavily dependent on imports of electricity. Provisional data from 2017 suggests 1.2 TWh was imported, which compares with 1.3 TWh of domestic coal-fired power and 1.1 TWh of renewable electricity production. The role of renewable power has been growing and that is expected to continue as WEM and WAM options are taken up.

4.2 Summary of the 'without measures' (WOM) reference scenario

The WOM scenario is a reference case that has been substantially updated from the second BUR. It should be noted that this scenario has no likelihood of occurring, because, as its name implies, it does not take into account any measures that have been implemented since 2015. It is of use, however, because it allows the impact of the WEM and WAM scenarios both financially and in terms of GHG emission reductions to be compared against a reference scenario.

The following sectors are included in the WOM scenario (and others):

- **Energy – stationary combustion:** The stationary energy sector includes both combustion in the power generation sector as well as in industry. For the former, there is also only one relevant fossil-fuel-fired plant: The thermoelectric power plant (TPP) in Pljevlja. This installation is the only national source of fossil-fuel-fired electricity for public consumption. The energy fuel demand consumption of the plant and its associated emissions are very significant. However, it is worth noting that imports of electricity and renewables are playing a similar and growing role. In 2017, provisional data from MONSTAT showed TPP power production of 1.3 TWh, net imports of 1.2 TWh, and renewable power production of 1.1 TWh.
- **Energy – mobile combustion:** Energy mobile combustion emissions are dominated by road transport. International aviation emissions are also important and currently are approximately 10% of the total for road transport emissions. If or when Montenegro joins the EU, flights between locations in the European Economic Area will be subject to the EU ETS[3].
- **Agriculture**: Agriculture is a source of methane (CH_4) and nitrous oxide (N_2O) for Montenegro, stemming from livestock and the use of fertilizers.
- **Industrial processes and product use** – the dominant source of emissions in this sector is that arising from the aluminium plant and F gases from the refrigeration sector.
- **Land use, land use change and forestry:** The National Forest Strategy published in March 2014 is the dominant source of information for developing the baseline and mitigation options for this sector. The NŠS mainly builds on the results of the first National

[3] The national air carrier Montenegro airlines has been already included in EU–ETS aviation activities.

Forest Inventory of Montenegro, published in 2013 and forest-sector data published annually by MONSTAT (State Statistical Office).

- **Waste:** Solid waste disposal is responsible for a large amount of methane emissions. Domestic wastewater treatment and discharge produce significant, but relatively low emissions of methane and nitrous oxide.

The WOM scenario contains the following assumptions:

- The economy grows under a medium case scenario, which is based on World Bank projections and then converges on a central IMF projection for Montenegro.
- The thermoelectric power plant will continue to run at current levels, i.e. 1.3 TWh per annum through to 2030;
- For the iron and steel plant, it has been assumed that energy demand and emissions would remain constant from the base year (2015) through to 2030. For Other industries it has been assumed that for each percentage point growth in the wider economy, growth in energy demand in the "Other industries" group is assumed to be 1.1%. For transport the figure was 1.2%;
- GHG projections for the agriculture sector are based on those developed by the UN Food and Agricultural Organization (FAO);[4]

Projections for the waste sector are driven by the growth of energy demand by household and others.

By sector, the WOM results show the following:

- Emissions from the **energy combustion sector** across all years are dominated by those from the Pljevlja coal-fired electricity generation plant and from road transport.
- In the **agriculture sector**, emissions from manure management will make up approximately 50% of the GHG emissions in 2030.
- In the **land use sector**, living biomass is an important sink of emissions.
- In the **waste sector**, the largest contribution is from solid waste disposal, with an 88% share in 2030.

The overall WOM results are shown in Figure 4.1 and Figure 4.2 below with the corresponding data provided in Table 4.2.

[4] http://www.fao.org/global-perspectives-studies/food-agriculture-projections-to-2050/en/.

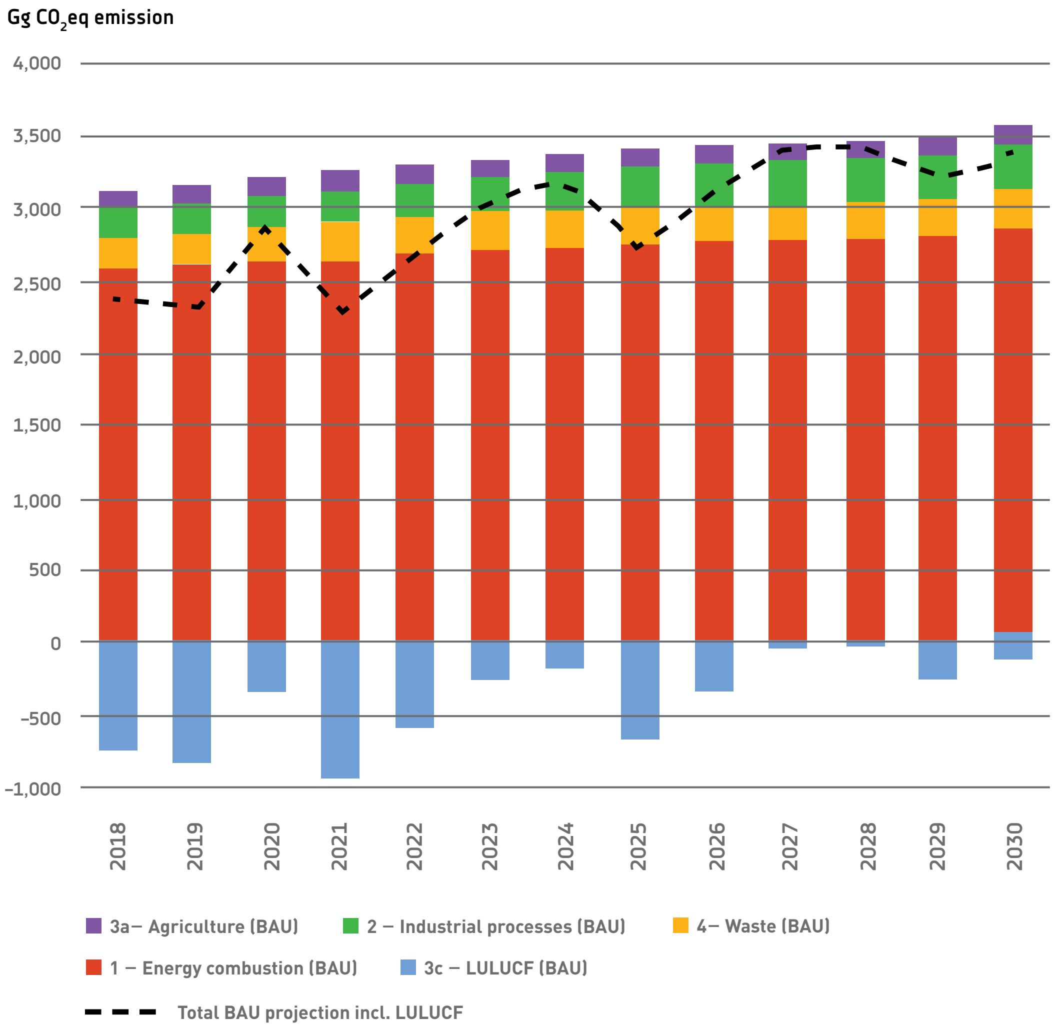


FIGURE 4.1 Estimated GHG emissions under the WOM/BAU scenario including LULUCF

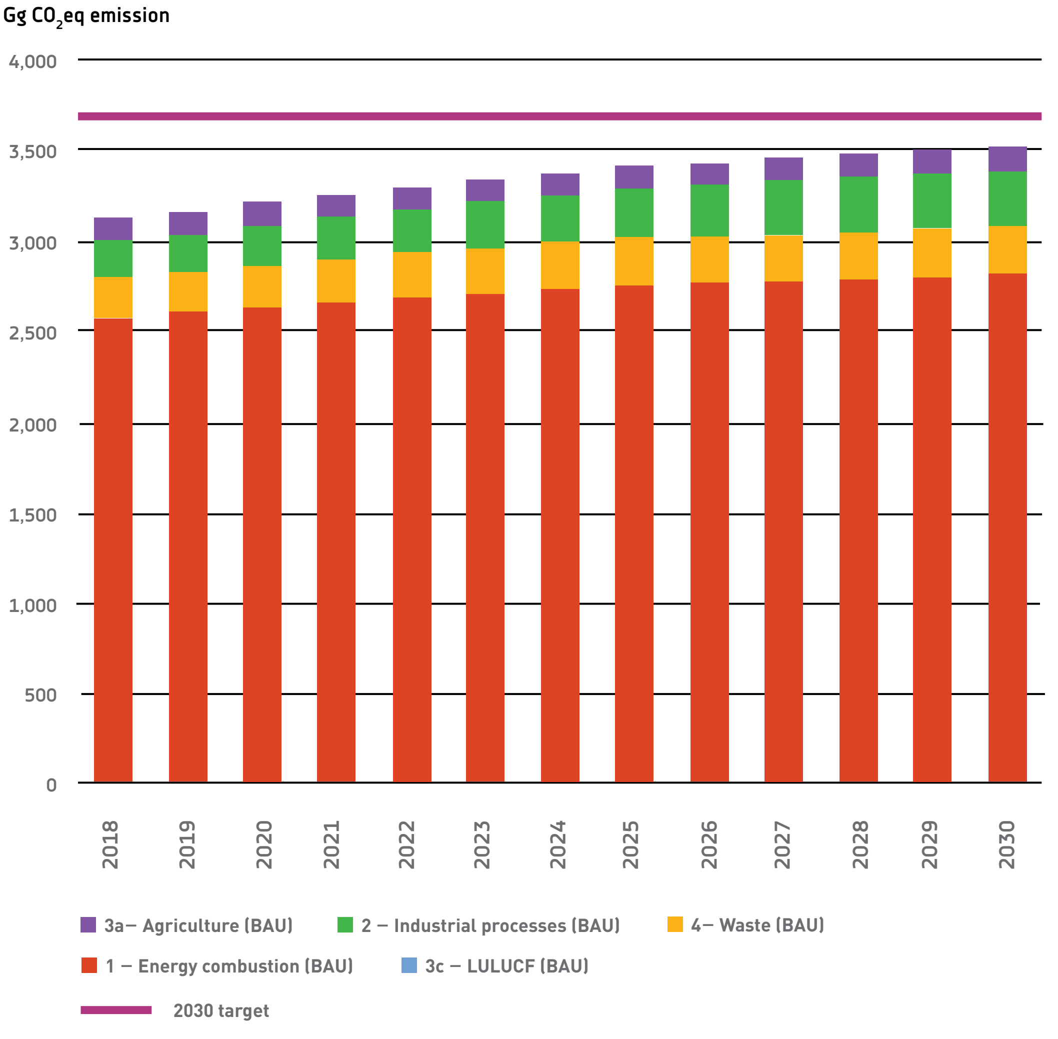


FIGURE 4.2 Estimated GHG emissions under the WOM/BAU scenario excluding LULUCF

TABLE 4.2:
Estimated GHG emissions under the WOM scenario (Gg CO_2eq)

	2018	2020	2022	2024	2026	2028	2030
Energy	2581	2645	2698	2741	2772	2794	2815
IPPU	203	215	243	270	290	301	308
Agriculture	123	124	125	126	127	128	129
LULUCF	–760	–345	–600	–185	–341	–41	–198
Waste	218	226	234	242	250	258	266
TOTAL excl. LULUCF	3125	3211	3301	3380	3439	3481	3519
TOTAL incl. LULUCF	2365	2866	2701	3195	3099	3440	3321

NOTE: *the sum of the component parts may not exactly equal the totals shown due to rounding*

4.3 Mitigation measures by sector

Montenegro has set an ambitious GHG mitigation target through its INDC, which is for a 30% reduction (excluding the LULUCF sector) in GHG emissions by 2030 (compared to the reference year 1990). At the time of producing the NDC, this equated to target GHG emissions of 3,667 Gg CO_2eq in 2030. Montenegro already achieved and exceeded this target in 2013 and continued to meet it in 2014 and 2015. This was achieved as a result of reduced economic activity by Podgorica Aluminium Plant (KAP) and in the agricultural sector, as well as a general decline in industrial activity since 1990 due to the financial crisis.

Montenegro's need to continue to reduce GHG emissions has been taken seriously by the Government, despite conflicting economically attractive opportunities for local coal and lignite, and a flourishing tourist industry. Montenegro plans to continue to use the energy resources trapped in the form of its coal deposits; hence plans for the modernization of its coal combustion plant to ensure the long-term stability of the power system and a reliable power supply from which to launch its low-carbon strategy. In the period 2017–2030, Montenegro hopes to continue to reduce GHG emissions without jeopardizing economic growth through specific actions in the key sectors: the energy sector, industrial processes and product use, agriculture, LULUCF, and the waste sector.

ENERGY SECTOR

Methodology to compile WEM and WOM projections

Economic growth is the main factor determining the growth in demand for energy services (i.e. demand for heating, lighting, transport, and the services of electrical plant/appliances). Emissions growth is rather different, because of the importance of the thermoelectric power plant (TPP) and Uniprom's aluminium smelter within Montenegro's total emissions. These two plants' emissions (as is the case with the smaller iron and steel works) are driven primarily by shareholder decisions, either by the Government (in the case of "Pljevlja" TPP) or by private shareholders (in the case of aluminium and iron and steel). Those decisions are probably influenced by international market outcomes and prospects, rather than national economic growth. For instance, the TPP sells its output at a benchmark price set on the international energy market; both the aluminium and iron and steel plants must sell their products on the international markets.

The Montenegrin economy has been categorized for this analysis using the IPCC/UN common reporting format (CRF) headings. The tables below show the sectors and subsectors analysed and projected under the three sections of interest in this chapter of the report.

In terms of direct GHG emissions, the subsector 1A1 – Energy Industries, has only one relevant sub-category: 1A1a – Public Electricity and Heat Production. Within this subcategory there is also only one relevant fossil-fuel-fired plant: the thermoelectric power plant (TPP) in Pljevlja. This installation is the only national source of fossil-fuel-fired electricity for public consumption. The energy demand of the plant and its associated emissions are very significant. For instance, in 2019 its GHG emissions are expected to make up about half of all the energy and industrial emissions from Montenegrin territory.

Whilst the significance of "Pljevlja" TPP is very important for the national power system, it is worth noting that imports of electricity are playing a similar and growing role. The role of national renewable power is also of a similar order and also expected to grow. In 2017 provisional data from MONSTAT shows TPP power production of 1.3 TWh, net imports of 1.2 TWh, and renewable power production of 1.1 TWh.

Table 4.3 below shows a summary list of the proposed mitigation measures for the energy industry sector and the type of scenarios considered. Further detail on each measure is also provided – along with indications about whether the scenario is linked to the European Emissions Trading System (ETS).

TABLE 4.3:
Summary of the proposed mitigation measures for the energy sector

ID	Measure	Description
1E		The eco upgrade is planned to start soon. This will entail the plant being out of operation for four months each year in 2020 and 2021. It is then envisaged that there will be a reduction in generation due to low market prices and then as a result of the ETS from 2025. In accordance with the Decision of the Ministerial Council of the Energy Community on the implementation of Directive 2001/80/EC on the reduction of emissions of certain pollutants/installations with a large combustion plant of the Energy Community, the TPP will operate with a reduced capacity of 20,000 operating hours in the period 2018–2023.
2E		It is assumed that the new renewable power plants that cover the country's electricity deficit will have no impact on GHG emissions. The electricity generation from new renewable power plants will only contribute to a GHG emission decrease once there is no electricity deficit.
3E		This measure will be implemented following the eco upgrade of the TPP, and its implementation is expected to further reduce GHG emissions, due to reduced coal use in individual combustion plants in the city.
4E		This measure has a major impact on the refurbishment of existing buildings and new buildings, as all fully refurbished buildings and new buildings must meet the minimum requirements. The estimated energy savings are presented in the NEEAP*.
5E		The goal of this measure is to improve energy efficiency and comfort conditions in selected public-sector buildings. €70m will be invested in various phases starting in 2020.

* Ministry of the Economy (2019).

6E	Financial incentives for citizens (for EE investments)	The objective of this measure is to make financial support mechanisms available to individuals for investing in energy efficiency and renewable energy sources. It includes an introduction of dedicated state and local government support programmes.
7E	Energy labelling and eco design requirements for energy-related products	In order to provide conditions and practices for the labelling and eco design requirements of devices, an appropriate legal framework is already in place obliging market players for placing certain products on the market. The estimated energy savings are presented in the NEEAP**.
8E	Establishing and implementing energy efficiency criteria in public tendering	The main objective of this measure is to establish systematic mechanisms for introducing energy efficiency criteria into the public procurement process, in order to achieve significant energy savings and achieve economic and other benefits. The implementation of this measure is one of the preconditions for meeting the requirements for environmental protection.
9E	Establishing and implementing energy efficiency criteria in public tendering	This includes public lighting, water supply and sewerage, and other utilities.
10E	Development of a transmission and distribution power grid (decrease in losses)	Montenegrin grid operators will invest in the grid in order to accommodate new consumers and power plants. This will result in a reduction in grid electricity losses.
11E	Refurbishment of hydroelectric power plants (increased EE)	The energy savings corresponding to this measure are achieved by replacing the existing, outdated electrical and mechanical equipment (presently available power transformers are characterized by higher efficiency due to higher regulatory requirements).
ADDITIONAL MEASURE IN THE 'WITH ADDITIONAL MEASURES' SCENARIO (WAM)		
12E	New renewable power plants	This measure introduces additional renewable power plants which are not currently in the definite plans. The following are included: HPP Morača, HPP Komarnica and SPP Velje Brdo. The GHG reductions and costs include the WEM element.

** Ministry of the Economy (2019)

Measure 1E: Eco upgrade of the thermoelectric power plant, Block 1

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Eco upgrade of the thermoelectric power plant, Block 1	WEM	2020–2021	Yes	€65m	221 Gg

An eco-upgrade of Pljevlja TPP will be performed during 2020–2021, during which for four months each year, the plant will not be operating. The upgrade includes flue-gas desulphurization (FGD) and selective catalytic reduction (SCR) systems, which will be implemented according to the recent law approximating the EU's Industrial Emissions Directive (IED – 2010/75/EU) as well as the Best Available Technique (BAT) requirements. These new installations will use up about 1.4% of the plant's annual generation, but this will not result in a decrease in CO2 emissions, since the same amount of coal will be combusted. However, the installation of FGD and SCR systems will increase the generated electricity price, which may affect the plant's operation during the low market prices periods. For the sake of the WEM scenario, a projection of market electricity prices is considered and it is concluded that there will be a need for minor reductions in the annual generation starting from 2023 due to the market price. A more significant decrease in generation will take place starting from 2025, due to the introduction of the EU Emissions Trading System (ETS). The price per kWh generated is increasing based on the cumulative effect of installation of the FGD and SCR systems and carbon pricing related to the EU ETS, which will make this plant less competitive on the market in the case of BAU generation capacity.

Measure 2E: New renewable power plants

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
New renewable power plants[5]	**WEM**	**2020–2030**	**No**	**€766m**	**21 Gg**

In order to make an estimate of the impact of new renewable power plants on the country's GHG emissions, a forecast of electricity demand has been prepared using the available national documents.[6,7] Along with the envisioned new renewable energy source (RES) plants, RES electricity generation is forecast to increase by nearly 1,200 GWh in 2030. It is assumed that whilst the country has an electricity deficit there is no impact on GHG emission levels; however, when there is no electricity deficit in the country, then a decrease in emissions will be seen as a result of the measure. The GHG reduction has been calculated using the national grid emission factor (0.34 Gg CO_2/GWh).

The following renewable power plants are taken under consideration:

- The new G8 turbine-generator unit in Perućica Hydroelectric Power Plant (HPP) (an additional 58.5 MW, 190 GWh generation per year)
- Reconstruction of Piva HPP (an additional 21 MW, 53 GWh)
- Reconstruction of old small HPPs (an additional 1.8 MW, 4.2 GWh)

[5] These include: the new G8 turbine-generator unit in Perućica Hydroelectric Power Plant (HPP), reconstruction of Piva HPP, reconstruction of old small HPPs, construction of small HPPs, the Gvozd Wind Power Plant (WPP), Brajići WPP, Briska Gora Solar Power Plant (SPP) and Biomass sTPP.
[6] Energy development strategy to 2030 with Action Plan 2016–2020, Ministry of the Economy, 2012..
[7] Transmission System Development Plan, 2020–2029.

- Construction of small HPPs (46.5 MW, 151 GWh)
- Gvozd Wind Power Plant (WPP) (50 MW, 139 GWh)
- Brajići WPP (75 MW, 208 GWh)
- Briska Gora Solar Power Plant (SPP) (250 MW, 300 GWh)
- Biomass sTPP (39 MW, 117 GWh)

Table 4.4 below presents an overview of the projected electricity production for the period 2020 to 2030.

TABLE 4.4:
Overview of power plants with respective projected electricity production [GWh] for selected years

Year /Power Plant	2020	2022	2024	2025	2026	2028	2030
Perućica HPP G8	0	0	190	190	190	190	190
Piva HPP reconstruction	0	0	53	53	53	53	53
Reconstruction of old SHPPs	0	4.2	4.2	4.2	4.2	4.2	4.2
New additional SHPPs	25	75	125	151	151	151	151
Gvozd WPP	0	139	139	139	139	139	139
Brajići WPP	0	208	208	208	208	208	208
Briska Gora SPP	0	60	60	120	120	300	300
Biomass sTPP	0	12	36	48	60	84	117
TOTAL	25	498.2	815.2	913.2	925.2	1129.2	1162.2

Measure 3E: District heating in Pljevlja

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
District heating in Pljevlja	WEM	2020–2030	No	€23m	12 Gg

The district heating development in the town of Pljevlja will occur after the eco upgrade of Pljevlja TPP. However, while the TPP is being refurbished, the preparatory works relating to the new heating system connection will be completed. The heating project will improve the long-lasting air pollution problem and other urgent environmental and public health issues in Pljevlja and its surroundings. The citizens of Pljevlja burn, for heating purposes, around 80% of the total coal used in the residential sector in the country. So, the air in Pljevlja during the winter season is heavily polluted (with SO_2, NO_x, $PM_{2.5}$, PM_{10}, ash, and dust), which are mostly the by-products of lignite combustion in individual furnaces in around 5,000 households.[8,9] The main objective of the DH project is to supply the town of Pljevlja with heat energy via a modern centralized heat supply system, from a central source, that will mean that households' coal stoves will no longer be used. It is assumed that this project will eliminate lignite as a fuel used for heating purposes in Pljevlja at the latest by 2030. The phasing out of lignite used in the residential sector in the Municipality of Pljevlja will result in GHG emission reductions that follow the anticipated decrease in lignite throughout the observed period.

Measure 4E: Development and implementation of energy efficiency regulatory framework in buildings

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Development and implementation of energy efficiency regulatory framework in buildings	**WEM**	**2020–2025**	**No**	**N/A**	**155 Gg**

This is a measure ensuring compliance with the standards relevant to the minimum requirements of buildings energy performance. The development of energy efficiency regulations for buildings is closely linked to meeting the requirements of the EU's Energy Performance in Buildings Directive (EPBD – 2010/31/EU) and the Energy Efficiency Directive (EED – 2012/27/EU), and activities based on the requirements of these directives will continue to be implemented in the coming period.[10]

Implementation mechanisms include control of: i) minimum energy efficiency requirements, ii) the certification obligation of both new and reconstructed buildings prior to their use, iii) the energy performance certificates correctness, iv) as well as inspection.

This measure is expected to have a major impact on the existing buildings refurbishment, as all refurbished buildings must meet the minimum requirements. The estimated energy savings are presented in the most recent (2019) National Energy Efficiency Action Plan (NEEAP).

[8] The Action Plan for the development and larger use of district heating and/or cooling and high-efficiency cogeneration in Montenegro.
[9] Final report – Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development.
[10] Energy Efficiency Programme for Public Buildings, Phase II – Realization Report 2015–2019.

Measure 5E: Increased energy efficiency in public buildings

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Increased energy efficiency in public buildings	WEM	2020–2030	No	€70m	23 Gg

The goal of this measure is to improve energy efficiency and comfort conditions in selected public-sector buildings. The implementation of the measure is expected to initiate the development of the services market in the construction sector and cause a positive impact on the overall socio-economic environment. It is also expected to achieve results in the area of environmental conservation.

Developed countries' experiences show that energy efficiency programmes in public buildings are an effective driving mechanism to motivate authorities at the state and local levels to implement their own energy efficiency programmes. These investments are also linked with the requirements of the EED.

Measure 6E: Financial incentives for citizens (for energy efficiency investments)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Financial incentives for citizens (for energy efficiency investments)	WEM	Current to 2030	No	€1.3m	4 Gg

The objective of this measure is to make financial support mechanisms available to individuals for investing in energy efficiency and renewable energy sources (RES). It includes an introduction of dedicated state and local government support programmes for the use of available RES. Measures that contribute to reducing energy needs, as well as use of solar energy and modern forms of biomass (pellets, briquettes, wood chips) should be primarily encouraged. Some of the programmes include:

- interest-free loans for the installation of modern biomass heating systems
- installation of photovoltaic solar systems in remote rural areas (off-grid PV systems)
- interest-free loans for improving the energy performance of the building envelope
- a subsidy programme for the installation of solar systems in new buildings, through the reduction of utility taxes (compensation for equipping communal land).

The estimated energy savings are presented in the National Energy Efficiency Action Plan. Existing programmes related to this measure have already been implemented and have been highly successful – indicating that if they are extended/scaled up the impact can be even larger.

Measure 7E: Energy labelling and eco design requirements for energy-related products

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Energy labelling and eco design requirements for energy-related products	**WEM**	**2020–2030**	**No**	**€14m**	**288 Gg**

The energy labelling and eco design requirements reflect the approximation of the EU's directives/regulations for energy-related products[11]for the Montenegrin context. The energy labelling legal provisions require that economic operators provide customers with information about the energy consumption of the devices. The eco design requirements set the minimum energy efficiency standards (and in some cases pollution standards) for a number of products, meaning that if they do not meet these standards they cannot be put on the market. These two areas of regulatory intervention choices depending on the energy efficiency of the devices available on the market.

In order to provide conditions and practices for the labelling and eco design requirements of devices, an appropriate legal framework is already in place obliging market players (suppliers and distributors) to comply with a number of legal requirements for products. Furthermore, training has been carried out for market inspectors to ensure that these regulations are complied with by economic operators. The estimated energy savings are presented in the National Energy Efficiency Action Plan published in 2019.

Measure 8E: Establishment and implementation of energy efficiency criteria in public tendering

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Establishment and implementation of energy efficiency criteria in public tendering	**WEM**	**2020–2030**	**No**	**Negligible**	**9 Gg**

[11] See here: https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign_en.

The main objective of this measure is to establish systematic mechanisms for introducing energy efficiency criteria into the public procurement process, in order to achieve significant energy savings and achieve economic and other benefits.

Considering that the public sector is a very important contracting authority for goods and services relevant to the energy consumption aspect, successful implementation of this measure can significantly transform the market towards more energy-efficient solutions, reducing the price of new technologies and promoting their wider use.

The implementation of this measure is one of the preconditions for meeting the requirements of the EU's Energy Efficiency Directive approximation.

Measure 9E: Implementation of energy efficiency measures in public municipal companies

Name	Scenario	Implementa tion timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Implementation of energy efficiency measures in public municipal companies	**WEM**	**2020–2024**	**No**	**€5.12m**	**12 Gg**

This measure accounts for the improvement of condition, monitoring, and maintenance, as well as investments in order to improve energy efficiency related to:

- public lighting
- water supply and sewerage
- other utilities

Measure 10E: Development of transmission and distribution power grid (decrease of losses)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Development of transmission and distribution power grid (reduction of losses)	**WEM**	**2020–2030**	**No**	**Approx. €704m**	**54 Gg**

The transmission and distribution grid suppliers have the obligation to provide enough grid capacity in order to enable a reliable electricity supply for all grid users (producers and consumers). However, there are electricity losses where the grid is not well-dimensioned. Therefore, grid operators invest in grid capacities and the grid control in order to improve grid operation and efficiency. Montenegrin grid operators are investing in the grid in order to accommodate new consumers and power plants. This will result in a decrease in the grid electricity losses.[12] A reduction in losses will directly affect the electricity deficit or the amount of electricity available for export. The effect of this measure on GHG emissions is estimated using the national grid emission factor.

Measure 11E: Refurbishment of hydroelectric power plants (increased EE)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Refurbishment of hydroelectric power plants (increased EE)	**WEM**	**2020–2022**	**No**	**Approx. €48m**	**10 Gg**

The operating life of the hydroelectric power plants Piva HE and Perućica HE, and the small hydroelectric power plants Rijeka Crnojevića, Podgor, Šavnik, Mušovića Rijeka, and Lijeva Rijeka is over 50 years. There is a clear need for a thorough revitalization in order to extend their operations, increase operational reliability and increase the energy efficiency i.e. increase the utilization of the hydroelectric power plant as a whole. As part of this revitalization, the reconstruction/replacement and modernization of equipment and facilities will be performed. The energy savings[13] corresponding to this measure are achieved by replacing the existing, outdated electrical and mechanical equipment which is operating outside the factory characteristics that are far from the modern solutions available on the market (presently available power transformers are characterized by higher efficiency due to higher regulatory requirements). The realization of this measure will start from 2020, and will be finalized in 2022, so its effect is visible throughout the whole observed period.

[12] See Ministry of the Economy (2019) Energy Efficiency Action Plan for the Period 2019–2021.
[13] See Ministry of the Economy (2019) Energy Efficiency Action Plan for the Period 2019–2021.

Measure 12E: New renewable power plants (WAM)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
New renewable power plants (WAM)	WAM	2025–2030	Yes	Approx. €1,512m	381 Gg

This measure introduces additional renewable power plants which are not currently in the definite plans (there is no tendering procedure or contracts signed). The following renewable power plants are considered within this scenario:

- Morača HPP (238.4 MW, 693 GWh)
- Komarnica HPP (156 MW, 213 GWh)
- Velje Brdo SPP (50 MW, 60 GWh)

The effect of the generation from these renewable plants on GHG emission is calculated using the same principle as Measure 2E. Table 4.5 below shows an overview of the power plants with respective production in the period between 2020–2030.

TABLE 4.5:
Overview of power plants with respective production [GWh]

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Morača HPP	0	0	0	0	0	693	693	693	693	693	693
Komarnica HPP	0	0	0	0	0	213	213	213	213	213	213
Velje Brdo SPP	0	0	0	60	60	60	60	60	60	60	60
Total	0	0	0	60	60	966	966	966	966	966	966

TRANSPORT SECTOR

Fuel combustion emissions in transport are dominated by road transport. International aviation emissions are also important, as they are about 10% of road transport GHG emissions. They are not currently required to be reported for UNFCC GHG inventory purposes, however, the element that is associated with flights between locations in the European Economic Area would become subject to the EU ETS when Montenegro joins.

As was the case for "other industry" the trend in total transport energy demand was compared with the trend in economic growth and a ratio or multiplier factor determined ("transmult" in the Assumptions tab of the tool). The value of this ratio is 1.2, meaning that for each percentage point growth in the wider economy, growth in energy demand in transport is assumed to be 1.2%. Rapid growth in demand for transport services is not unexpected given the relatively low base level of demand.

According to the study on electric mobility , there are two scenarios for the penetration of electric vehicles in the current Montenegrin vehicle stock – a vehicle stock that includes 206,000 vehicles. The second scenario is regarded as optimistic and it is treated in the WAM scenario. Table 4.6 presents a summary of the proposed mitigation measures in the transport sector.

TABLE 4.6:
Summary of the potential mitigation measures for the transport sector

ID	Name	Note
1T		It is assumed that 13,000 electric cars will replace diesel cars.*
2T		This scenario assumes 21,000 electric cars. The GHG reductions and costs include the WEM element.

* This assumption can be justified assuming that professionally driven vehicles (such as delivery vehicles and buses) will be amongst the first to switch due to the relative financial benefits of a vehicle driven more km in a year.

Measures 1T (WEM) and 2T (WAM): Electric cars

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Electric cars (WEM)	WEM	2020–2030	No	Approx. €381m	23 Gg
Electric cars (WAM)	WEM	2020–2030	No	Approx. €622m	38 Gg

Results of the WEM scenario show that by 2030 there will be approximately 12,000 electric cars in Montenegro. Table 4.7 below shows details from the projection.

TABLE 4.7:
WEM scenario of electric vehicle number increase

WEM	2025	2026	2027	2028	2029	2030
Number of electric vehicles	1,419	2,255	3,765	5,944	8,881	12,674
Share in the total vehicle stock (%)	0.60	1.00	1.60	2.50	3.60	5.00

Results of the WAM scenario – a more optimistic scenario for the increase in vehicles – estimates that by 2030, there will be approximately 21,000 electric cars in Montenegro. Table 4.8 below shows details from the projection.

TABLE 4.8:
WAM scenario of electric vehicle number increase

WAM	2025	2026	2027	2028	2029	2030
Number of electric vehicles	2,189	3,613	6,185	9,899	14,815	21,054
Share in the total vehicle stock (%)	0.90	1.40	2.30	3.50	5.10	7.10

In order to estimate GHG savings, several assumptions according to Montenegrin statistics and studies are taken into account:

- average annual mileage of replaced car is 10,000 km.
- average diesel consumption of a replaced car is 7 l/km.
- average energy consumption of an electric vehicle is 16 kWh/100 km.

The GHG savings result from the decreased consumption of diesel fuel due to the penetration of electric vehicles in the fleet wherein the emissions factor per km travelled for electricity is lower than for diesel fuel.

INDUSTRIAL PROCESSES AND PRODUCT USE

Aluminium production

Process emissions from the anode effects at the aluminium smelter are, by far, the largest element in industrial process GHG emissions (about two-thirds). The only representative of the nonferrous metal industry in Montenegro is the aluminium smelter – KAP. Information gathered during investigation of potential mitigation in this area suggests that output of aluminium billet from the Uniprom smelter was around 40,000 tonnes in 2018. Also, the mission found that it is possible to increase output to a maximum of 60,000 tonnes from 2022 and continue at that level to 2030. This production profile has been assumed for estimating the mitigation potential for the sector.

Non-ferrous (aluminium) CO_2eq emissions originate from the use of fuel oil for energy at the plant (relatively modest) and the very significant process emissions from the anode in the smelter. Published data suggests that process emissions from the anode per tonne of output were 2.34 tCO_2eq (2014–2015). The World Aluminium Association has a benchmark of 1.52 tCO_2eq per tonne of output for anode effects – indicating that there may be significant potential for reductions.

Under the BAU/WOM projection, it is assumed that the anode effects continue at 2.34 tCO_2eq per tonne of output (other direct fuel use is proportional to output). Table 4.9 below shows a summary list of the proposed mitigation measures for the sector.

TABLE 4.9:
Summary of mitigation measures for the aluminium production sector

ID	Name	Description
1IP	Uniprom KAP: electrolysis cells replacement and overhaul (2020–2024), and ETS (2025–2030) (WEM)	Currently 155 out of the 264 cells are in operation, while the remaining cells have to be either overhauled or replaced by 2024, when the electrolysis plant will achieve full capacity of liquid metal production. The WEM scenario has envisaged all the technological improvements on the electrolysis cells.
Additional measure in the 'with additional measures' scenario (WAM)		
2IP	Uniprom KAP: Cell hibernation	In the WAM scenario, decreased PFCs occur due to F-gas capturing from all cells and results in almost 100% of PFC captured and at the same time electricity consumption savings (5.5%). According to the installation business plan, they envisaged investing in PFC capturing technology in all cells (approximately 33 cells per year), starting in 2022. In such case, by 2030, all cells will be covered, so zero PFCs will occur in the electrolysis plant. The estimated GHG reductions and associated costs are included the WEM element.

Measure 1IP: Uniprom KAP: electrolysis cells replacement and overhaul (2020–2024) and ETS (2025–2030) (WEM)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Uniprom KAP: electrolysis cells replacement and overhaul (2020–2024) and ETS (2025–2030) (WEM)	WEM	2022–2026 and impact of ETS 2025–2030	Yes	Approx. €26m	43 Gg

Starting from 2019, only two energy sources: electricity and liquified natural gas (LNG) are used in the facility's technological processes. This situation will remain throughout the whole period until 2030. According to the operator development plan, there will be an increase of production according to the Table 4.10.

TABLE 4.10:
Planned production of KAP

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Foundry [t]	36.9	45	50	55	60	65	70	75	80	85	90	90
Electrolysis [t]	35	40	45	50	55	60	65	65	65	65	65	65

The part of KAP characterized by the dominant use of electricity is electrolysis (over 97%). The rest of factory operations use natural gas as the only fuel used for combustion.

Starting from 2022, a new energy efficiency measure considered in the KAP development plan would result in a 5.5% reduction of electricity consumption in 2030. This is indicated from results from the piloting phase, which is currently applied to very few cells. It is calculated with the introduction of EU ETS there would be an additional triggered investment of approximately €31.5 million (not fully accounted for in the estimated budget).

Measure 2IP: Uniprom KAP: Cell hibernation

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Uniprom KAP: Cell hibernation	**WAM**	**2022–2030**	**Yes**	**€32m**	**50 Gg**

In the WAM scenario, the company would eliminate PFCs by investing in PFC capturing technology in all cells (approximately 33 cells per year), starting in 2022. In such case, by 2030 all cells will be covered, so zero PFCs will occur in the electrolysis plant. The estimated GHG reductions and associated costs include the WEM element.

Iron and steel production

For the process emissions arising from the above categories the starting point for projections was to find the process emissions associated with energy use in the recent past. The Second BUR (page 83, Table 2.3) provides CO_2eq emissions which can be associated with the energy used in 2014 and 2015. For iron and steel, it has been assumed that demand and hence emissions will stay constant through to 2030. No mitigation measures in this sector which deal with industrial process emissions GHG reduction are envisaged for the time being.

EU ETS Emissions

About half of the total fuel combustion and IPPU emissions are expected to be captured by the EU ETS when Montenegro potentially joins the scheme in 2025. Four installations are currently expected to be affected. These are:

- The thermoelectric power plant (Pljevlja TPP)
- Iron and steel (Nikšić Steel)
- The aluminium plant (KAP)
- Brewing (Trebjesa brewery)

Part of the international aviation emissions will also be affected: the element associated with flights between locations in the European Economic Area (EEA). However, it is not known what proportion would fall within the EU ETS.

AGRICULTURE SECTOR

Agriculture is a source of methane (CH4) and nitrous oxide (N2O), stemming from livestock and the use of fertilizers. The national GHG inventory shows that these two gases are most prevalent in agriculture, while CO2 emissions are negligible. This sector accounts for approximately 10% of total emissions (11.5% in 2017).

Methodology for mitigation scenarios in the agricultural sector

The overall methodological approach considers only the effect on N_2O emissions and not CH_4, from animal manure management and fertilizers applied to soils, and does not incorporate the link between manure management and the manure applied to soils, or the impact on indirect N_2O from a decrease in synthetic fertilizer applied to soils. These are aspects that can be improved in the future, based on an enhanced harmonization of the inventory estimates and projections.

Two main sources have been used: the GHG Montenegro inventory, time series 1990–2015; and a database containing the projections used for the preparation of the report "The Future of Food and Agriculture – Alternative Pathways to 2050" and the methodology used in line with the 2016 IPCC guidelines. The following sections further present the methods, data sources, and assumptions for each of the scenarios and measures.

For both scenarios, livestock numbers in the future are assumed to remain the same. Although there may be some policies that may affect livestock numbers, these are mostly driven by market drivers. The projection of livestock numbers is based on the FAO dataset (referred to above) that provides estimates of the main livestock categories by country or region. To project the livestock numbers in the future, it has been assumed they will follow the trend presented for the Rest of Europe–Central Asia region, since numbers referring only to Montenegro are not presented in the dataset for the BAU scenario.

Montenegro's 2nd BUR presents two actions already taken and planned for agriculture:

- **Support for manure management:** that refers to the construction and/or reconstruction of manure storage facilities or the purchase of specialized manure storage tanks to prevent adverse environmental impacts; and
- **Support for organic agricultural production:** which has objectives and specifications that include:
  - sustainable management of natural resources;
  - reduction of adverse impacts of agriculture on the environment;
  - biodiversity preservation;

– upgrading the quality of agricultural produce and
– further positioning of Montenegro as an ecological state.

To be able to estimate the mitigation potential of these actions, it is necessary to know how they will impact the activity data, parameter, and emission factors used in the emission estimates. Therefore, the actions need to be described in terms of the change in manure management practices, the fertilizer applied to soils, and application techniques. In particular:

- **Support for organic agricultural production**: consists of the reduction of the amount of synthetic nitrogen fertilizers applied to soils and improvements in manure application techniques to reduce ammonia emissions, that will in turn reduce the indirect N_2O emissions from cultivated soils (1A).
- **Support for manure management**: consists of a change to other manure management systems in cattle and pig farms with reduced emissions of N_2O compared to what is currently being used (2A).

Both actions are included under the WAM scenario, and no measures are included in the WEM scenario (i.e. the WEM and WOM/BAU scenarios are the same for agriculture). The actions above have been split into three different measures and presented in Table 4.11.

TABLE 4.11:
Summary of mitigation measures for the agricultural sector (WAM scenario)

ID	Name	Description
1A	Support for organic agricultural production	A reduction of 20% in the total amount of synthetic nitrogen fertilizers applied to soils is assumed.
2A	Support for manure management	The change of manure management system affects not only direct N_2O emissions, but also methane emissions (more anaerobic systems emit less N_2O and more CH_4). The figure provided relates to general improvements to the agriculture sector to reduce GHG emissions.

Although the 2nd BUR indicates 2018–2030 as a timeframe for these two actions, the three descriptive measures have been considered as starting in 2020, due to a lack of data to analyse the current (2018–2019) implementation of such actions.

The following are the methods, data sources, and assumptions considered for each of the actions. A note on the constraints that Montenegro will face in implementing these measures, costs, and co-benefits, and the impact on the UN's Sustainable Development Goals (SDGs) are included as well.

Measure 1A: Support for organic agricultural production (WAM)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Support for organic agricultural production a) Reduction of synthetic nitrogen fertilizers applied to soils b) Ammonia abatement techniques to apply manure to soils	**WAM**	**2020–2030**	**No**	**€13m**	**1 Gg**

REDUCTION OF SYNTHETIC NITROGEN FERTILIZERS APPLIED TO SOILS

One of the main sources of N_2O emissions from soils, together with manure applied to soils, is the used of synthetic nitrogen fertilizers. Fertilizers are used to improve productivity, but in some cases the actual needs and uptake potential of the plants are not considered, and fertilizers are over-applied with little efficiency. In the particular case of synthetic nitrogen fertilizers, these are prohibited in organic agricultural production.

For an estimate of emission projections, it has been assumed that total nitrogen input into soils is higher than is needed by the crops, and that the amount of organic fertilizer currently used in the country will suffice to compensate for the reduction in input needs of synthetic nitrogen fertilizers. Therefore, there is scope for a potential reduction of synthetic nitrogen fertilizers applied to crops.

Use of synthetic fertilizers: compared to the WEM/WOM (BAU) scenario, a reduction of 20% in the total amount of synthetic nitrogen fertilizers applied to soils is assumed; a linear reduction from 2015 to 2030 is applied.

The emission factor for N_2O due to synthetic nitrogen fertilizers being applied to soils is the same as is used in the WEM/WOM (BAU) scenario, i.e. the default IPCC 2006.

This measure assumes that the total amount of nitrogen input (manure and synthetic fertilizers) is reduced and that there is no increase in the use of manure applied to soils as fertilizer. If it were the case that an increase in manure applied compensated for the reduction of synthetic nitrogen fertilizers, the measure would not have any impact on N_2O emissions (as the default EF for N_2O emissions from soils due to organic fertilizers and synthetic fertilizers is the same).

The cost of this measure is difficult to estimate since different actions can be taken to implement it. For example, costs can be related to the amount of fertilizer needed, with the aim being to determine the different crop requirements. It is also possible to invest in training for farmers to encourage a more sustainable use of fertilizers.

Several co-benefits can be linked: the reduction of synthetic nitrogen fertilizer used will contribute to a reduction in ammonia emissions, and therefore will have a positive impact on air quality, and indirect nitrogen losses from the manure systems, and therefore will avoid pollution of water.

AMMONIA ABATEMENT TECHNIQUES TO APPLY MANURE TO SOILS

The application of manure as a fertilizer to soils is a significant source of GHG and air pollutant emissions in the agriculture sector. In addition to direct N_2O emissions, the use of manure produces volatilization of other nitrogen compounds, mainly ammonia and nitrous oxide, that in turn produce indirect N_2O emissions due to atmospheric deposition. The use of ammonia abatement techniques reduces the amount of nitrogen compounds that are volatilized after the application of manure and therefore reduces indirect N_2O emissions. These techniques include machinery for substantially decreasing the exposed surface area of slurries applied to the surface of soil or burying slurry or solid manure through injection or incorporation into the soil.

To project the potential mitigation effect, it has been assumed that:

- **Amount of nitrogen in manure applied to soils**: the ratio of nitrogen in manure applied to soils/total number of animals is kept constant, and the total number of animals is the same as is assumed for the WEM/WOM (BAU) scenario.
- **Application techniques of manure to soil**: it is assumed that the proportion of nitrogen in manure applied to soils that is volatilized is halved by 2030, i.e. an unknown combination of ammonia abatement techniques used in an unknown part of the crops leads to a reduction in the fraction of nitrogen that is volatilized from manure applied to soils as NH_3–N and NO_X–N, that lead to indirect N_2O emissions (fracGASM) from 0.2 in the WEM/WOM (BAU) scenario to 0.1 in the WAM scenario.

According to Bittman et al. (2014), which provides information on the costs for each of the abatement techniques, the economic costs of these techniques are in the range of €0.10 to €5 per kg NH_3–N saved, with the smallest costs for immediate incorporation of slurries and solid manure, where this is feasible (i.e. on bare arable land). The estimates are very sensitive to the assumed farm size, with substantially improved economies of scale on larger farms, where low-emission equipment is shared between several farms, or where specialist contractors are used.

Several co-benefits will occur with this measure: the reduction of the synthetic nitrogen fertilizer used will contribute to reduced ammonia emissions, and therefore will have a positive impact on air quality; and indirect nitrogen losses from the manure systems, therefore avoiding water pollution. Better use of the management of manure as a fertilizer would also reduce the need of synthetic nitrogen fertilizers.

Both the reduction in synthetic nitrogen fertilizers and ammonia abatement can have positive impacts on the following SDGs:

Measure 2A: Change of manure management systems for cattle and pigs (WAM)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Support for manure management	**WAM**	**2020–2030**	**No**	**€6m**	**9 Gg**

Different manure management systems produce different amount of direct N_2O emissions, as such the shift to other manure management systems reduces (or increases) the potential emissions.

- **Manure management system usage**: the WAM scenario assumes a change in cattle manure management systems from 'Liquid/Slurry' to 'Liquid with Natural Crust' (i.e. all liquid systems have natural crust in 2030). The WAM scenario also assumes more pig manure is treated in pit storage, rather than solid storage. The uptake of the change is linear from 2015 to 2030. The fraction of manure managed under 'Daily Spread and Pasture' is not changed.
- **Emission factor by manure management**: default IPCC 2006, as used in the emissions inventory.

The change of manure management system not only affects the direct N_2O emissions, but also methane emissions (more anaerobic systems emit less N_2O and more CH_4) and ammonia emissions (covered systems reduce the emissions of ammonia and N_2O). In the case of these mitigation measures, only the effect on direct N_2O emissions has been considered.

In addition, lower emissions of nitrogen compounds in the manure management phase are likely to lead (assuming no change in manure application to soil techniques) to more N_2O being emitted in the soil phase. This effect has not been considered in the current mitigation potential estimates.

Interlinkage of the estimates of projections with the current emissions inventory would allow the consideration of the effects of one measure in various categories (livestock and soil) and gases (N_2O and CH_4, and even NH_3 if this is estimated and relevant).

The costs associated with this measure are difficult to estimate. There will be costs related to the investment to modify/improve the manure management system and these can widely differ depending on the farm structure and currently used systems. For small farms, the implementation of these changes can be onerous and less cost-efficient.

Better management of manure will contribute to a reduction in ammonia emissions, and therefore will have a positive impact on air quality. In addition, there will be lower indirect nitrogen losses from the manure systems, and therefore water pollution is of less concern. Although it has not yet been considered in Montenegro, anaerobic digestion facilities can be used on individual farms or on a cluster of farms and can be used to generate electricity.

LULUCF

The basis for the forestry sector development in Montenegro is represented by the National Forest Strategy (Nacionalna šumarska strategija, NŠS) published in March 2014. The strategy is implemented through action plans. The NŠS is comprehensive in the sense that it covers the entire forestry sector, i.e. from forest management to final wood use. The NŠS mainly builds on the results of the first National Forest Inventory (Nacionalna inventura šuma, NIŠ) of Montenegro, published in 2013 and the forest-sector data published annually by MONSTAT (Zavod za statistiku Crne Gore).

According to the latest 'Intended National Determined Contribution' (INDC) submission to the UNFCCC[14], Montenegro's current approach is to not account for GHG emission/removals in agriculture, forestry, and other land use sectors, with the intention that "it can be included at a later stage when technical conditions allow for that".

Regarding the forests available for wood supply (FAWS), the following information was obtained:

- The average standing volume was 155.4 m^3/ha, with 224.5 m^3/ha in state-owned forests and 87.5 m^3/ha in private forests.
- The average annual volume increment was 3.7 m^3/yr/ha, with 5.3 m^3/yr/ha in state-owned forests and 2.2 m^3/yr/ha in private forests.
- The harvest is around 1 million m^3, of which some 50% is from coppice stands.
- The total amount of industrial and technical roundwood processed in wood processing companies in 2011 amounted to 326,649 m^3, of which 81% or 264,586 m^3 is coniferous.
- 72.4% of processed round wood originated from state-owned forests.
- A significant area of forest is included in the Emerald Zone and national parks (17% and 6% respectively of the total forest area).

The main features affecting the GHG profile of the forestry sector are driven by:

- Wildfires are identified as the main natural disturbance, i.e. according to the NIŠ 30,532 ha in 2010 was affected by wildfires, of which 56% of the affected amount was coppice stands. According to the 2nd BUR, a significant share of the annual amount of wood removals occurs because of salvage logging related to wildfires (30%).
- The structure on the development stages of high forests shows the highest share being within maturing stands (medium-age range), with very low shares being within very young and young stands.
- A significant share of the areas and wood supply are from coppice stands.

According to the 2nd BUR, since 1990 Montenegro has reported an average forest removal of about 1.5 million tCO_2eq per year, compensating for approximately 30% of the total annual national GHG emissions.

[14] INDC submission at: https://www4.unfccc.int/sites/submissions/indc/Submission%20Pages/submissions.aspx.

Methodology for mitigation scenarios for LULUCF

Projections for the WOM, WEM, and WAM scenarios include CO_2 emissions and removals from forest and harvested wood products (HWP). For forests only, the carbon (C) stock change in living biomass pools (above ground and below ground) is considered, while other C pools (dead wood, litter, and mineral soils) are assumed to be in a neutral balance. The reason for this is that, for these C pools, there is not enough information at this point to make an accurate estimate. The methodology for the calculation of GHG emissions has been taken from the IPCC's 2006 guidelines "production approach", i.e. it excludes semi-finite products produced from imported roundwood.

Data on forests was available from the NIŠ for 2010 – the initial year of the projections.

The NŠS has defined two major objectives for the period 2014–2023. The first one consists of the measures currently under implementation – thus corresponding to the WEM scenario, and a second one consisting of more ambitious measures which were planned but still have not been implemented, corresponding to a WAM scenario. Defining whether measures are being implemented or not is based on relevant indicators reported in the 2nd BUR, referencing MONSTAT or forest service data (e.g. similar wildfires area as in the past means actions are not implemented).

With existing measures (WEM)

This corresponds to NŠS Objective 1: Improvement of forests and sustainability of forest management. This means multiple combined measures targeting increasing standing stock in forests available for wood supply from 104 million m^3 in 2010 to 115 million m^3 in 2023. This is further defined by:

- An increase in the standing stock by cumulation of 30% of the annual increment in state-owned forests, anticipating an increase of the growing stock from 225 to 240 m^3/ha; and
- Cumulation of 50% of the annual growth in private forests resulting from an increase in the standing stock from 88 to 100 m^3/ha. The harvest level was on average 1.05 million m^3/year, with a slight increasing trend since 2000 and a peak in 2006 (according to the 2nd BUR). It is worth noting that a large share, approximately 30%, of this harvest level was related to post-fire logging salvage.

Among the underlying measures listed in the NŠS, two measures would have a significant impact on the forest sector, with a knock-on effect on GHG emissions:

- There is a limitation on the harvest amount to 1.225 million m^3/year, of which an amount of 0.912 million m^3 is in state-owned forests and 0.312 million m^3 is in private forests. According to the 2nd BUR this level is 20% higher than the 1990–2012 average, while over 2010–2017 this harvest level has seen a general increase of approximately 10%. The use of roundwood for long-term products increased by 44% since 2010, although in 2016–2017 it reached approximately

25% of annual removals, compared to 20% in 2010. In fact, since 2006 there has been an increasing trend of industrial roundwood in an increasing level of total harvest.

- There has been an improvement in degraded forest by conversion from coppice to high forest by 15,000 ha, e.g. by 1,500 ha per year or a total of 0.42% of the total coppice area;
- Wildfires are a key source of GHG emissions. Enhanced fire protection was defined as part of Objective 1 in the NŠS; however, there is no evidence of less area being affected by wildfires, while salvage volumes from after the fires did not change the trend over the last few years. Therefore, effort is apparently still needed to implement this measure. Thus, this measure cannot be considered part of the WEM scenario.

No specific measures are included in the WEM scenario. The WEM scenario leads to a decrease in the annual CO_2 removals because of a slight increase in the harvest compared to the historical period, which is just slightly compensated for by the small increasing trend in the annual amount of roundwood used in long-life products. Coppice conversions to high forest also provide for an insignificant sink in such early stages of the transformation to high forest.

With additional measures (WAM)

A number of GHG mitigation measures are listed in the NŠS under Objective 2: Increase the forestry sector contribution from 2% to 4% of total GDP. Among the different measures suggested to achieve this objective are two with significant GHG impacts. The current status of each measure is, however, unknown. Additionally, measures defined under Objective 1, which are not implemented but could be, are included here.

The most feasible measures, which could be implemented from 2020 onwards, in addition to measures already considered under implementation, are described below.

TABLE 4.12:
Summary of the potential mitigation measures for the LULUCF sector (WAM)

ID	Measure	Description
1L	Limitation of harvest amounts in state-owned and private forests	Limitation of harvest amounts to 1.575 million m^3/year, of which 1.195 million m^3 is in state-owned forests and 0.380 million m^3 in private forests, or 28.6% more in 2023 vs. 2010. Therefore, the limit is higher than historical levels but would still mean a reduction in net emissions compared to the WOM (BAU) scenario.
2L	Reduction in the area annually affected by wildfires	Wildfires are a key source of GHG emissions. Enhanced fire protection was defined as part of Objective 1 in the NŠS. However, there is no evidence of less area being affected by wildfires, while the salvage volume from post-fire periods has not changed over the last few years. Therefore, effort is still needed to implement this measure.
3L	Further increases in the share of industrial roundwood used for long-term products	As a consequence of increasing the harvest, it seems meaningful that there would be a 30% increase in the amount of "industrial roundwood" used for long-term products. This means an increase from a share of 20% within the total regular harvest in 2010 to 40% in 2023.

Measure 1L: Limitation of harvest amounts in state-owned and private forests (WAM)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Limitation of harvest amounts in state-owned and private forests	WAM	2020–2030	No	N/A	37 Gg

This measure involves the limitation of harvest amounts to 1.575 million m^3/year, of which 1.195 million m^3 would be in state-owned forests and 0.380 million m^3 would be in private forests, or 28.6% more in 2023 vs. 2010. There is no explicit mention in the NŠS of the certainty of the additional roundwood amounts, although it is mentioned that an increase in the consumption of wood biomass for heating is of importance, with 5,357 m^3 consumed in 2011 and forecasts of 35,000 m^3 by 2020.

Measure 2L: Reduction in the area annually affected by wildfires (WAM)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Reduction in the area annually affected by wildfires	WAM	2020–2030	No	N/A	717 Gg

A reduction in the area annually affected by wildfires by 70%. This is linked to large areas affected by fire and large amounts of wood subject to post-fire salvage logging (on average 30% per year since 2006).

Measure 3L: Further increases in the share of industrial roundwood used for long-term products (WAM)

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Reduction in the area annually affected by wildfires	WAM	2020–2030	No	N/A	0,06 Gg

A further increase in the share of industrial roundwood used for long-term products (e.g. sawn wood and panels). As a consequence of increasing the harvest, it seems meaningful that there would be a 30% increase in the amount of "Industrial roundwood" used for long-term products. This means an increase from a share of 20% within the total regular harvest in 2010 to 40% in 2023. Thus an additional amount, ca. 100,000 m^3, would be further added to the amount reported for 2017 of ca. 300,000 m^3 per year. This is not expected to result in high competition with other roundwood uses, e.g. household heating, especially due to an improvement in the general low efficiency of wood use.

Much higher efficiency in wood use can be achieved by: a) restricting high-quality roundwood use to industrial use; and b) prevention and limitation of damage of wildfires (as long as some 24% of the annual total harvest volume originates in salvage logging after wildfires), or measures in the bio-energy sector. Implementation of such a measure depends on many other support measures in the implementation of the NŠS.

Many soft measures mentioned in the NŠS may also have a small GHG impact:

- Extension of the forest road network to support the expansion of areas accessible to forest interventions and harvesting
- Limits to forest expansion through the maintenance of open areas between forests and support for the mowing of meadows
- Limited afforestation of abandoned land
- Application of forest management in national parks in accordance with the protection and sustainable development objectives
- Enhancement of forest status for degraded forests by associated research and technical support
- Establishment of fire brigades
- Development of a full GIS database of forest ownership
- Technological modernization of enterprises in the wood-processing industry
- Compliance with GLEGT and FSC
- Sustainable management and use of non-wood products.

The implementation of the WAM measures shows a continuously decreasing sink by 2030. It is worth noting that the WAM measures result in slightly higher sink amounts than the WEM scenario. The data shows that the forestry sector would not become a source until the mid-21st century (2050). This is due to the predicted increase in wood allocation in HWP, while also the annual removals in living biomass are slightly higher due to the shifting age-structure toward younger stands.

WASTE SECTOR

Solid waste is responsible for a large amount of methane emissions. Domestic wastewater treatment and discharge produce significant, but relatively fewer, emissions of methane and nitrous oxide. The projected growth in these emissions is assumed to be linked to economic growth forecasts. They are expected to follow the same path as 1A4 – Other sector energy demand, as discussed above, i.e. growing at a rate slightly below that of economic growth in the wider economy.

TABLE 4.13:
Summary of the potential mitigation measures for the waste sector (WAM)

ID	Measure	Description
1W	Reduce the share of bio-waste within municipal waste	Projected waste treatment pathways have been developed under a WEM scenario, dependent upon the treatment pathway of biogenic waste.
2W	Reduce the share of bio-waste in municipal waste + additional diversion to recycling/composting	The WAM scenario assumes that there is an additional effort to divert waste, specifically to recycling and/or composting. Note, the GHG savings for this measure include the WEM element.

Measures 1W and 2W: Reduce the share of bio-waste within municipal waste

Name	Scenario	Implementation timeframe	EU ETS	Budget (Euros)	Potential for CO_2eq reduction in 2030
Reduce the share of bio-waste within municipal waste	WAM	2020–2030	No	Not known	144 Gg
Reduce the share of bio-waste in municipal waste + additional diversion to recycling/composting	WAM	2020–2030	No	Not known	170 Gg

The projected waste treatment pathways are available under a WEM and WAM scenario dependent upon the treatment pathway of biogenic waste (the component that impacts CH_4 generation). The WAM scenario assumes that there is an additional effort to divert waste, specifically towards recycling and/or composting. The data is derived from negotiation processes with the EU and is also based on the legislation and strategic framework. Currently the implementation dates have been postponed, while the Government intends to request derogation for the implementation of some of the demanding EU requirements, while negotiating EU accession. The Table 4.14 provides the data that has been applied within the solid waste generation scenarios.

TABLE 4.14:
Solid waste generation scenarios

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Solid waste generation (t)	273,697	278,288	282,969	287,741	292,607	297,569	302,628	307,786	313,046	318,410	323,878
Bio-waste to landfills (t) WEM	146,000	138,500	131,000	123,500	116,000	109,500	101,000	91,000	82,500	73,000	67,500
WAM % reduction*	10%	12%	14%	16%	18%	20%	22%	24%	26%	28%	30%

4.4 Summary of the key findings

KEY HIGHLIGHTS OF THE WEM SCENARIO

The 'with existing measures' (WEM) scenario builds on the WOM scenario and incorporates 15 measures/policies from the list of measures given in the sections above. The measures included in this scenario have been agreed and the funding identified, and they will have already been implemented or are about to be soon. They are likely to have been identified as a priority in sector plans and strategies. This scenario can be thought of as a scenario that is likely to be achieved. The key findings include:

- By 2030, annual GHG emission reductions of 1,019 Gg CO_2eq under the WOM (BAU) scenario are estimated.
- Of the 15 measures identified, 11 relate to actions implemented to the stationary energy combustion sector, and one to each of the transport, IPPU, land use, and waste sectors.
- The highest emission reductions are achieved from the measure that relates to energy labelling and eco-design requirements. Other significant measures include upgrades to the thermoelectric power plant, energy efficiency regulations in buildings, and a reduction of the share of bio-waste within municipal waste.
- Overall, as a result of the WEM scenario, GHG emissions in 2030 are expected to decline from 3,321 Gg CO_2eq under the WOM (BAU) scenario to 2,301 Gg CO_2eq (including LULUCF). With LULUCF excluded emissions decline from 3,519 to 2,499 Gg CO_2eq. Therefore, under this scenario, the NDC 2030 GHG target is expected to be met.

Economic analysis

The overall extra capital cost of the WEM programme is estimated at around €2.1 billion over the entire course of implementation. However, it is worth noting that it was not possible to provide costs for all measures and therefore this is likely to be an underestimate. It is worth noting that most measures – particularly related to the energy sector – can be expected to be highly cost-effective with good payback periods. The overall estimated GHG emission savings as a result of the WEM scenario is shown in Figure 4.3 and Figure 4.4, with the accompanying data in Table 4.15 below.

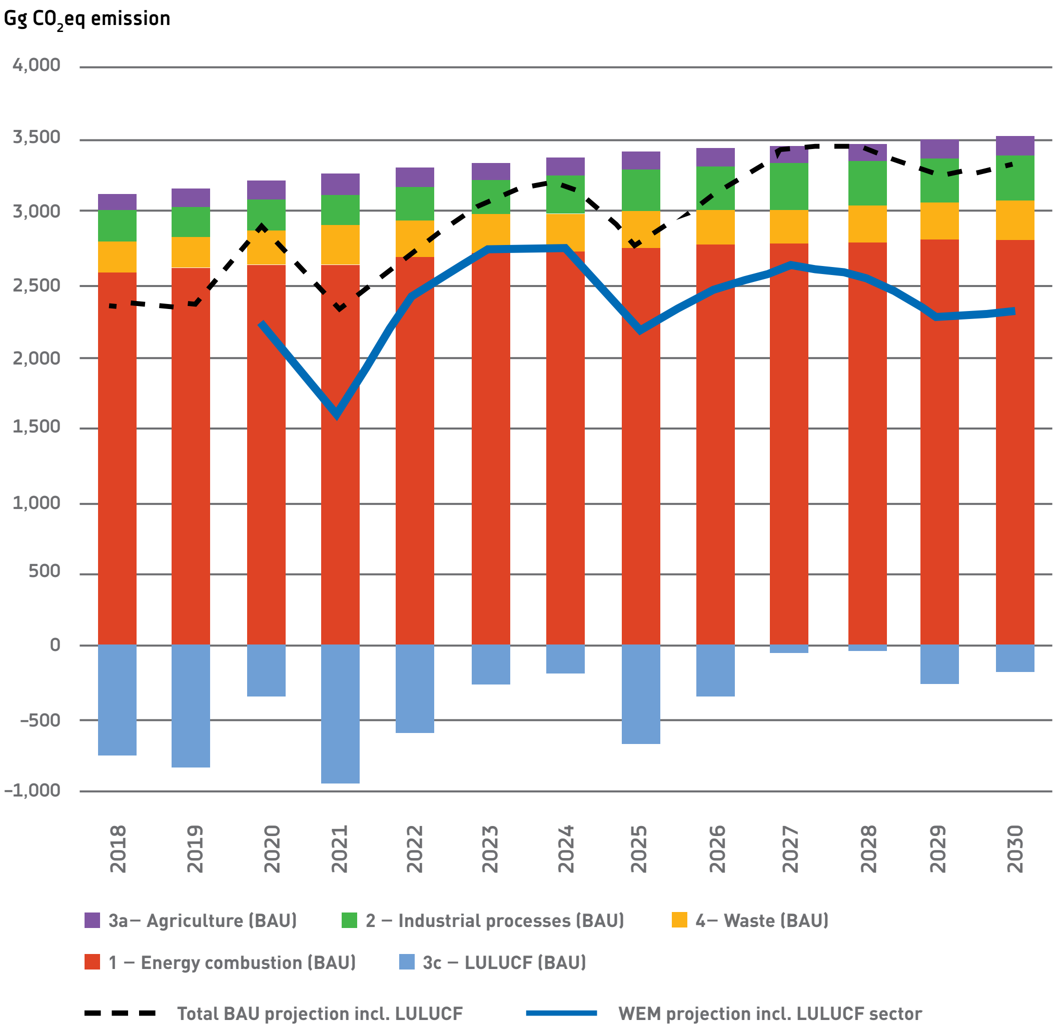


FIGURE 4.3 Estimated GHG emissions under the WEM scenario including LULUCF

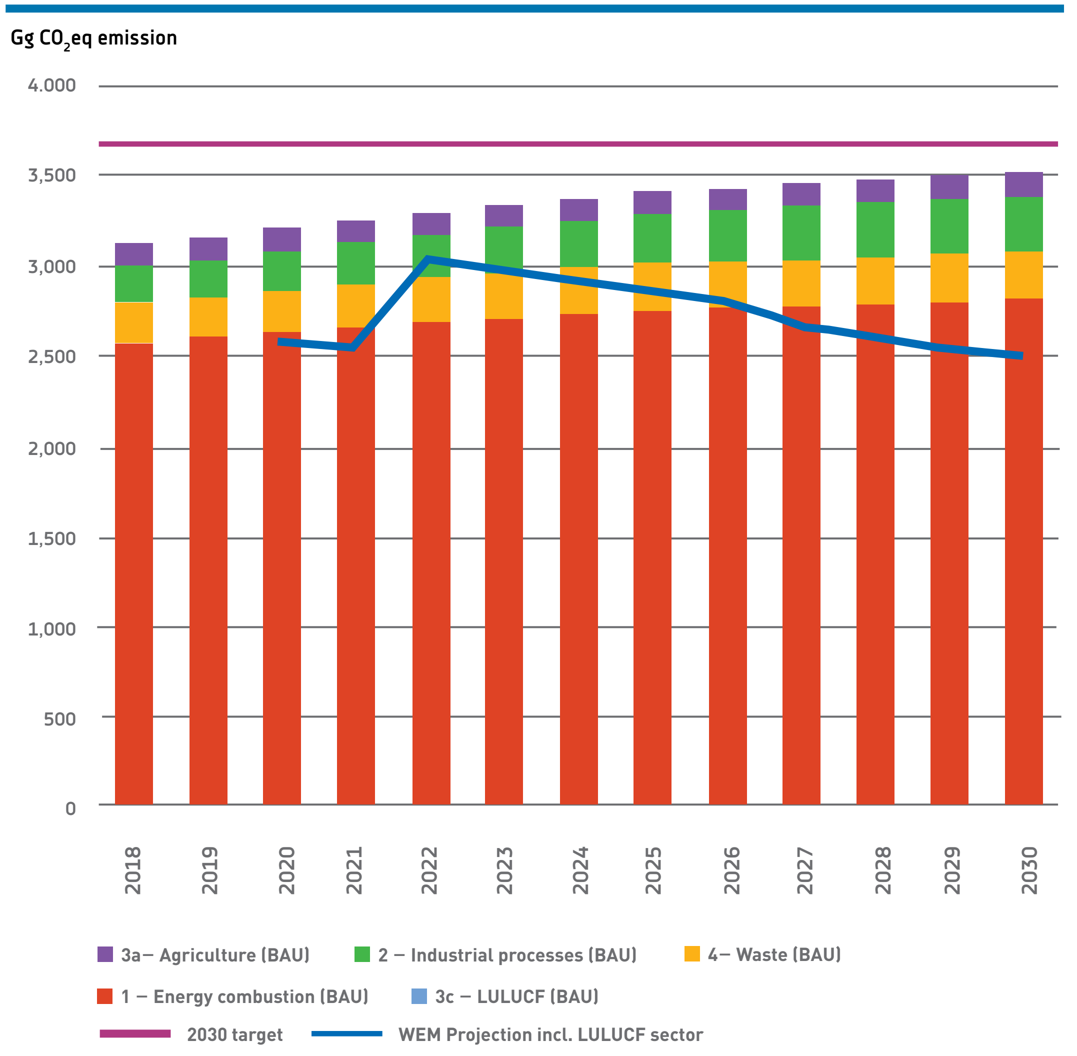


FIGURE 4.4 Estimated GHG emissions under the WEM scenario excluding LULUCF

TABLE 4.15:
Estimated GHG emissions under the WEM scenario (Gg CO_2eq)

	2018	2020	2022	2024	2026	2028	2030
WOM excluding LULUCF	3,125	3,211	3,301	3,380	3,439	3,481	3,518
WOM including LULUCF	2,365	2,866	2,701	3,195	3,099	3,440	3,320
GHG reductions as a result of WEM	51	634	268	457	645	881	1,019
GHG emissions under a WEM scenario excluding LULUCF	3,075	2,577	3,033	2,922	2,795	2,600	2,499
GHG emissions under a WEM scenario including LULUCF	2,315	2,232	2,434	2,737	2,454	2,559	2,301

NOTE: *the sum of the component parts may not exactly equal the totals shown due to rounding.*

THE KEY HIGHLIGHTS OF THE WAM SCENARIO

The 'with additional measures' (WAM) scenario includes all the WEM scenario measures/policies, but also includes nine additional measures/policies from the list of measures. These WAM measures are less likely to be taken up, as in many cases funding has yet to be obtained and therefore, they are referred to as "Additional measures". None of these measures are currently in progress. The key findings include:

- By 2030, annual GHG savings of 2,160 Gg CO_2eq (if the LULUCF sector is included) are anticipated under the WAM scenario (WOM minus (WEM + WAM)).
- Of the nine measures that have been identified and are included in the analysis, one relates to the stationary energy combustion sector, one to industrial processes, one to transport, one to waste, three to land use, and two to agriculture.
- The most effective measures are a reduction in the area subject to wildfires and the generation of more power from renewable sources.
- Overall, as a result of the WAM scenario, GHG emissions in 2030 are expected to decline from 3,518 Gg CO_2eq under the WOM scenario to 2,038 Gg CO_2eq (when the LULUCF sector is excluded). This is a large decline and is probably unlikely to be achieved, but it highlights what could result from the implementation of additional measures not currently agreed.

Economic analysis

An initial estimate of the capital cost involved in delivering the WAM programme beyond the WEM scenario is €1 billion. However, it is worth noting that not all measures have been costed due to a lack of available information. Private-sector funds are likely to be the main source of finance, although the LULUCF package will require state support to be developed.

The overall estimated GHG emission savings as a result of the WAM scenario is shown in Figure 4.5 and Figure 4.6 with the accompanying values in Table 4.16.

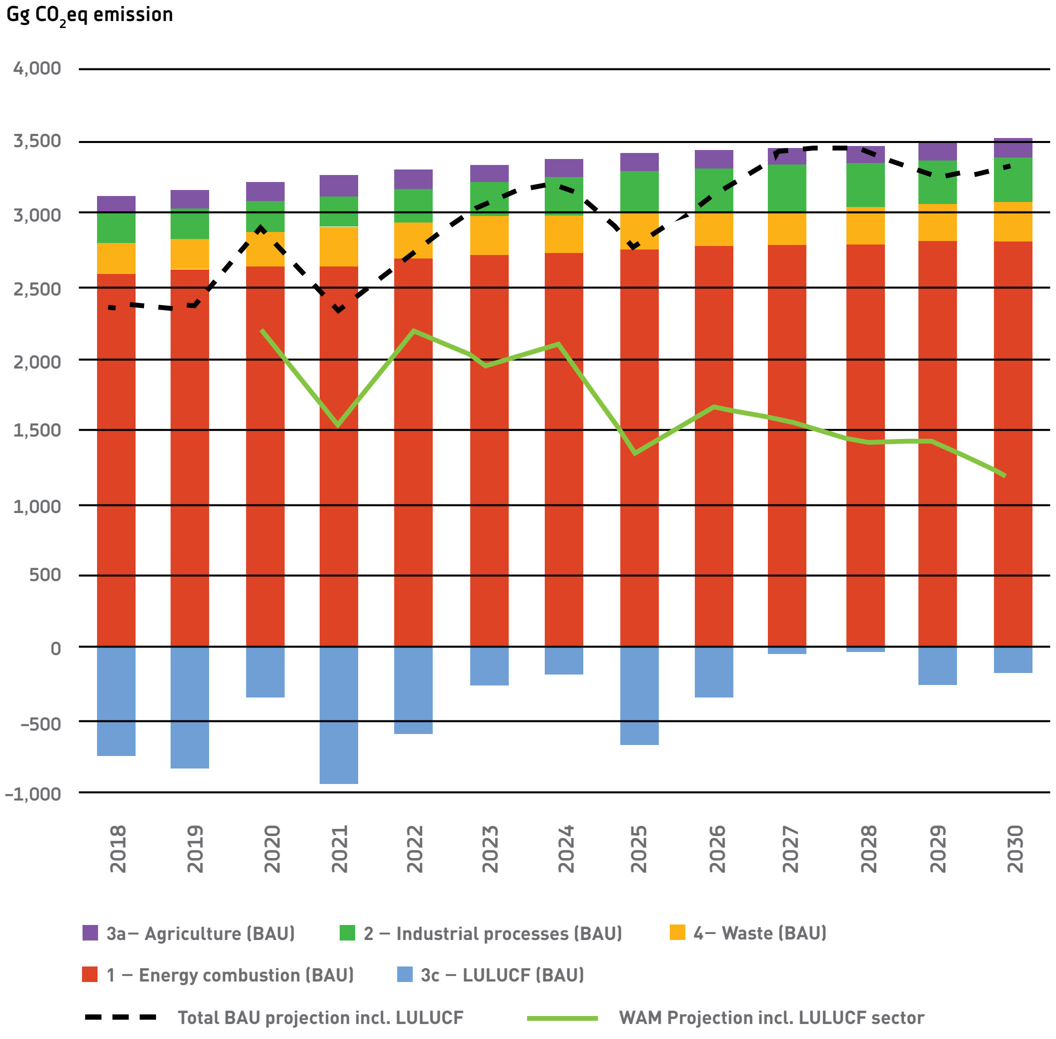


FIGURE 4.5 Estimated GHG emissions under the WAM scenario including LULUCF

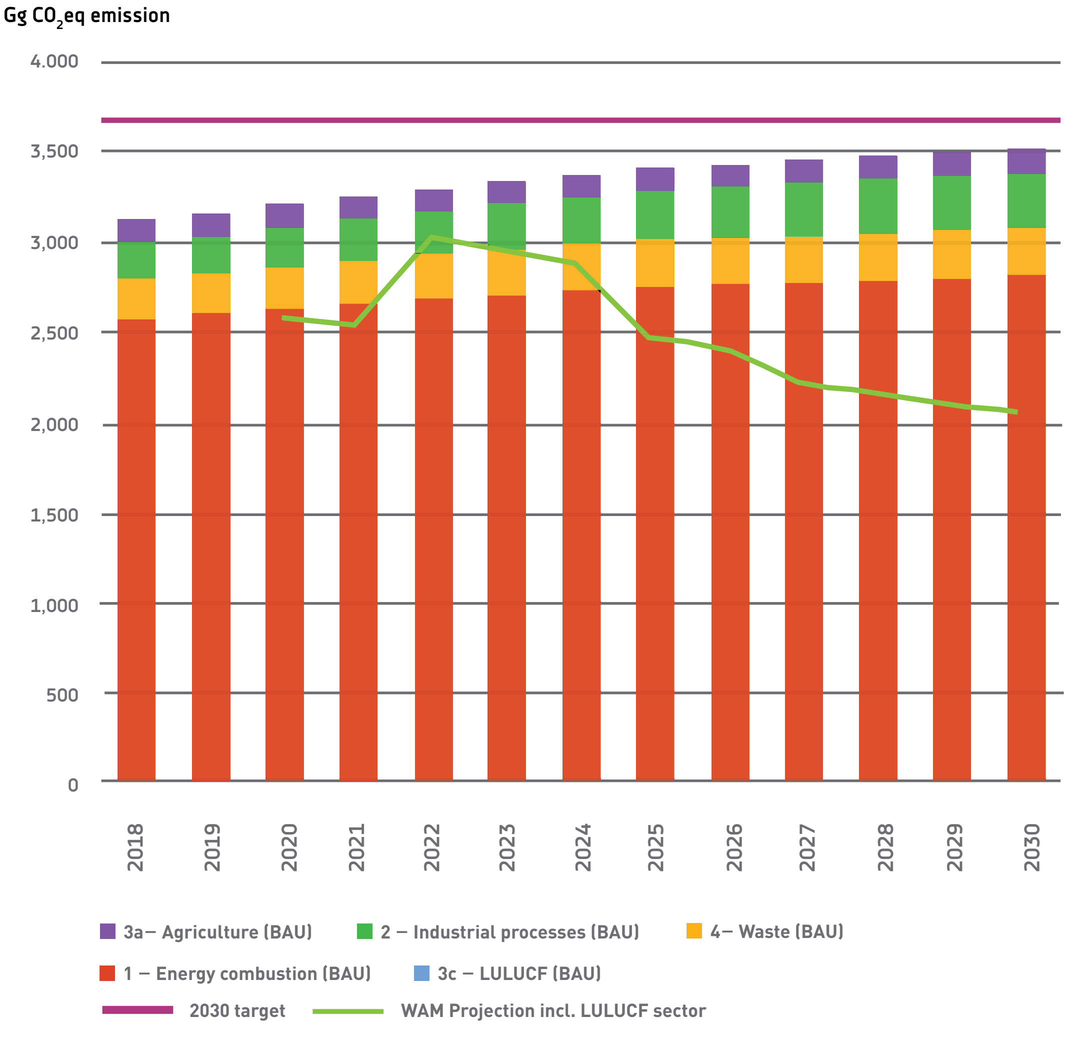


FIGURE 4.6 Estimated GHG emissions under the WAM scenario excluding LULUCF

TABLE 4.16:
Estimated GHG emissions under the WAM scenario (Gg CO_2eq)

	2020	2022	2024	2026	2028	2030
WOM excluding LULUCF	3,211	3,301	3,380	3,439	3,481	3,518
WOM including LULUCF	2,866	2,701	3,195	3,099	3,440	3,320
GHG reductions as a result of WEM	634	268	457	645	881	1,019
GHG reduction as a result of all WAM	55	278	658	825	1,162	1,140
GHG reduction as a result of non LULUCF WAM	17	25	60	397	457	461
GHG emissions under a WAM scenario excluding LULUCF	2,561	3,008	2,863	2,397	2,143	2,038
GHG emissions under a WAM scenario including LULUCF	2,177	2,155	2,079	1,628	1,397	1,161

NOTE: *the sum of the component parts may not exactly equal the totals shown due to rounding.*

4.5 The wider impacts of mitigation measures and links to sustainable development goals

GREEN JOBS

In addition to assessing the impact of each of the measures on the UN's sustainable development goals, the contribution towards green job creation has also been assessed. The following findings are relevant:

- Green jobs involved in the WEM programme could total around 8,000 – based on the capital spend involved; however, this is likely to be an upper estimate. This is largely associated with the roll-out of higher thermal standards in new buildings and for renovations, if the same teams can be scheduled to work on the project over a number of years then the total jobs will be much smaller, but the jobs will last for longer.
- The WAM programme may lead to another 20,000 jobs (again based on the capital spend expected) they would be largely associated with the construction of new wind and solar power plants, so relatively short-term – though some ongoing jobs for operations and maintenance would also be created.
- It is important to note that green jobs do not always represent additional jobs in the economy as they may simply represent a move away from traditional jobs.

SUSTAINABLE DEVELOPMENT GOALS

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015 and contains at its heart 17 Sustainable Development Goals (SDGs).[15] These 17 goals 'provide a shared blueprint for peace and prosperity for people and the planet, now and into the future'. The mitigation actions that Montenegro have adopted, or plan to adopt, will have wider co-benefits and help to promote these SDGs, as seen in Figure 4.7 and Figure 4.8. Only those SDGs that are impacted are shown in the Figures.

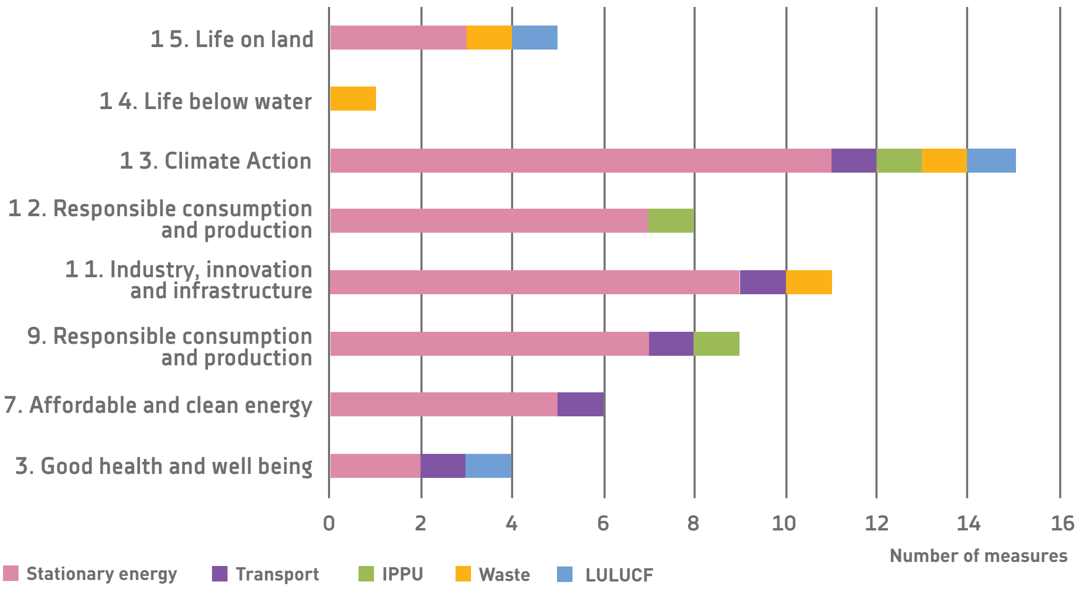


FIGURE 4.7 The impact of the 'with existing measures' on the SDGs

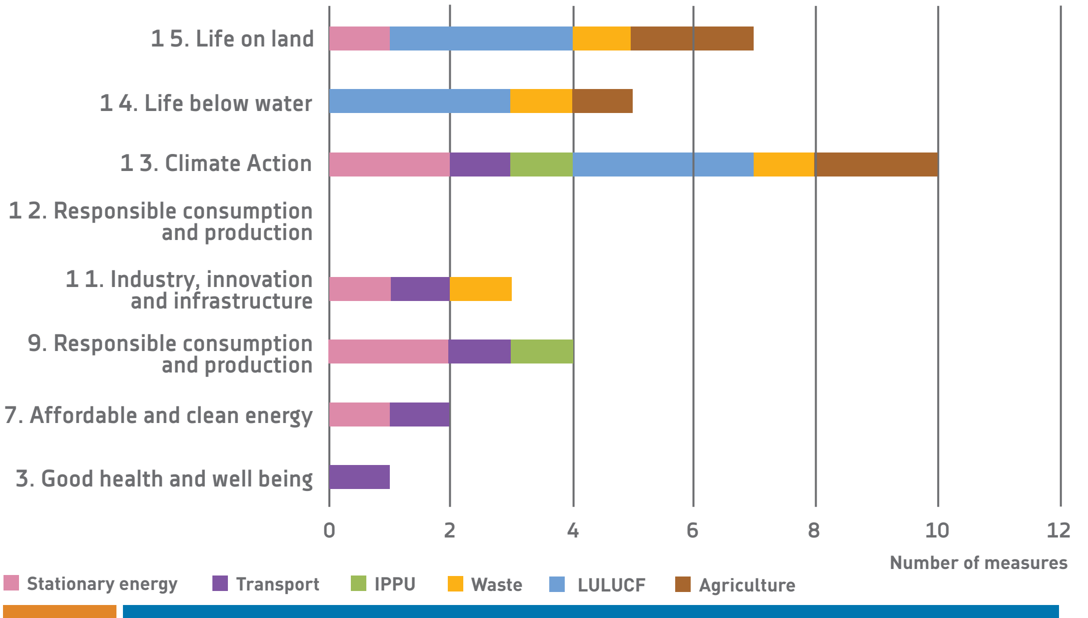


FIGURE 4.8 The impact of the 'with additional measures' on the SDGs

[15] http://www.undp.org/content/undp/en/home/sustainable-development-goals.html.

4.6 Implementation framework for action implementation and tracking

The Ministry of Sustainable Development and Tourism's (MSDT) Directorate for Climate Change (DCC) has a crucial role in engaging the relevant ministries across sectors and in the coordination of mitigation policy. The National Council for Sustainable Development and Climate Change and Integrated Costal Management (National Council) will play an important role for implementing and tracking mitigation actions through its Working Group for Climate Change Mitigation and Adaptation. The engagement of the National Council will also promote high-level public and private support for the tracking of progress with the NDC.

Related to Measurement, Reporting, and Verification (MRV), Montenegro has developed a conceptual framework for its own integrated MRV system to support climate change mitigation and delivering on its Nationally Determined Contribution (NDC)[16]. The framework provides a structure and recommendation for the key components of the MRV system and the implementation of this framework will be crucial for supporting Montenegro in achieving its ambitious national targets outlined in the INDC[17], submitted in response to the 2015 Paris Agreement. The MRV system was developed not only to support Montenegro in achieving its national climate change targets of a 30% GHG reduction by 2030 (against the baseline year of 1990), but to also provide a mechanism to align climate change mitigation with the Sustainable Development Goals (SDGs). Montenegro has developed a conceptual institution framework which involves:

- Identification and recommendation of components of the conceptual framework for the National MRV system to facilitate and build up the data collection and analysis needed to meet the key objectives for the MRV system
- Gathering of example information on Montenegro's climate change mitigation and adaptation actions into a structured form that could be used for stakeholder engagement and reporting. This illustrated the functional needs and types of data required for the system
- Creating an MRV data-sharing portal that could be used to consolidate all information on the MRV system, to structure collected data, and to support the retention of institutional memory.

The Inventory MRV system has well-defined institutional arrangements with the Directorate for Climate Change (DCC) as the National Focal Point, and the Environmental Protection Agency (EPA) as the inventory agency, responsible for the management of the inventory. However, additional expertise is required for both inventory and projections compilation to provide support and additional capacity for the existing experts. This is a key priority for Montenegro going forward.

Additional information on the key institutions involved in Montenegro's MRV system is included in Annex 3.

[16] https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/ndc-registry.
[17] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Montenegro%20First/INDCSubmission_%20Montenegro.pdf.

4.7 Conclusion

This chapter provides a summary of the greenhouse gas mitigation options and measures which can be or are being implemented in Montenegro. This has built on analysis developed for the 2nd BUR and incorporated national policies. Emission estimates under the 'without measures' (WOM), 'with existing measures' (WEM), and 'with additional measures' (WAM) scenarios have been developed.

The mitigation measures assessed in the WEM and WAM scenarios were obtained from national strategic and planning documents, as well as from stakeholder consultation. A total of 23 measures (12 in the stationary energy sector, two in the mobile energy sector, two in the industrial process sector, five in the AFOLU sector, and two in the waste sector) were prioritized and assessed for their GHG emission reduction potential and economic effectiveness.

Under the WEM scenario, by 2030, annual GHG emission savings of 1,019 Gg CO_2eq are estimated. The highest emission reductions are achieved from the measure that relates to energy labelling and eco-design requirements. Other significant measures include the upgrades to the thermoelectric power plant, energy efficiency regulations in buildings, and reducing the share of bio-waste within municipal waste. The estimated capital cost under this scenario is €2.1 billion, with the creation of 8,000 jobs. Both of these figures are, however, likely to be underestimates, as it was not possible to find information on both of these elements for all of the measures assessed. At the same time, most measures are expected to have highly positive net economic benefits.

Under the WAM scenario (which includes the impact of the WEM scenario), by 2030, annual GHG savings of 2,160 Gg CO_2eq are anticipated. The most effective measures are reducing the areas subject to wildfires and generating more power from renewable sources. This is an ambitious reduction in GHG emissions, but highlights what could be achieved if all the additional measures are put in place. The estimated capital cost under this scenario is an additional €1 billion beyond the WEM scenario, with the creation of 20,000 jobs. As with the WEM estimates, these are, however, likely to be underestimates.

It may also be possible for Montenegro to reduce emissions further through the REDD+ programme (See Annex 2), which focuses on reducing emissions from deforestation and/or forest degradation, while supporting the conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks.

As well as the measures contributing towards climate action, the measures included in this National Communication also have positive impacts on many of the Sustainable Development Goals, such as: sustainable cities and communities; responsible consumption and production; and affordable and clean energy.

VULNERABILITY AND RISK ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

5

Montenegro is a country that is particularly vulnerable to the impacts of climate change due to its geographical location, its topography, and its socio-economic characteristics. Climate change impacts have already manifested themselves in the country and are expected to result in more impacts for key sectors, such as water availability and agricultural production. Therefore, adaptation actions and strategies are necessary and urgent. Montenegro recognizes that adaptation is a fundamental component in the long-term global response to the impacts of climate change and has promoted the importance of the adaptation component through its participation in the UN negotiation processes and in the development of instruments that link international agreements with national policy.

5.1 Conceptual framework for climate adaptation in Montenegro

Montenegro has adopted the conceptual approach of the Intergovernmental Panel on Climate Change (IPCC), which defined that the level of vulnerability of human and natural systems to climate-related impacts is a result of the level of sensitivity and adaptive capacity to cope with climate change (IPCC, 2014). Both changes in the climate system and socio-economic processes are drivers of vulnerability.

To understand how to adapt to climate change, it is necessary to define and understand the concept of vulnerability, defined by the IPCC as the "propensity or willingness to be adversely affected". This term comprises a number of concepts, such as "sensitivity or susceptibility to damage and lack of responsiveness and adaptability" (Figure 5.1) (Agard et al., 2014).This means that a system will be more vulnerable the more it is affected by climatic variables (sensitivity) and that it has little or insufficient ability to adjust to them (adaptive capacity).

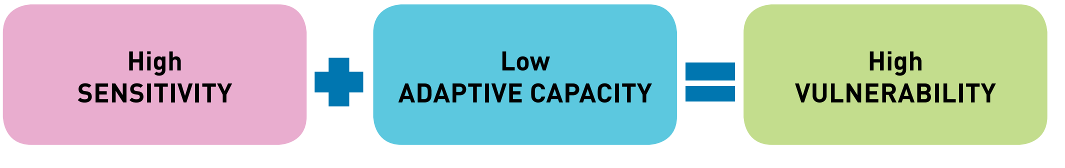


FIGURE 5.1 Vulnerability and its components

Adaptation actions are oriented towards reducing the vulnerability of the people and nature system affected by climate events. Adaptation to the effects of climate change refers to adjustments in social, ecological, or economic systems as a response to the current or expected impacts of climate change. It refers to adjustments in processes, practices, and structures to moderate potential damage or to take advantage of opportunities.

Adaptation processes must start by knowing who the most vulnerable people are and what should be protected, which is why Montenegro has conducted a vulnerability analysis to determine the sectors most vulnerable to climate change.

5.2 Climate change profile for Montenegro

OBSERVED CLIMATE CHANGE TRENDS

According to geographical position, Montenegro is in the central part of the moderate warm belt of the northern hemisphere. Additionally, the vicinity of the sea, morphological profiles, and atmospheric circulations form complex climatic characteristics in terms of high variability in space and time.

The country's relief has an important role in modifying the climate. The sharp changes of altitude over a small distance and the prevailing mountainous regions over 1000 m in altitude shape a highly variable climate. The mountain chains of Orjen, Lovćen, Rumija, and Sutorman reduce the influence of the Adriatic Sea on the littoral part. On the other hand, the River Bojana, Podgorica, the Skadar Basin, the valley of the Rivers Morača and Zeta, and Nikšić Valley are influenced by the Mediterranean climate. That area acts as a border zone between the Mediterranean and continental-mountainous climate. It consists of the mountains: Golija, Vojnik, Lola, Kapa Moračka, Babin Zub, Crkvine, Komovi, and Prokletije. Beyond that zone there are high mountain chains with a severe sub-alpine climate and moderate mountainous climate in the valleys up to the north of the country.

Historic trends for temperature and rainfall

The valley of the River Zeta has the hottest summers in Montenegro, mainly due to having the highest number of clear days. The highest mean summer temperature is in Podgorica, 29.2°C with the highest maximum daily temperature of up to 44.8°C recorded in August 2007. The lowest minimum daily temperature was −32° C, recorded in Rožaje in January 1985. Figure 5.2 shows the mean annual temperature in Montenegro recorded by the two monitoring stations – Podgorica and Žabljak.

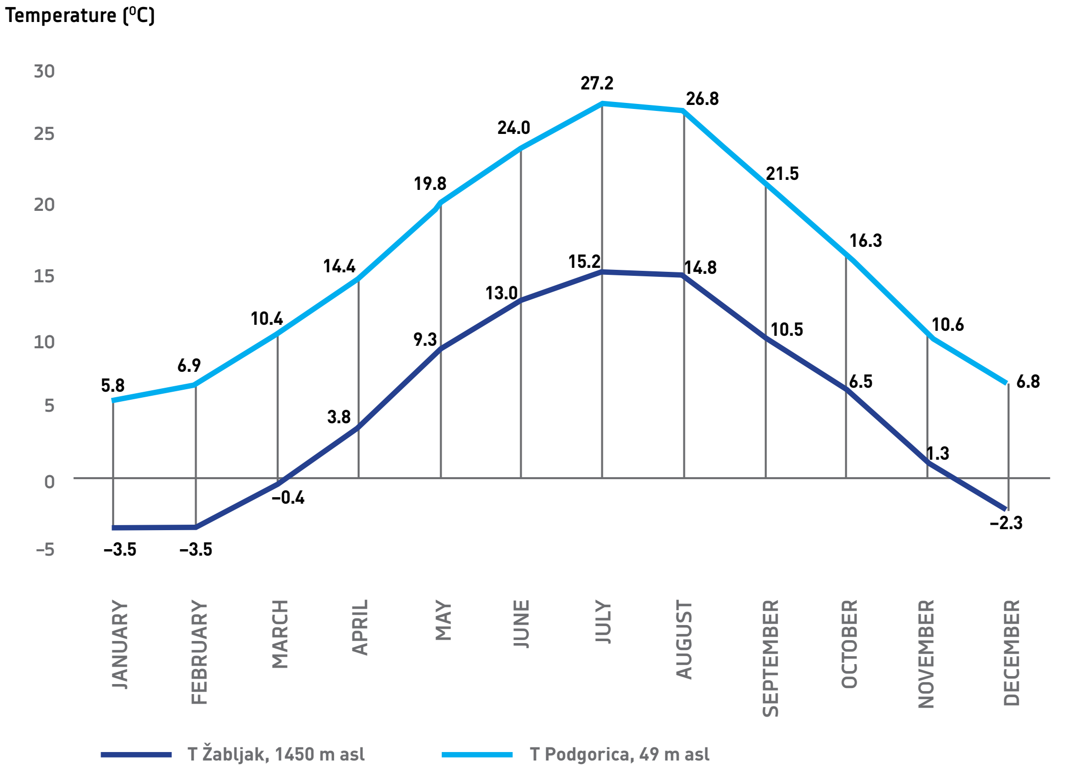


FIGURE 5.2 **Distribution of annual mean temperature in Montenegro**

Source: Institute of Hydrometeorology and Sesimology

Annual precipitation in Montenegro is very uneven, ranging from about 800 mm in the north to about 5,000 mm in the southwest. On the slopes of Mt. Orjen, in the village of Crkvice (940 m above sea level), precipitation may even reach 7,000 mm.

Figure 5.3 shows the annual distribution of air temperature and precipitation for the period 1981–2010 at the two stations (Podgorica and Žabljak) at different altitudes and in different climatic zones.

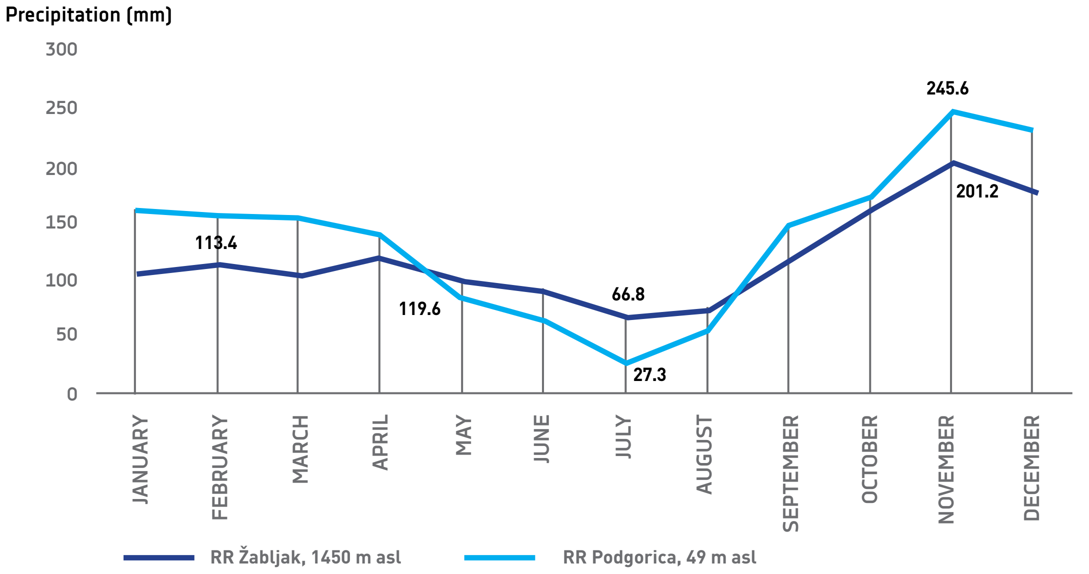


FIGURE 5.3 **Distribution of annual precipitation for the period 1981–2010 at the two stations (Podgorica and Žabljak) at different altitudes and in different climatic zones**

Source: Institute of Hydrometeorology and Sesimology

During the period 1949–2018 changes in mean annual temperature and precipitation were observed at the national level. Measurements indicate a trend towards an increase in temperature throughout most of the territory of Montenegro since the second half of the 20th century. Summers have become very hot, especially over the last 20 years. For the summer period from 1991 to 2018, average temperature deviations from the climatological norm ranged from 90% to 98%.

Figure 5.4 and Figure 5.5 show the deviation of annual mean temperature for the period 1958–2018 for the Žabljak and Podgorica stations.[1] A trend of increasing temperature in each decade since the 1970s can be observed. The period 2011–2020 will be the warmest on the record.

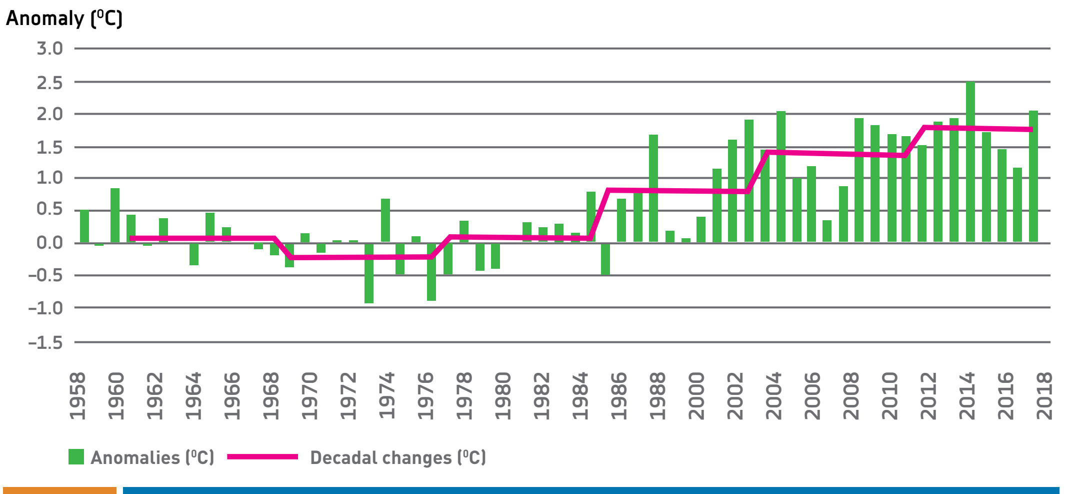


FIGURE 5.4 **Deviation of annual mean temperature for Žabljak in the period 1958–2018 (with the reference period 1961–1990)**

Source: Institute of Hydrometeorology and Sesimology

[1] Reference period 1961–1990.

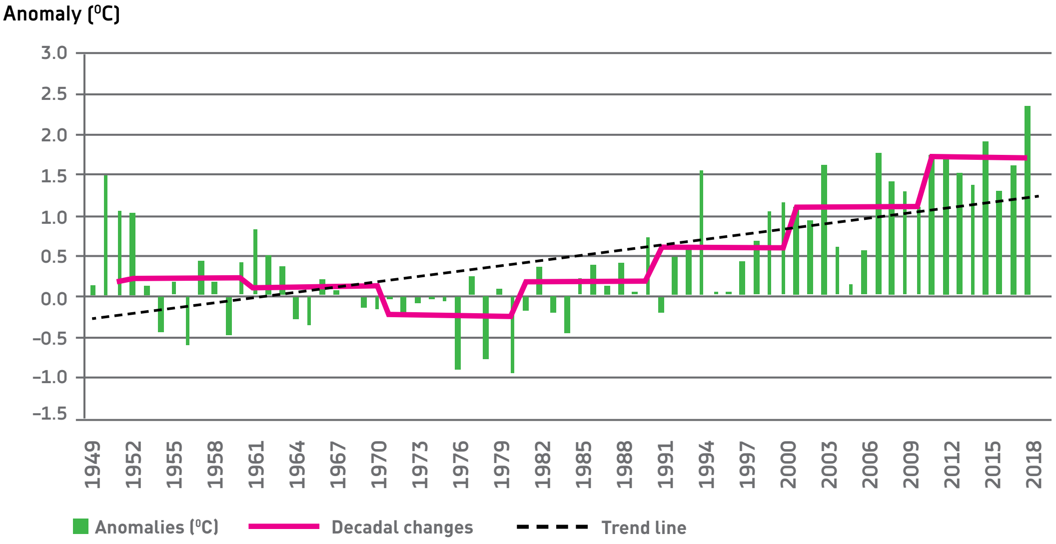


FIGURE 5.5 **Deviation of the annual mean temperature for Podgorica in the period 1949–2018 (with the reference period 1961–1990)**

Source: Institute of Hydrometeorology and Sesimology

The decadal representation of the change in mean annual temperature is presented in Table 5.1. This change is the largest in Žabljak by +1.8° C compared to the climatic normal of 1961–1990.

The extreme temperature indicators show that in the northern region of Montenegro the number of summer and tropical days and nights has changed significantly compared to the reference period of 1961–1990. The same applies to warm days and nights, the length of heat waves, and the number of frosty days. Significant changes in the length of the growing season were recorded only in Žabljak.

TABLE 5.1:
Deviation of the annual mean temperature for Podgorica in the period 1951–2018 (with the reference period 1961–1990)

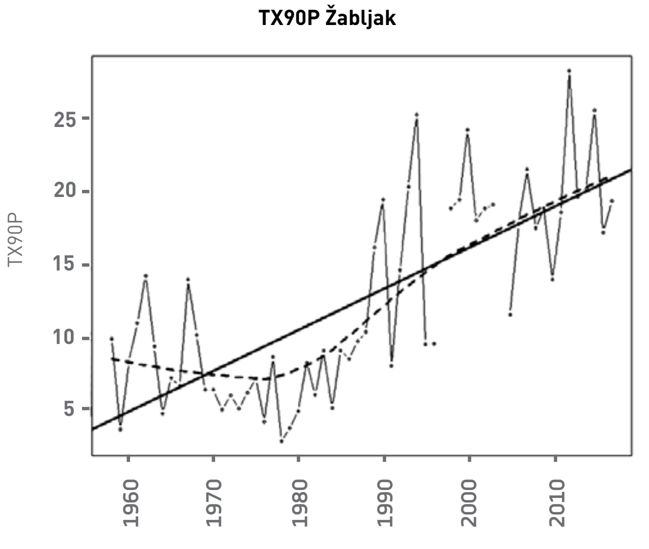
	Reference period	Mean annual temperature (C) per decade							
	61–90*	51–60	61–70	71–80	81–90	91–00	01–10	11–17**	Δ1	Δ2
Station: Žabljak	4.6	-	4.7	4.5	4.7	5.4	6.0	6.4	+1.4	+1.8
Station: Podgorica	153	15.5	15.4	15.0	15.4	15.8	16.3	17.0	+1.0	+1.7

Source: Institute of Hydrometeorology and Sesimology

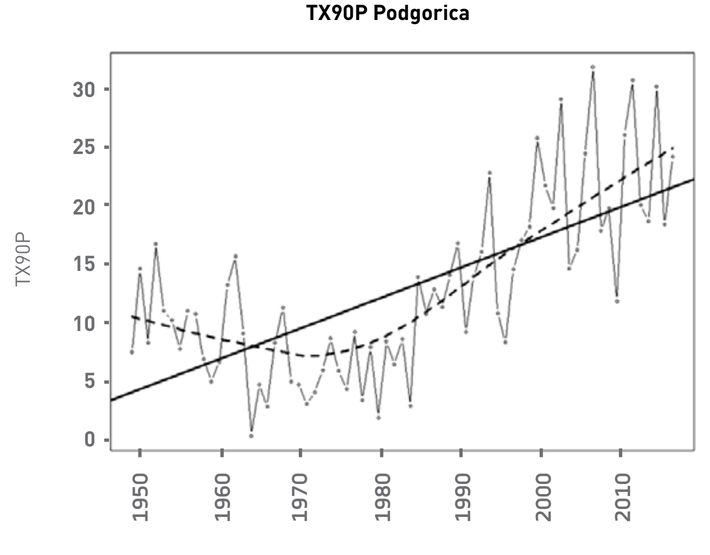
Δ1 – The average annual air temperature deviation for the period 2001–2010. from the reference period 1961–1990;
Δ2 – The deviation of the mean annual air temperature for the period 2011–2018 in relation to the reference period 1961–1990

**The period 1961–1990 represents the climatological norm in relation to which climate change is observed. The period was chosen by the WMO and refers to the climate described by the mean values of the meteorological elements obtained from the 30-year measurement period. At the end of 2020, the period 1991–2012 will be used as the next reference period instead of the current one. More information about choosing a base period can be found on the WMO website: http://www.wmo.int/pages/themes/climate/statistical_depictions_of_climate.php.
**Although not a complete decade, this eight-year period for Podgorica is shown informatively to monitor the trend of temperature and precipitation.

The central region in Montenegro also recorded positive changes in the number of summer and tropical days, warm days and nights, and the length of heat waves. The trend is positive, increasing with time, unlike in the northern region where no significant changes in the number of frosty days were observed. There are no significant changes in the length of the growing season, neither for the central region nor for the northern region. Only in Bar is there a significant reduction in the number of frosty days. Figure 5.6 shows an example of the recorded number of warm days in Žabljak, Podgorica, and Bar for the period 1950–2010.



R2 = 55,2; p-value = 0; Stope estimate = 0,284; Stope error = 0,034



R2 = 46; p-value = 0; Stope estimate = 0,257; Stope error = 0,034

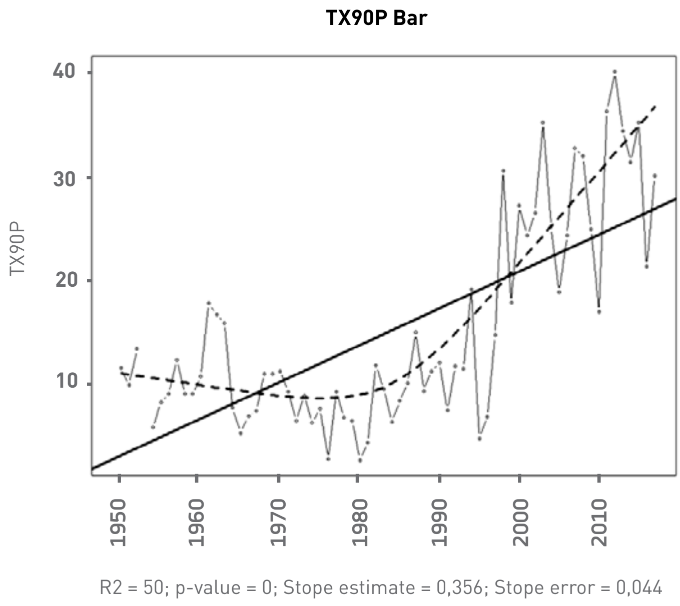


FIGURE 5.6 Number of warm days Tx90 in Žabljak, Podgorica, and Bar in the period 1950–2010

Source: Institute of Hydrometeorology and Sesimology

The decadal view of the change in mean annual precipitation for the period 1951–2017 shows that the decade 2011–2020 is expected to have a lower average annual precipitation compared to the previous decade, primarily due to hydrological droughts during 2011, 2012, 2017, 2018, and 2019. Figure 5.7 and Figure 5.8 show the annual rainfall and temperatures for the stations in Podgorica and Žabljak. The rainiest year was 2013 in the central region (in Podgorica), and in 2010 in the mountainous region (in Žabljak), while the driest year was 2011 in all regions of Montenegro.

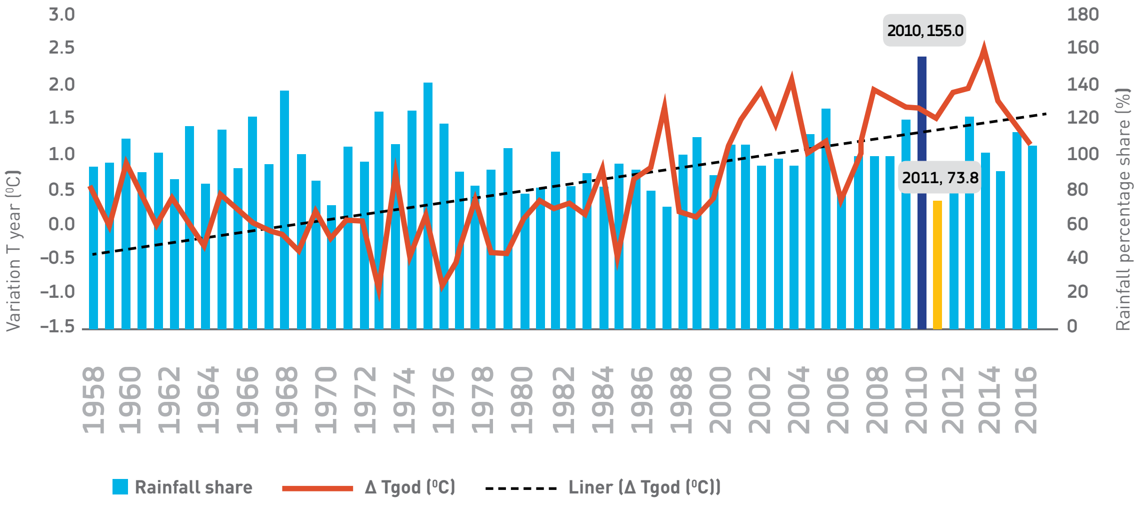


FIGURE 5.7 Annual rainfall share and deviation of temperature in regard to 1961–1990

Source: Institute of Hydrometeorology and Sesimology

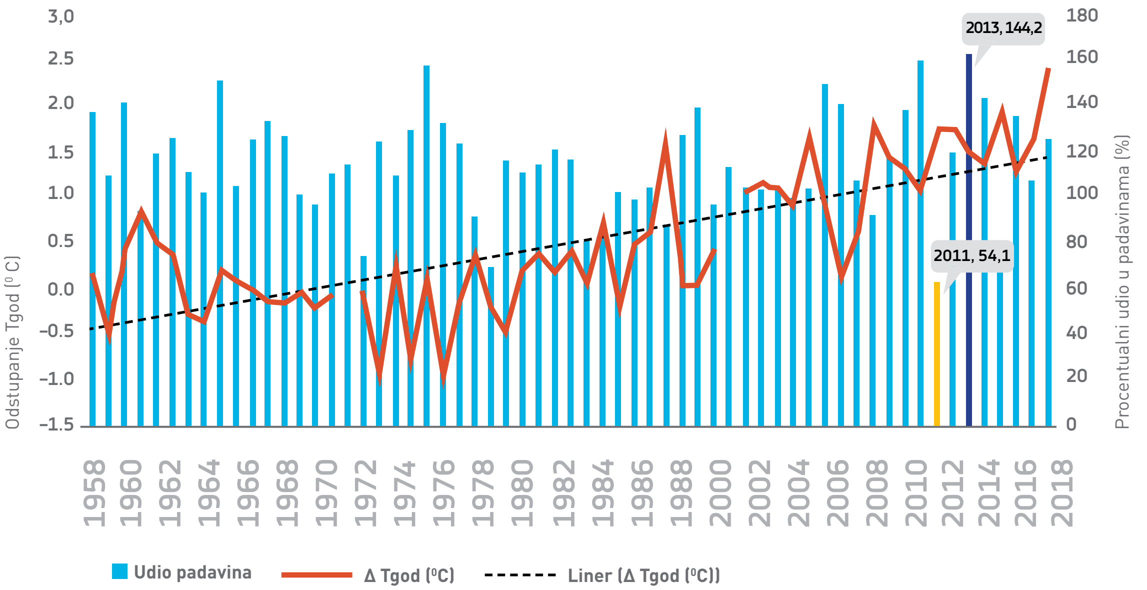


FIGURE 5.8 **Annual rainfall share and deviation of temperature in regard to 1961–1990**

Source: Institute of Hydrometeorology and Sesimology

TABLE 5.2:
Decadal representation of the percentage of rainfall for the period 1951–2017 in relation to 1961–1990

	Reference period	Decadal representation of the percentage of rainfall relative to the reference period						
	61–90	51–60	61–70	71–80	81–90	91–00	01–10	11–17
GMS Žabljak (1,450 m asl)	1455.4 (100%)	-	-	108%	89%	94%	111%	100%
GMS Podgorica (49 m asl)	1657.9 (100%)	98%	106%	102%	92%	96%	108%	104%

Source: Institute of Hydrometeorology and Sesimology

HYDROMETEOROLOGICAL HAZARDS

The term "hydrometeorological hazards" refers to physical events or trends related to the climate or the physical impacts of the climate (IPCC, 2014). Changes in temperature and precipitation averages, increased climate vulnerability, and intensified extreme events lead to hydrometeorological hazards hazards, such as those of a hydrometeorological origin (e.g. floods, and droughts), as well as heat waves. It is impossible to link an individual natural hazard directly to climate change, but the link between climate change and an overall increase in the frequency and intensity of hydrometeorological hazards is recognized. Montenegro is prone to several hydrometeorological hazards, including floods, drought, heavy rainfall or snowfall, windstorms, heat waves, landslides, and forest fires.

Floods

Extreme rainfall episodes generally lead to significant floods. Individual daily rainfall is often linked to flash floods of limited spatial extent, but multi-day rainfall generally has a broader spatial footprint and, thus, more extensive flooding can be explained. High-intensity rainfall, among other things, can cause flooding, landslides, landslides, spills of streams and drainage channels, impeded traffic flow, decrease in water quality, pollution of groundwater released, and a reduction of arable land. A significant positive change exists in the daily intensity of precipitation in the northern region. In the cities of the coastal region (Herceg Novi and Bar) there are no significant changes in the extreme precipitation indicators. A downward trend is seen in the number of days with heavy rainfall R60mm, the maximum 5-day rainfall in Herceg Novi, as well as 5% of the highest rainfall. Figure 5.9 shows the daily precipitation intensities in Žabljak and Podgorica.

Particularly sensitive areas for heavy rainfall are Ulcinj Field (at the River Bojana's high-water levels), the zone from Vladimir to Veliki Ostros, and from Sutomore to Virpazar, the area of the old town of Kotor, Sutorina, Herceg Novi, Crkvica, and part of the Luštica Peninsula.

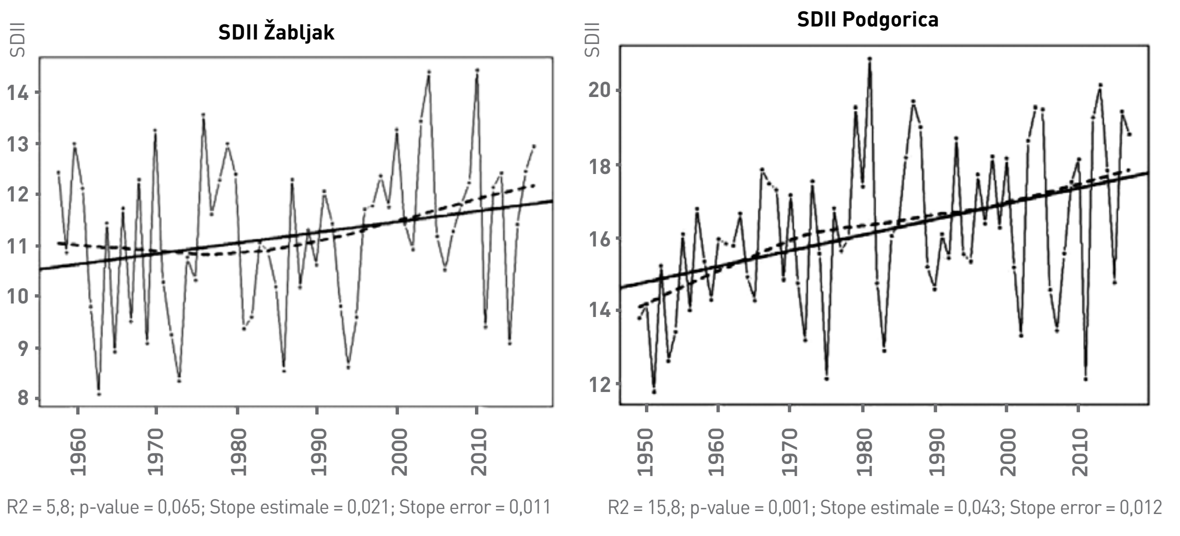


FIGURE 5.9 **Daily precipitation intensities – SDII in Žabljak and Podgorica**

Source: Institute of Hydrometeorology and Sesimology

The International Disaster Database (www.emdat.be) reports that Montenegro has suffered three major floods (2007, 2009, and 2010). The damage and losses caused by the 2010 flood alone amounted to around €44 million (1.4% of gross domestic product) (EM-DAT, 2019). The FAO estimated that this flood impacted around 30,000 hectares of agricultural land. The most affected was the area around the River Zeta valley and the area around Lake Skadar, specifically the territory of Golubovci, where most of the national vegetable production occurs. Total agricultural damages and losses were estimated at over €13 million, of which over €6 million was in damages and over €7 million was in losses (FAO, 2015). The most recent significant flood was in November 2019 resulting in multiple impacts for people and infrastructure in municipalities of Nikšić and Kolašin. The total estimated damage on households from this flood was around €73,000 and for infrastructure (e.g. roads, bridges) it was around €211,500.

In Montenegro, protection from floods has not been given much attention so far, although the consequences are frequently significant.

Droughts

Drought can have multiple negative impacts on the economy, the environment, and human health. The sectors of agricultural, forestry, and tourisms are the most affected by droughts in Montenegro. The occurrence and magnitude of droughts is expected to increase in the future, with decreasing rainfall and increasing temperatures, especially during the summer and autumn.

Drier and warmer conditions in the future will also favour more frequent occurrences of forest fires in the coastal area, and the vulnerability of the area to this phenomenon will increase, especially in the summer and autumn. Changes in the water balance are of increasing concern for drought-susceptible countries, such as Montenegro. Areas that are traditionally dry are expected to become drier. But that average pattern is also reflected in the inter-annual variability, as higher temperatures enhance the feedback from more quickly drying soils, even if the precipitation does not change. Therefore, there is a need to plan for more severe and more frequent drought years in Montenegro as climate projections show an increase in the average temperature. Drought monitoring in Montenegro is based on a standardized precipitation index (SPI), remote sensing data, Drought Watch, and a national network of reporters.

The drought of 2011 evolved into a social and economic challenge that affected the whole country and led to an extreme hydrological deficit in the Zeta–Bjelopavlići region, which includes the largest agricultural area in Montenegro. These extreme dry conditions led to forest fires in the following year. The frequent and intense drought impacted the quality and quantity of the agricultural yield, revenues, the costs to prevent and control the spread of diseases, insects, and weeds, as well as the irrigation rate.

Hydrological droughts occurred during 2017, 2018, and 2019, significantly affecting the water levels of important rivers and lakes, such as the Rivers Morača and Zeta, as well as Lake Skadar. This resulted in impacts in the fisheries, agriculture, and energy sectors.

The agricultural drought during the autumn of 2017 developed into a hydrological one, and this affected the water levels in the rivers and hydroelectric plants. This was observed in 2018 and 2019. In 2017 and 2018 the intensity of the drought varied from moderate, very arid to extremely arid (Figure 5.10).

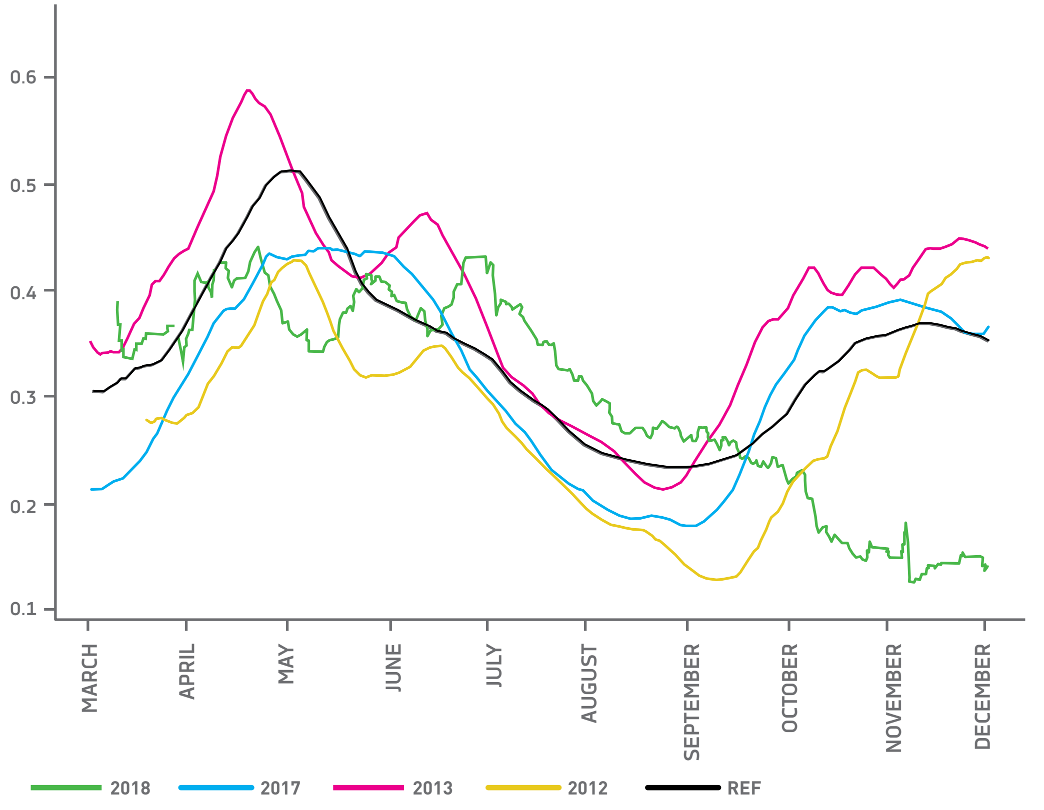


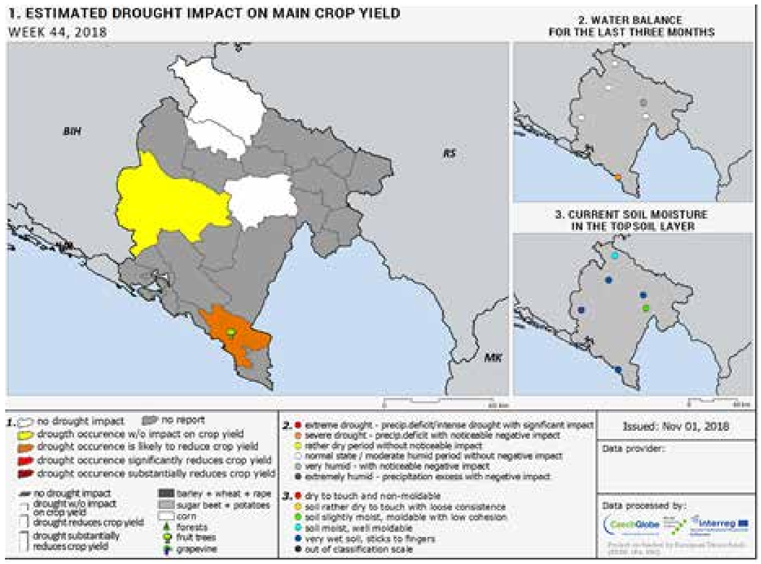
FIGURE 5.10 **Vegetation situation in the period 2012–2018 described by FVC**

Source: DMCSEE drought bulletins

DriDanube was an EU Interreg project (2017–2019) which had the objective to increase the capacity of the Danube region to manage drought-related risks. The project supported the development of maps to monitor drought impacts in Montenegro. An example of such maps for the drought during 2018 (week 44) is presented in the figure below, which includes three kinds of maps:

1. Map of the estimated drought impact on main crop yield
2. Map of the water balance for the last three months
3. Map of the current soil moisture in the topsoil layer.

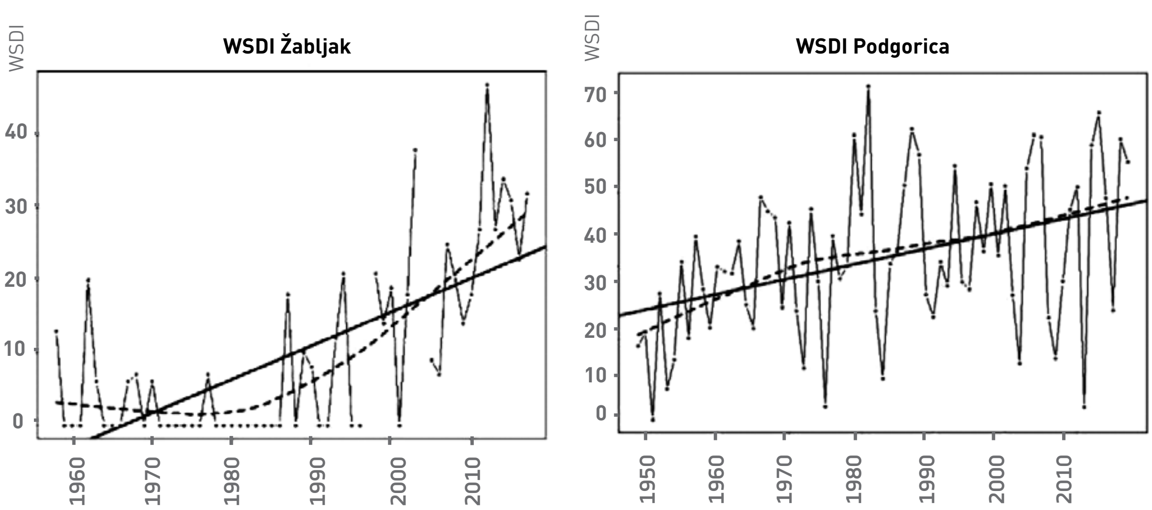
The map shows that the southern part of Montenegro had a less-than-normal water balance in the late autumn and therefore drought occurrence was likely to reduce crop yields.



Source: http://www.interreg-danube.eu/approved-projects/dridanube

Heat waves

Heat waves are an increased climate hazard for Montenegro with higher frequency and length. From a long-term perspective, there is a trend of continuous increases in the length of heat waves. The figure below shows the occurrence of heat waves recorded by the stations in Podgorica and Žabljak for the periods 1949–2017 and 1958–2017 respectively. In 2012 a strong heat wave hit Montenegro, affecting more than 4,500 people (EM-DAT, 2020), which are presented on the Figure 5.11 below as examples.



R2 = 46,1; p-value = 0; Stope estimale = 0,465; Stope error = 0,067

R2 = 29,2; p-value = 0; Stope estimale = 0,495; Stope error = 0,094

FIGURE 5.11 **Occurrence of heat waves recorded by the stations in Podgorica and Žabljak**

Source: Institute of Hydrometeorology and Sesimology

Analyses for Montenegro show that long heat waves predominate in August, while in June and July Montenegro experiences more frequent but shorter heat waves.

Forest fires

Forests and forest land in Montenegro covered 69.8% (964,262 ha) of the total land area in 2013 (FAO, 2014). In the period 2005–2015, there were around 800 large forest fires in Montenegro, and more than 18,000 ha of forests and over 800,000 m^3 of wood mass were damaged or destroyed (REC, 2015). Montenegro's fire season was the worst in 2017. There were 124 fires covering over 30 ha, affecting a total of 51,661 ha, six times the area mapped in 2016. Fires were recorded through the year from February to November, although the worst of the damage occurred in July and August. The largest fire of the year burned 5,687 ha in Danilovgrad in July, but there were also 28 other fires larger than 500 ha (Jesús San-Miguel-Ayanz et al., 2018).

A lack of rain has affected water resources, and high temperatures contributed to the spread of the fire, followed by a strong wind. The temperature of 43.9°C in Podgorica on 7 August 2017 was the second-highest temperature in the last 63 years.

The calculated and analysed values of the FWI indexes showed the fire risk was in the following classes: very high – severe – extreme. The most affected was: the region of the Municipality of Nikšić, Pljevlja, and Žabljak, the coast, the area of Cetinje, and Podgorica.

Because of the very high degree of drying of the total vegetation in those areas, fires started very easily.

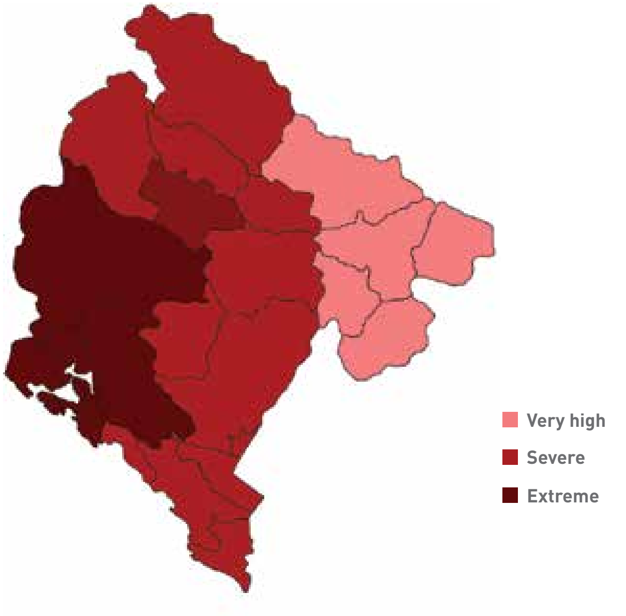


FIGURE 5.12 Areas exposed to fire risk in 2012

Source: Institute of Hydrometeorology and Sesimology

FOREST FIRE IMPACTS:

Health – watery eyes, coughing, and choking due to large amounts of dust particles in the air; the concentration of dust particles in the air in Podgorica was four times higher than permitted.

Forest – the loss of 6,500 hectares of forests due to fires was estimated at about €6 million according to information from the Ministry of Agriculture and Rural Development.

Traffic – the traffic on the Podgorica–Cetinje road was periodically closed in order for fire trucks to get closer to the location of the fire in the village of Dobrsko.

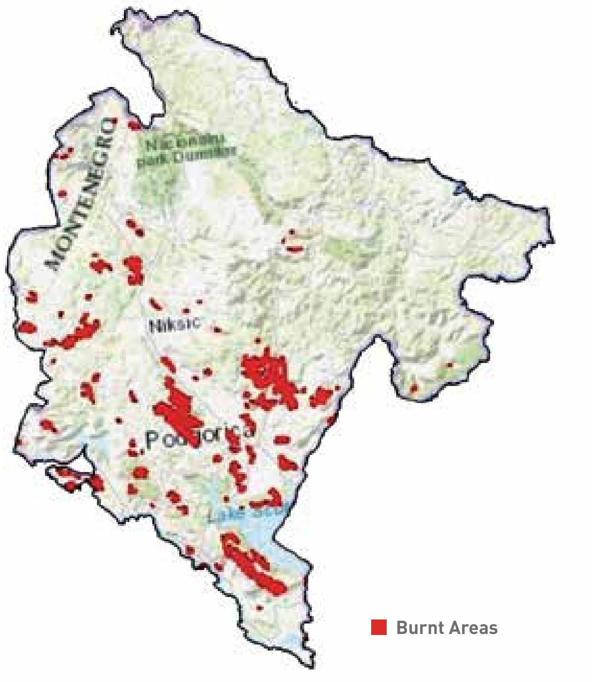


FIGURE 5.13 **Map of burnt areas in Montenegro in 2017**

Source: Jesús San-Miguel-Ayanz, et al., 2018

CLIMATE CHANGE PROJECTIONS

To design climate projects for Montenegro, the analysis of the Third National Communication used the regional GHG emission scenario RCP8.5 established by the IPCC – AR5 (IPCC, 2014).

The Initial and Second National Communications for Montenegro analysed the A1B and A2 scenarios from the Special Report on Emission Scenarios (SRES). These scenarios, compared to the RCP8.5 scenario, predict lower CO_2 concentrations at the end of the 21st century, at about 690 ppm (A1B) and about 850 ppm (A2). In this respect, scenario RCP8.5 is closer to scenario A2. The advancement of new results is primarily reflected in the use of a more modern, non-hydrostatic, high-resolution model that allows more accurate simulation of climatic conditions, especially in territories with complex orography, such as Montenegro.

Methodology used to build the climate projections for Montenegro

The climate projections used the regional IPCC scenario RCP8.5, which was done using the NMMB regional non-hydrostatic model. The horizontal resolution of the model was 8 km, and the results of the CMCC-CM global climate model were used as boundary conditions. The reference period is defined as the 30-year period 1971–2000, while integration of the future climate predictions has covered the period 2011–2100. The results are presented as deviations of the mean annual and seasonal values of temperatures, precipitation, and selected climatic indices on the territory of Montenegro for the three future 30-year periods, 2011–2040, 2041–2070, and 2071–2100, compared to the reference period 1971–2000.

The analysis of climate projections presented below shows that the mean annual and extreme temperatures may increase, which may lead to more frequent and longer heat waves, more hot days and nights, fewer days with frost, and fewer cold days and nights. In addition, less precipitation is expected, which may lead to more frequent droughts, as well as an increase in the number of forest fires. It is expected that climate change will increase the frequency and severity of many types of extreme weather events; besides droughts and forest fires, there may also be floods and storms, among other things. Moreover, seasonal patterns may shift, which will lead to greater variability that may affect agriculture in Montenegro.

Projections for mean annual and seasonal temperatures

The results from the climate projections show an increase in the annual temperature of 1.5° C to 2° C by 2040 throughout the country (Figure 5.13). The increase in the temperature during the winter months December–January–February (DJF) is expected to be between 2° C and 2.5° C, and in the summer months June–July–August (JJA) it is expected to be on average around 2° C.

For the period 2041–2070 the deviations of the mean annual temperature range from 2.5° C to 3° C. The predicted warming in winter and summer is on average the same, with a more prominent increase in the north in winter and in the south in summer.

For the period 2017–2100, the deviation in the mean annual temperature over most of the territory is around 5.5° C. During the winter, the projected increase in temperature is expected to exceed 6° C in the northern mountain areas, while during the summer it will be higher with 6° C in the southern, coastal part, at lower altitudes.

The predicted increase in temperature during winter months is expected to lead to a decrease in the total accumulation of snow, but also to a decrease in the number of days with snowfall in the territory of Montenegro.

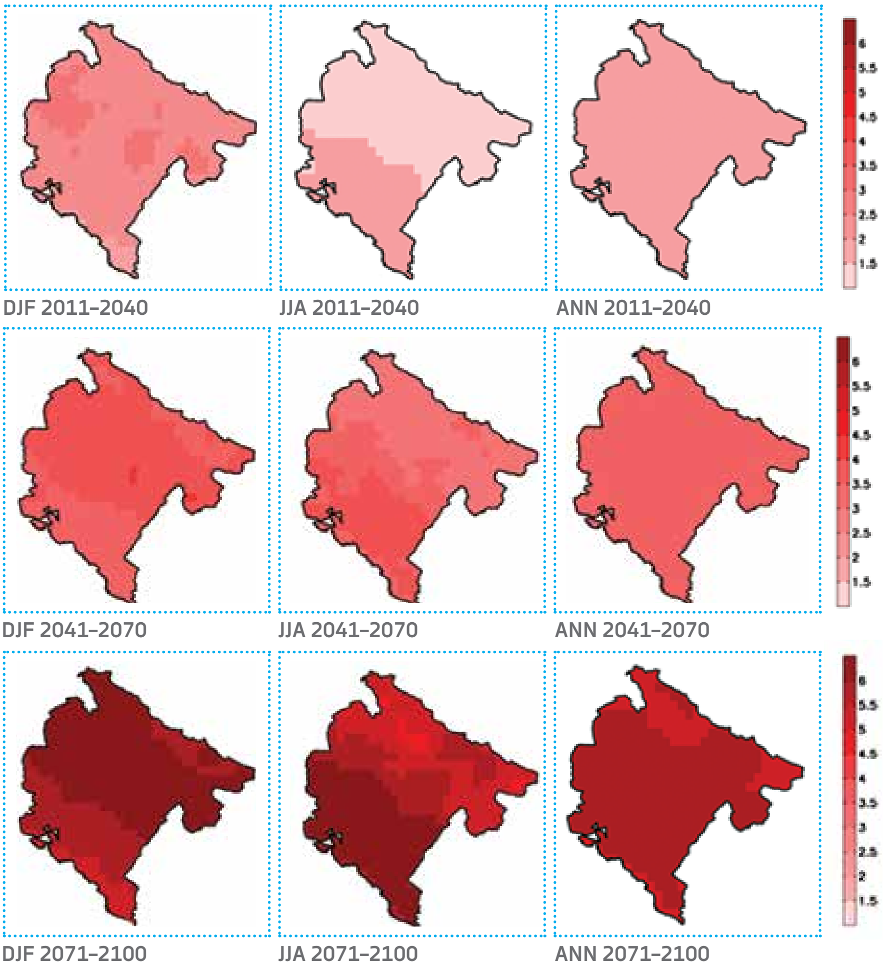


FIGURE 5.14 **Change (° C) of the mean winter (DJF), summer (JJA), and annual (ANN) temperatures, for the periods 2011–2040, 2041–2070, and 2071–2100, compared to the period 1971–2000, according to scenario RCP8.5**

Mean annual and seasonal rainfall

The results from the climate projections show a decrease in rainfall especially during the summer months and increase in winter months in some parts of the country (Figure 5.15).

For the period 2011–2040, the north of the country is expected to experience an increase in rainfall of up to +5%, while in the southern part of the country the rainfall it is expected to decrease by up to −5%. For the DJF season, rainfall is expected to increase by up to +5%, with a slightly more pronounced change in the north, while for the JJA season the rainfall is expected to decrease slightly, especially in the southeast regions.

For the period 2041–2070, the country is expected to experience a decrease of up to 20% in the mean annual rainfall throughout the territory. The changes during the winter are similar to the annual deviations during the period 2011–2040, while the summer season is characterized by a decrease of rainfall of up to −45%.

For the period 2017–2100, the mean annual rainfall is expected to decrease by up to –20% over most of the country. The rainfall can be expected to increase by about +20% on average in winter, while in summer there is a clear decrease with values more than –45%.

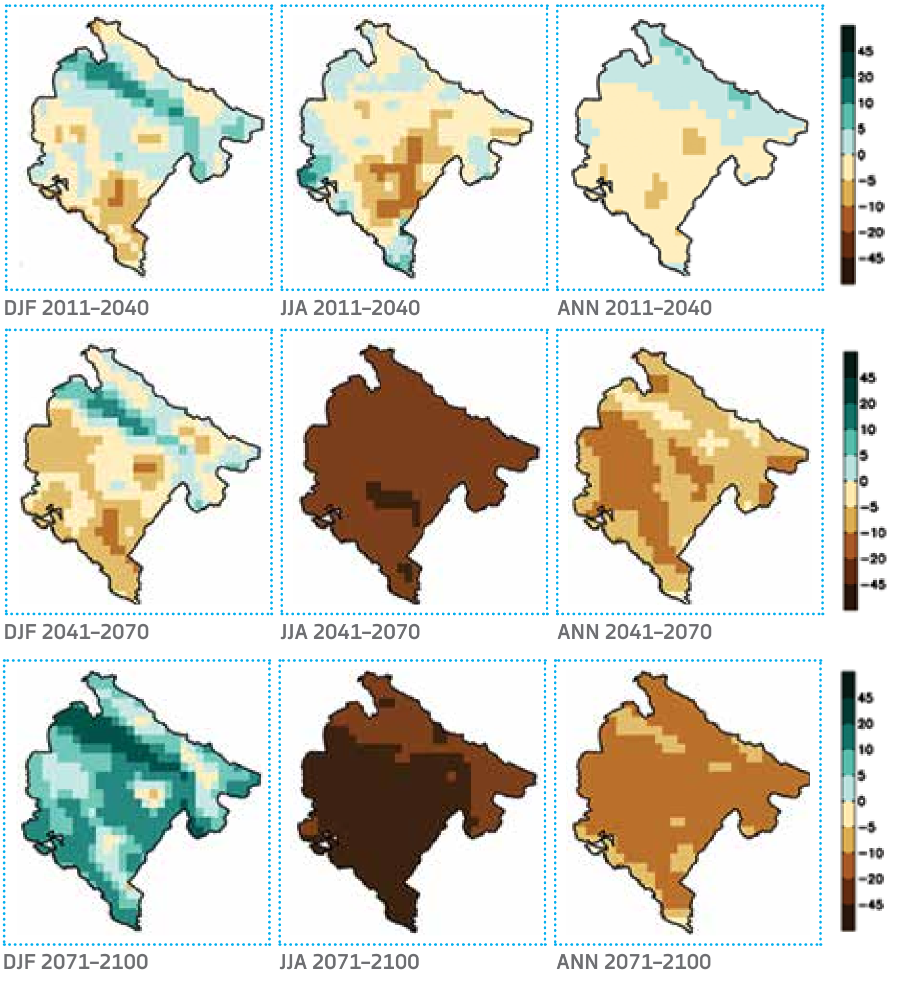


FIGURE 5.15 **Change (%) in the mean winter (DJF), summer (JJA) and annual (ANN) precipitation accumulation, for the periods 2011–2040, 2041–2070, and 2071–2100 compared to the period 1971–2000, according to scenario RCP8.5**

Snowfall

Climate projections show an overall decrease in snowfall in the coming decades:

- For the period 2011–2040, the deviation in the mean annual snow accumulations for both seasons relative to the reference period ranges from –30% in the north of the country to –80% in the central parts. The number of days with snowfall is expected to decrease by the same percentage, from –30 to –80%.

- For the period 2041–2070, expected changes in snowfall range from –50% in the north to a change of more than –90% in the central parts. At the same time, the number of days with snow is expected to decrease from –50% to over –70%.
- For the period 2071–2100, almost the entire territory except the northernmost part can expect a change of snowfall of more than –90%. The number of days with snowfall is expected to decrease by over –70% over the reference period.

Figure 5.16 shows the changes in ***mean seasonal snow accumulations***, for the December–January–February (DJF) and November–April (N2A) seasons, in the territory of Montenegro for the three future time horizons: 2011–2040, 2041–2070, and 2071–2100, compared to the reference period 1971–2000.

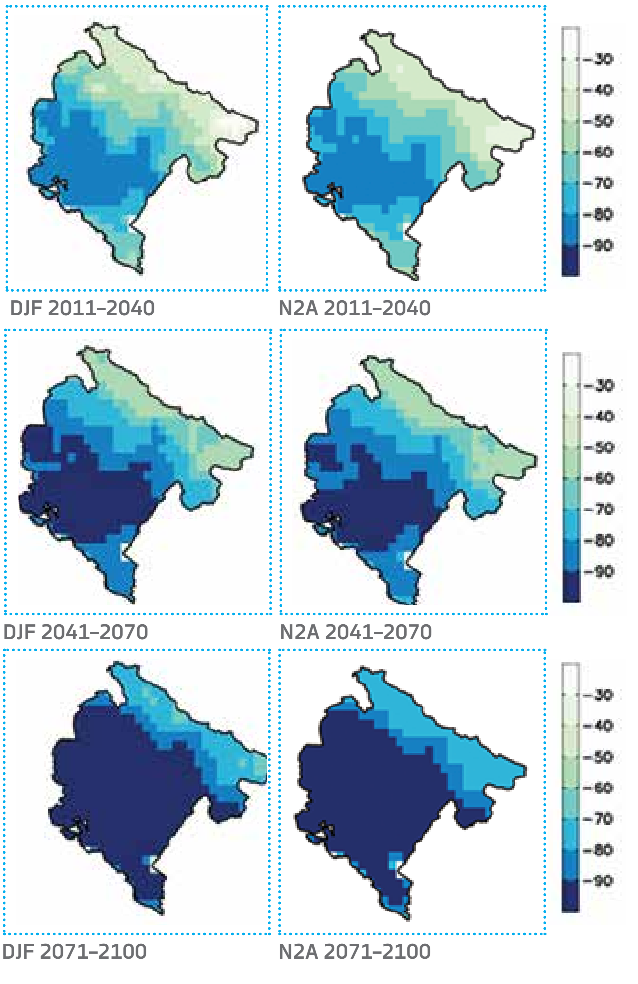


FIGURE 5.16 **Change in seasonal (winter (DJF) and November–April (N2A)) snow accumulations in %, for the periods 2011–2040, 2041–2070, and 2071–2100 compared to 1971–2000, according to the RCP8.5 climate change scenario**

Figure 5.17 shows changes in the ***mean number of days*** with snowfall, for the December–January–February (DJF) and November–April (N2A) seasons, in Montenegro for three future time horizons: 2011–2040, 2041–2070, and 2071–2100, relative to the 1971–2000 reference period.

As seen, the range of changes is very similar to the changes in the snow cover accumulations. It can be seen that the smallest change for all three periods in the future is in the areas with the highest topography, which is expected, since during the winter months in these areas the temperature conditions, primarily due to the altitude, will allow the formation of snow cover.

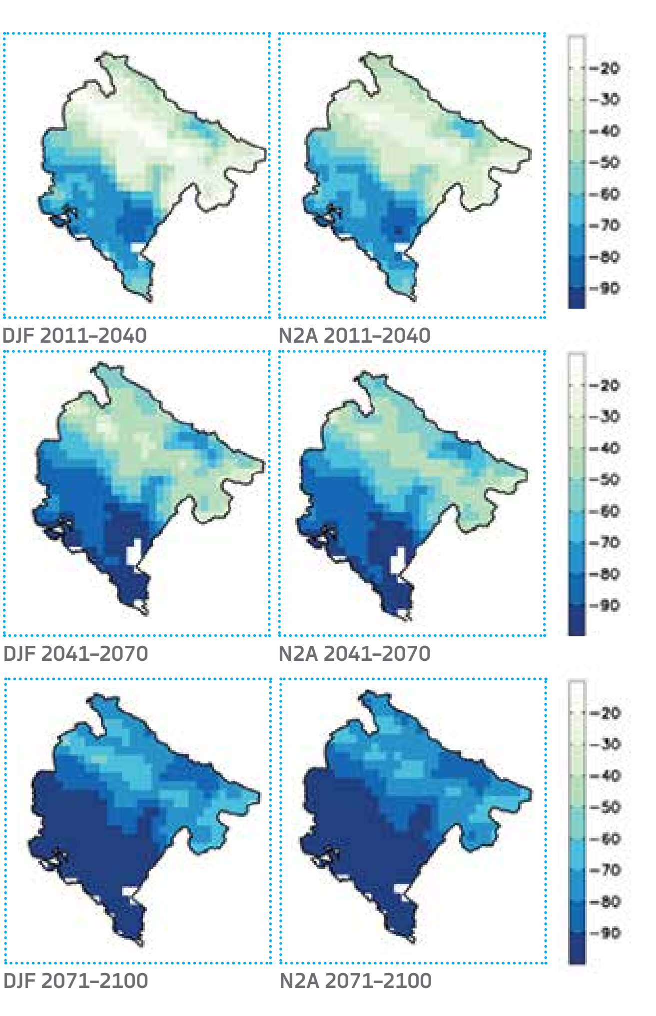


FIGURE 5.17 **Change in the number of days during the seasons (winter (DJF) and the period from November to April (N2A)) with the occurrence of snowfall, expressed in %, for the periods 2011–2040, 2041–2070, and 2071–2100, compared to the period 1971–2000, according to the change scenario climate RCP8.5**

Based on the results presented, further climate change in the case of the RCP8.5 scenario and a further increase in temperature in Montenegro will lead to a significant decrease in the total snow accumulation, but also to a decrease in the number of days with snowfall.

Extreme temperature indices

The number of summer and tropical days, as well as days with tropical nights, is expected to continue to increase until the end of this century in the case of the scenario under consideration. Heat waves will become more frequent and longer. At the same time, the number of frost days is expected to decrease. As a consequence of the increase in temperature, vegetation extension is also predicted.

During the period 2011–2040, a relatively uniform change in the number of summer and tropical days in the entire territory of Montenegro can be expected, and their number is expected to increase by 100%, i.e. twice as many compared to the reference period 1971–2000. The number of days with tropical nights is expected to increase by about 50% over most of the territory, while the change in the southeast may be up to 100% (Figure 5.19).

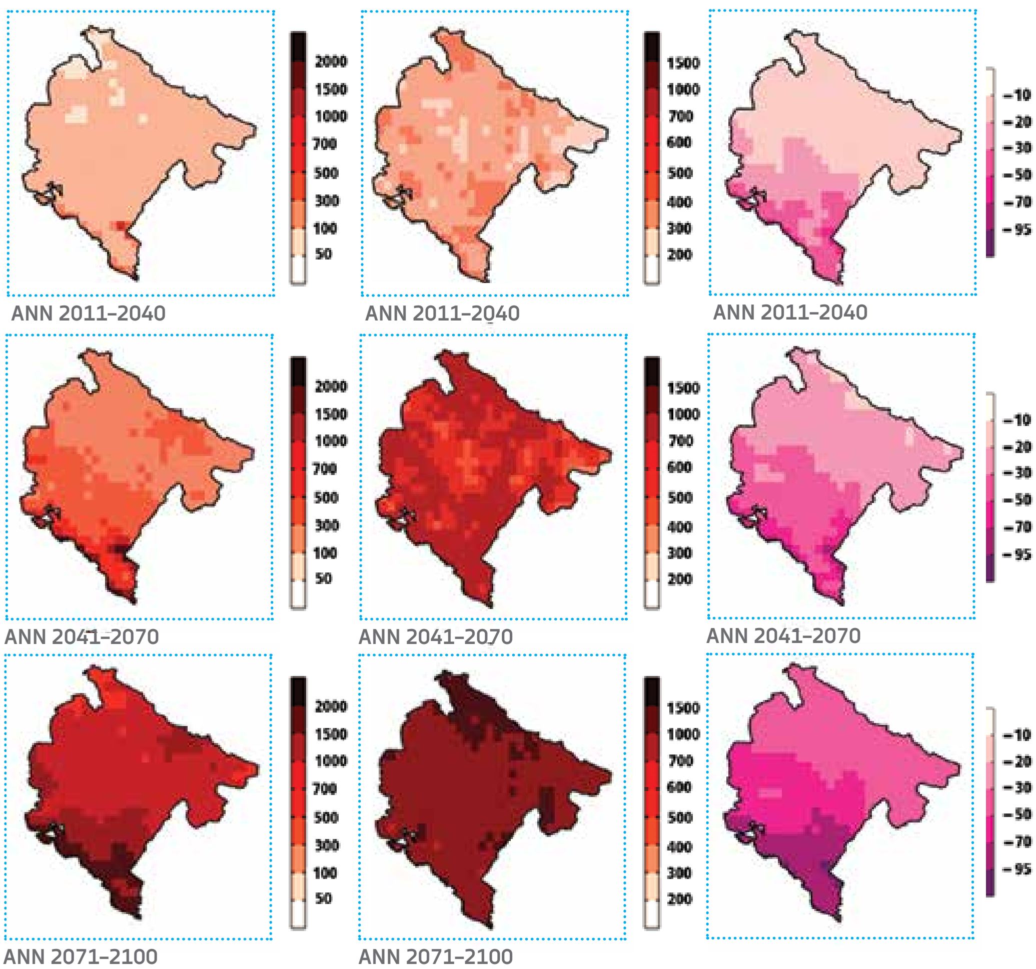


FIGURE 5.18 **Change (%) of average heatwave length, average number of heatwaves, and average number of frosty days, for the periods 2011–2040, 2041–2070, and 2071–2100, compared to 1971–2000, ac cording to scenario RCP8.5**

During the period 2041–2070 the change in the number of summer and tropical days is expected to be more pronounced in the northern, mountainous part of the country, where up to 200% more summer days and up to 500% more tropical days are expected compared to reference period 1971–2000. The number of days with tropical nights is expected to increase by about 50% in the north, with the biggest change expected in the southeast.

The spatial distribution of changes in the period 2071–2100 follows the changes from the previous period, but they are of a higher intensity. Thus, an increase of 500% in the number of summer days in the north of the country is expected and of about 200% in the southeast. The number of tropical days can be expected to be up to 15 times as high as the reference period in the north and three times as high in the southeast (i.e. a 200% increase). At the same time, the number of tropical nights can be expected to rise more than 10 times relative to the reference period in the southeast.

Although the relative change in the number of summer and tropical days is expressed as a percentage relative to the reference period for the south and southeast of the country, the change in the absolute number of days may be greater for the northern mountain areas, given the fact that the number of such days in the southern areas during the reference period is significantly larger than their number in the northern parts.

Extreme rainfall indices

The main feature of the change in the number of days with daily rainfall exceeding 20 mm is that they can be expected to increase in the far north of the country, with maximum values greater than 80% in all three future periods, during almost all seasons, as well as annually (Figure 5.19):

- In the period 2011–2040, the change in numbers during the summer is positive in the west, northwest, and southeast of the country, and negative in the east and in one part of the Adriatic coast.
- For the periods 2041–2070 and 2071–2100, the changes during the summer are negative over almost the entire territory, with a maximum value greater than –80%.
- On the other hand, in the winter season during the period 2071–2100, the change in the number of days with daily rainfall exceeding 20 mm is positive over almost the entire territory, and in the majority of the area it is +20%.

At the same time, during all seasons and for all three periods in the future, there is a positive change in the amount of daily rainfall accumulation on days when their value is greater than 20 mm. Such a change indicates that, on the average, although we can expect a decrease in the number of days on which rainfall exceeds 20 mm, on the other hand, the intensities i.e. accumulations during these days may be higher than the values from the reference period. Precipitation intensification is most noticeable during the winter and autumn for the 2071–2100 time period, for which the maximum positive change is 30%. The biggest change can be observed for the summer season and period 2071–2100 in the southeast, with values higher than 60% compared to the reference period 1971–2000.

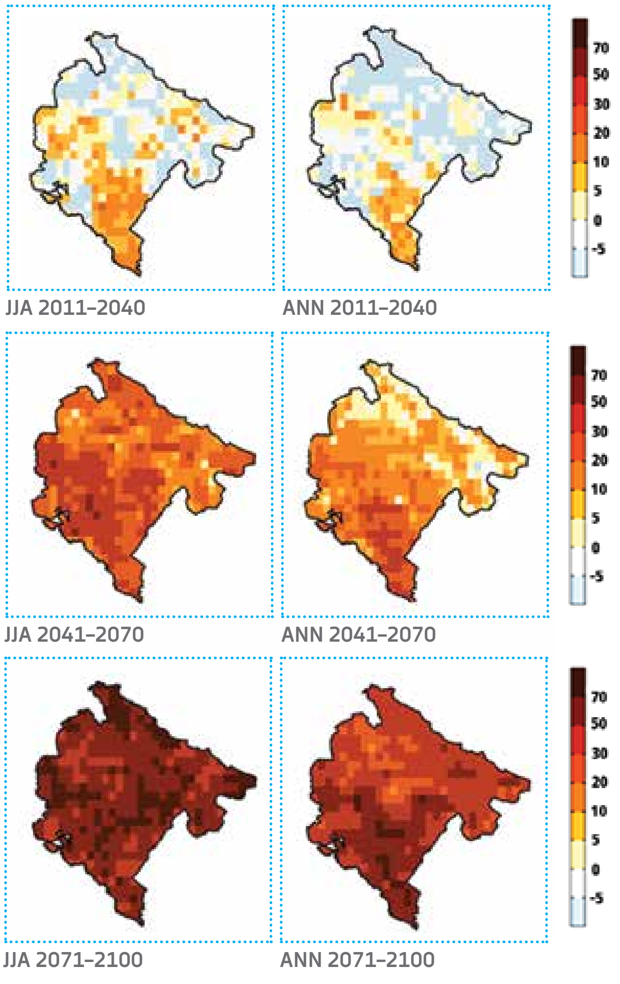


FIGURE 5.19 **Change (%) of days with precipitation greater than 20 mm during the winter (DJF) and annually (ANN) and change (%) of consecutive days without precipitation during the summer (JJA) and annually (ANN) for the periods 2011–2040, 2041–2070, and 2071–2100 compared to the period 1971–2000, according to scenario RCP8.5**

An increase in the average annual number of episodes with five-day rainfall greater than 60 mm based on the selected scenario is expected in the north of Montenegro during all of the three future periods analysed, with local peaks exceeding 40% over the 1971–2000 reference period. In the rest of the country, this change is negative and its maximum amount is around −40% for the period 2071–2100. On the other hand, the average change in rainfall accumulation per episode of five-day rainfall greater than 60 mm is positive over most of the territory for all three periods, and its maximum of 20% occurs for the period 2071–2100 and is located in coastal areas.

Thus, in the case of the RCP8.5 scenario, during this century, in most of the territory of Montenegro one can expect a decrease in the number of episodes when five-day rainfall exceeds 60 mm, but also an increase in accumulations during individual episodes. Although the number of such episodes will be smaller, the accumulated precipitation during individual episodes will be on average higher. This change can be particularly important when analysing the risk of torrential floods, triggering landslides, and landslides.

In the period 2011–2040 in the north of the country, the change in the average number of consecutive days without precipitation ranges by around −5% both in the summer and all-year-round. A positive change, with a maximum value of around 30%, is expected in the south-eastern part of the country, and is slightly higher for the summer season than on a yearly basis. An increase in the number of consecutive non-precipitation days throughout the territory of Montenegro is expected over the remaining two analysed periods. The change will be greater for the period 2071–2100 and will range from 30% to over 70% during the summer season. The drastic increase in the number of consecutive days without rainfall by the end of the century clearly shows that in the future there will be an intensification of droughts, which will lead to an increased risk of droughts.

Changes in surface temperature of the Adriatic Sea

The estimation of the sea surface temperature change for scenario RCP8.5 was performed based on the results of two regional climate models from the Med-CORDEX International Initiative and seven global climate models from the CMIP5 project.

Two related regional models predict an increase in the mean annual sea surface temperature in the coastal area of Montenegro. The change for the period 2011–2040 is in the range from 0.5° C to 1.5° C, for the period 2041–2070 it is in the range from 1° C to 2° C, while for the last period 2071–2100 the change is from 2.5° C to 3.5° C, in comparison to the mean value for the 1971–2000 reference period. Compared to the predicted changes in temperature above land, changes in the sea surface temperature are slightly smaller, which is a consequence of the higher heat capacity of the water compared to the thermal capacity of the land. This difference in the rate of warming is present in all projections of the global climate, in which it is clear that temperature changes will be more pronounced on land.

The temporal evolution of the change in mean annual sea surface temperatures in the coastal region of Montenegro from the integration of two regional and seven global connected climate models predicts changes ranges from about 0.5° C to 1° C for 2011 and from 2.5° C to 5° C for 2085 relative to the reference period 1971–2000. In addition to the relatively large range of possible future changes, their mean values from regional and global models overlap between 2011 and 2085 and range from about 0.5° C to about 3.5° C (Figure 5.20). The thick red line shows the mean of changes of the two regional models, and the thick blue line shows the mean of changes of the seven global models.

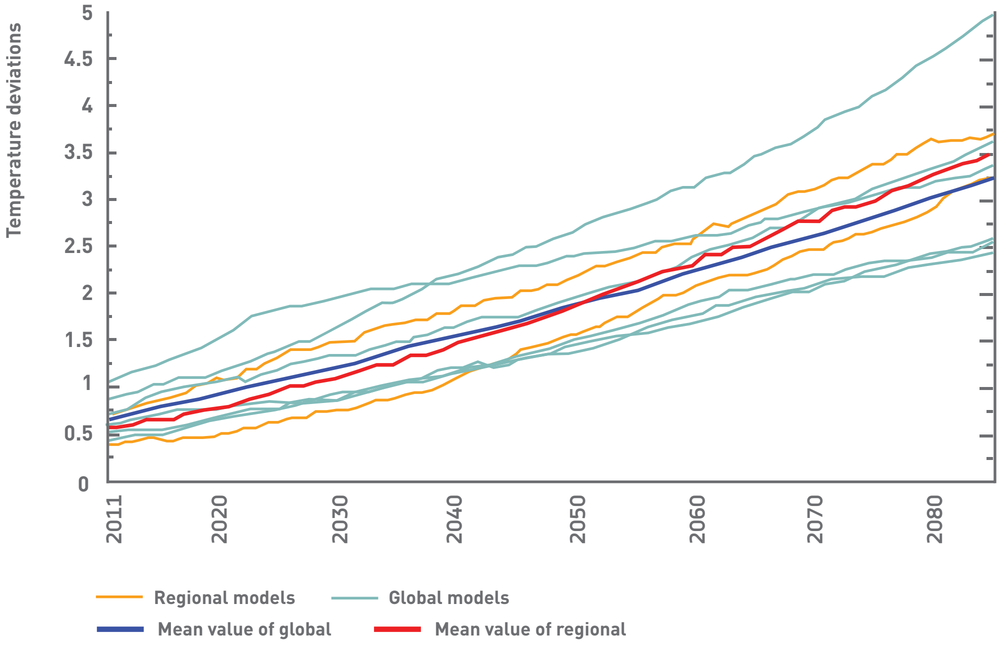


FIGURE 5.20 **Changes (° C) of the mean annual sea surface temperature from the integration of two coupled regional climate models (yellow lines) and seven coupled global climate models (light blue lines) relative to the period 1971–2000 from projections for scenario RCP8.5**

Estimation of uncertainty in projections of future climate

The uncertainty of future climate projections stems from: (1) the choice of future emissions scenarios; (2) the imperfection of climate models; and (3) the processes that contribute to the internal variability of the climate system.

The uncertainty of the presented results on temperature and precipitation change under scenario RCP8.5 was assessed by analysing the results of 18 regional climate models participating in the EURO-CORDEX initiative. Mean temperature and precipitation anomalies were calculated for successive 30-year periods beginning with the period 2011–2040. Based on the distribution of the anomalies of the individual models, the mean values and ranges, within which 66% and 98%, respectively, of the results of the analysed models were estimated, and then the results of the regional NNMB model were compared with these values (Figure 5.21). The black line indicates the mean of these results, the orange lines define the range within which 66% of the results of the analysed models lie, the red lines show the range defined with 98% of the analysed results. The result of the NMMB regional model is shown by a brown line.

The mean of the 18 models for temperature change in the period 2071–2100 according to scenario RCP8.5 compared to the period 1971–2000 is slightly higher than 4° C. The range of the probable value (with a probability of 66%) of change for the same period is from 3.4° C to 5.1° C, while the range from 3.2° C to 5.5° C contains 98% of the analysed results. The result of the NMMB regional model during the first half of the 21st century is within the probable range (66%) of temperature change, while in the second half it is slightly above this range, but still within 98% of the range.

The mean of the 18 models for the change of accumulated precipitation in the period 2071–2100 according to the scenario RCP8.5 compared to the period 1971–2000 is about −5%. The range of probable value (with a probability of 66%) of change for the same period is from 0 to −10%, while the range from +3 to −20% contains 98% of the analysed results. The result of the NMMB regional model for the period during the first half of the 21st century is within the probable range (66%) of precipitation change, while in the second half it is slightly below this range but still within 98% of the range.

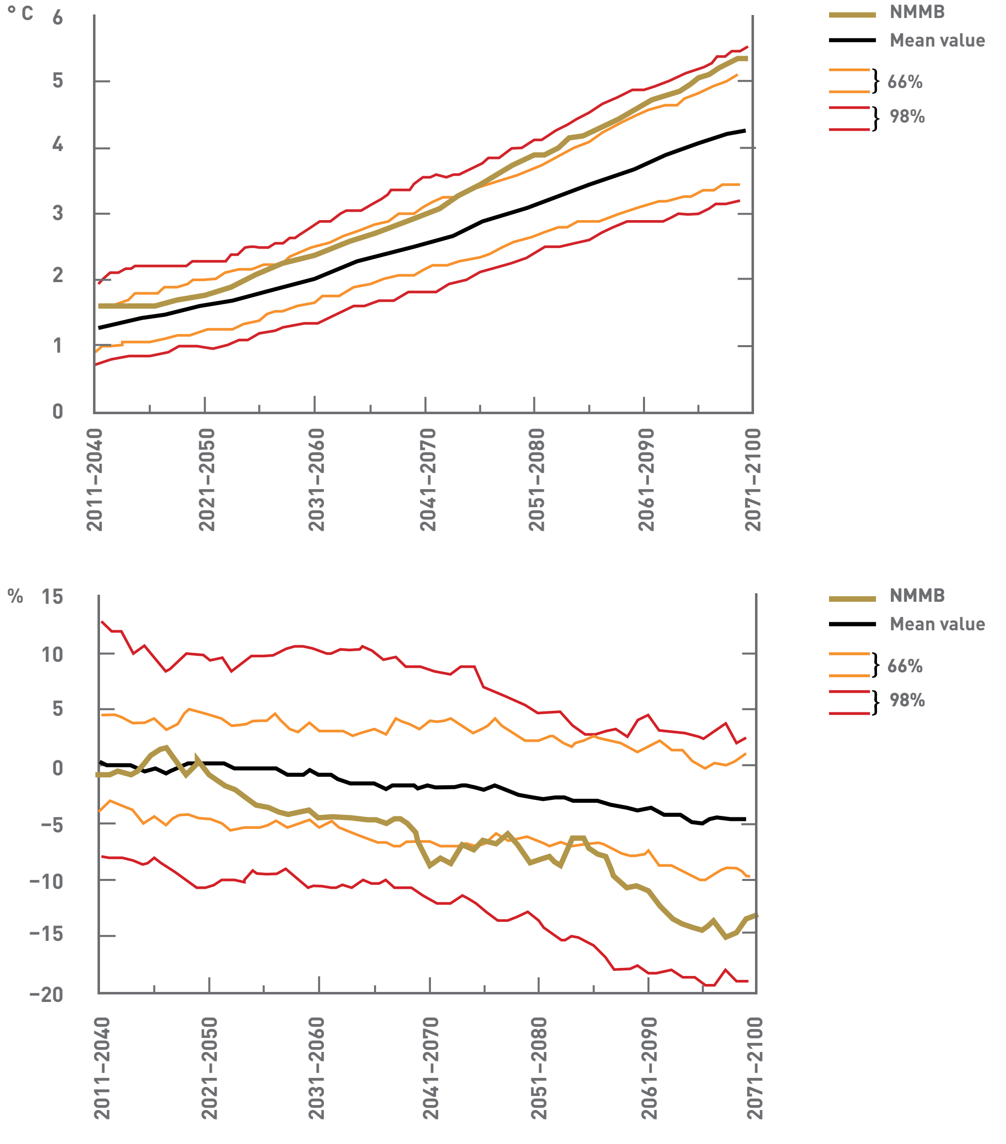


FIGURE 5.21 Extent of possible change in mean annual temperatures and precipitation for the period 2011–2100 compared to the period 1971–2000, according to scenario RCP8.5, based on the results of the 18 different models that were part of the EURO-CORDEX project

5.3 Sector vulnerability and adaptation analysis

Montenegro recognizes the urgent need to address the effects of climate change through initiatives and actions to facilitate adaptation to climate change in the key vulnerable sectors. However, lack of knowledge in planning adaptation measures in all sectors represents an obstacle to successful climate change adaptation. Key support in approaching the issue of reducing climate change vulnerability refers to building the knowledge base and capacities to observe and analyse data, information exchange mechanisms, and development of local and sector-level specific action plans for climate change adaptation, risk prevention plans, and management at the national, regional, and local levels.

A priority activity is the strengthening of the strategic planning for climate change adaptation at the local and regional levels, as well as in the sector-level planning process. This can be accomplished through the development of action plans for climate change adaptation at the local and regional levels, development of action plans for climate change adaptation of vulnerable sectors, integration of adaptation measures in strategic and development documents, preparation of plans for the prevention of climate change impacts in sectors vulnerable to climate change, and through the development of methods and standards for implementation of adaptation measures. Also, one of the necessary measures is the strengthening of local and regional governments and other relevant national, regional, and local stakeholders regarding climate change adaptation.

There is no comprehensive estimation of the investments needed for the adaptation measures; however the Technology Needs Assessment for Adaptation and Mitigation Measures for Montenegro (2012) gives an indication of the costs of priority measures of adaptation for the most vulnerable sectors: the water sector, the agriculture and forestry sector, and coastal areas.

WATER RESOURCES

The impacts of climate change on water resources are very diverse and cut across many sectors of Montenegro's economy. These include: water for consumption by humans; agriculture and industry; water for non-consumptive uses, such as waste-water treatment, thermal cooling, hydroelectric generation, transportation and recreation, and a host of water-related services provided by natural ecosystems, such as habitat and species preservation and flood control.

Vulnerability and climate impacts in the water resources sector

Water resources in Montenegro refer to surface and underground water, which are affected by climate change in different ways. In Montenegro, the water supply for domestic use is a priority for the water management system. The Water Management Strategy of Montenegro (2017) aims to ensure the protection and conservation of water resources in the country, especially drinking water. However, despite the existing legal provisions, according to the Water Directorate, only 49 of about 90 springs have designated protection zones. For a more rigorous water management process, additional information and expertise is required to define and establish protection zones, especially in defining a wider protection zone of a source that coincides with a source basin. Given the vulnerability of urban areas and the enormous pressure on space in catchment areas, it is a realistic fear that climate change will further complicate the protection of wells.

The SNC highlights that the water balance in all river basins shows a reduction in the amount of precipitation of, on average, 4% during the period 2001–2030 and a reduction in the amount of precipitation on average of 14% during the period 2071–2100 in comparison to the period 1961–1990. By the end of the 21st century a reduction of 27% is expected in the average annual flow (Ministry of Sustainable Development and Tourism, 2015). Similarly, projections indicate that the reduction in the amount of snow cover for the River Lim basin amounts to about 25%, while in the River Tara basin it amounts to 36%. By the end of the 21st century, a reduction is expected to be observed in the amount of water present in the snow cover of about 70%–80% as compared to 1961–1990. The reduction of rainfall and snow cover will directly affect the water balance in Montenegro and the surface and groundwater resources. Table 5.3 presents a summary of the potential climate impacts for the water resources sector.

TABLE 5.3:
Summary of climate change impacts in the water resource sector

Climate variability and hazards	POTENTIAL IMPACTS
Increase in temperature	– Causes an increase in water use especially in the summer period and this can reduce the net water supply, increase competition for water and reduce access to water quality and quantity – Increases in temperatures and water temperatures reduce habitat quality and productivity and can degrade ecosystems
Decrease in precipitation	– Water quality will decrease and sediment transport will increase due to reductions in runoff and warmer water temperatures – Insufficient water for irrigation – Affects the performance and operation of existing and planned manmade hydrological systems. – Decreases in average annual yields of rechargeable systems and/or increase pumping costs for groundwater supply – Ground water-table levels decrease
Heavy rains	– Increases in the peak runoff increase flooding, erosion, and sediment transport, and adverse health impacts – River and lake flooding of urban, suburban, and rural land – Drinking water safety – Waterborne disease vectors – Affect rural and suburban drainage

Surface water resources

Local water sources are used for water supply to the municipalities in Montenegro. In addition, in the Municipalities of Budva, Kotor, Tivat, Ulcinj, and Bar, water from the regional water supply system for the Montenegrin coast is available, while in the Municipality of Herceg Novi, water from the Plat system (Croatia) is also used. Water for the water supply is provided by 70 springs, most of which are impacted by wells in non-continuous karst sources, with some from continual sources (10), while in two water supply systems, water from surface reservoirs is used (Pljevlja and Herceg Novi). The operation covers a relatively large number of wells, averaging about three per water supply. Therefore, there are a large number of springs, which, when considering the areas covered by the sanitary protection zones, occupy a significant part of the territory of Montenegro (Figure 5.22).

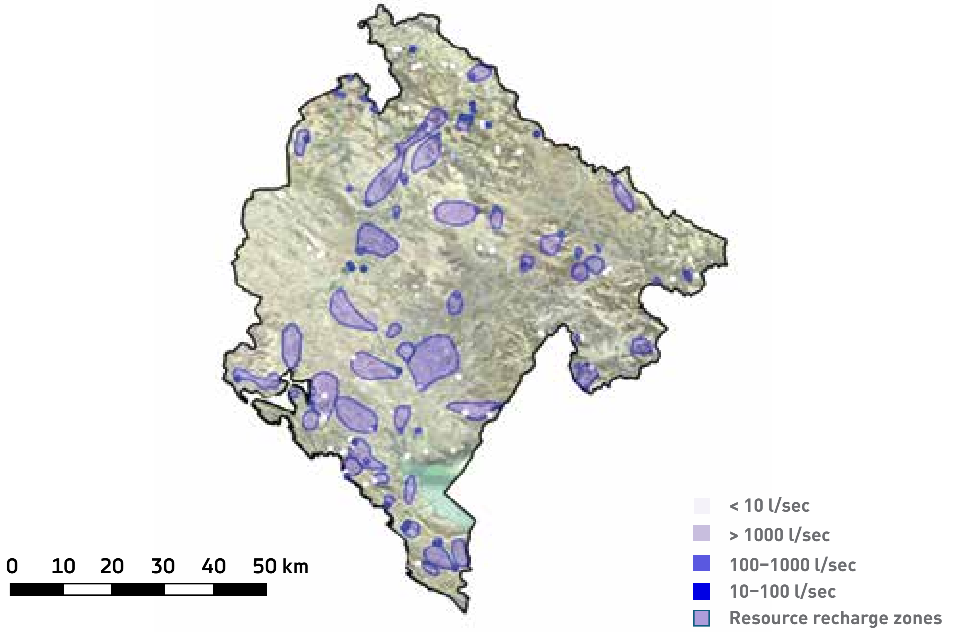


FIGURE 5.22 A map of the wider protection zones of the sources for public water supply in Montenegro

Considering the basic function of water in preserving public health, and the fact that the water supply has priority over the use of water for other purposes, the problem of protecting the source of drinking water is imposed as a primary obligation. The Water Management Strategy of Montenegro (2017) also states that one of the operational objectives is the protection of sources, research, protection, and conservation of water resources used or intended for human consumption in the future. Among other things, this includes determining the size and physical characteristics of the catchments from which the springs are fed, the manner of land use and water quality in the area of those catchments, as well as developing a cadastre of existing and potential water contaminants.

However, despite the existing legal provisions, according to the Water Directorate, only 49 of about 90 wells have been designated as sanitary protection zones. In addition, where the process of defining protection zones has been carried out, problems are often noted with the lack of data that should help in defining and establishing protection zones, especially in defining a wider protection zone of a source that coincides with a source basin.

Of the total population of Montenegro, over 63% lives in urban areas, and public water supply systems cover 99% of the urban population, or about 400,000 inhabitants. Given the vulnerability of urban areas and the enormous pressure on space in catchment areas, it is a realistic fear that climate change will further complicate the protection of wells. Increasing the average rainfall intensity, reducing the annual amount of snow, increasing the frequency of heat waves, extending the vegetation period and the increasing number of consecutive days without precipitation will affect both the availability of water in the springs and its quality.

Groundwater resources

Montenegro has a large number of karst springs, which supply the underground water in some areas of the country. Karst watersheds play a very useful role, since they accumulate water taken in during the rainy period of the year and release it during the dry period when water is most needed (Mareza and Oraška Jama springs, etc.).

Karst is a spatially and temporally very dynamic phenomenon whose geometry is subject to rapid changes. The karst water regime is conditioned by a number of factors: the geological composition of the terrain, the geomorphological and hydrogeological characteristics of the terrain, as well as climatic factors. The karst recharge and discharge regime, and the change of water's physical and chemical properties depend on: (1) the conditions of the intensity of recharge and discharge of waters; (2) the pluviometric and temperature regime of the area; and (3) the layout and the character of the vegetation cover. Therefore, groundwater is a resource that is very vulnerable to climate change. Increasing air temperatures, prolonged drought, uneven rainfall, increasing rainfall, and a reducing annual amount of snow lead to disruption of the runoff and more pronounced formation of torrential flows, floods, landslides, and landslides.

At the low coastal karst, extended periods of prolonged drought lead to disruption of the equilibrium boundary zone between brackish and fresh water and salinity of springs. Such is the case with: the karst spring of Škurda, included in the water supply system of Kotor; spring Spilja, included in the water supply system of Risan; and Plavda, included in the water supply system of Tivat.

A reduction in the annual amount of snow could have a negative impact on water supply through the earlier occurrence of the hydrological minimum at these sources (early August instead of September), so it may occur during periods of peak water use due to tourism.

Adaptation measures for the water resource sector

Specific adaptation measures described in this National Communication are based on a combination of expert analysis, measures which are still relevant and included in the Technology Needs Assessment (TNA) from 2012, the Second National Communication, as well as new analysis for this Communication.

Possible adaptation measures in the water sector listed below include planning and capacity-building measures, technology/information-oriented responses (Table 5.4) but have not yet included "hard" investment measures which are likely also to be useful but have not yet been properly scoped.

In order to increase the adaptive capacity of water supply in a timely manner, it is necessary to harmonize the relevant legal rules and guidelines. Analysing and reviewing the quality of existing documentation on sanitary protection zones would help in defining deficiencies and adopting a new methodology for designing sanitary protection zone projects, with the establishment of multidisciplinary expert committees. Consideration should also be given to the feasibility of designing sanitary protection zone projects at all sources, which would, in accordance with the amended and amended legislation, include the future impact of climate change on the water regime of the particular source. Finally, it is necessary to define clear and effective protocols for compliance with the designated sanitary protection zones and the prescribed conditions for those territories.

Furthermore, significant data compilation and analysis of precipitation intensity in urban areas is required.

Recommendations for completion of data on precipitation intensity in urban areas

Precipitation, both spatially and temporally, is a highly variable climate element. This is especially true of short-term, heavy rains of a local character. Their analysis is one of the main interests in engineering hydrological practice, because short-term, heavy rains are the most common cause of the increasing frequency of floods in urban areas and beyond, especially the large number of torrential streams in Montenegro. These changes in the frequency and intensity of brief rainfall are linked to climate change.

Short-term rainfall is therefore the starting point for the design, construction, and maintenance of hydro-technical facilities (bridges, culverts, etc.), as well as water management infrastructure systems (drainage systems, sewer systems, drainage of airports and highways, etc.). It can be stated that short-term intensive rainfall is very important issue of the safety and functionality of facilities and the safety of the population and material goods.

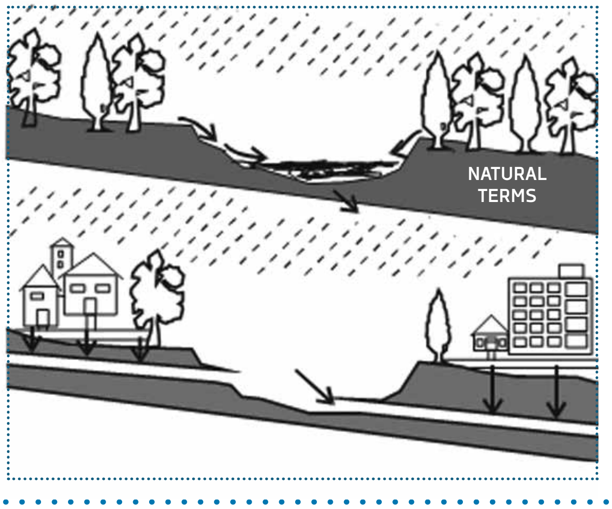
The relevant characteristics of the rainfall in question are evaluated on the basis of long-term, continuous observations and measurements of rainfall in such a way as to give rainfall heights at different time intervals ranging from minutes to 24-hour periods (1,440 minutes) for different occurrences. On the other hand, the basic feature of short-term precipitation events is that they cover relatively small areas. Under these conditions, it would be necessary for automatic continuous measurements to be made at a large number of points in order to cover low-frequency rainfall events. However, equipment for collecting and maintaining such data is relatively expensive, and even more wealthy societies than Montenegro are not able to finance the formation and maintenance of such a dense network.

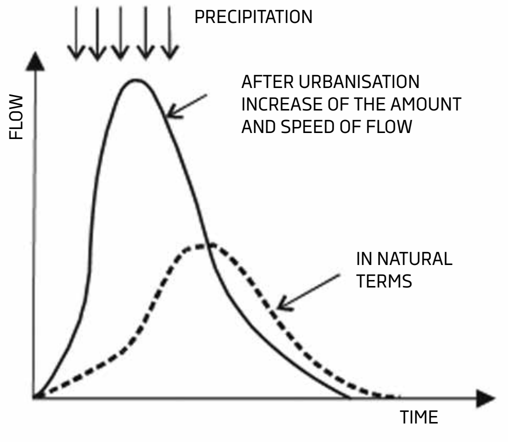
It is common practice in the world for automatic and continuous precipitation measurements to be made at a limited number of locations, while in parallel a network of much more numerous stations is used to monitor precipitation once a day (or even less frequently). Using certain procedures and methods, the results of measurements from automatic stations are transposed to a denser network and thus throughout the territory.

As already mentioned, the data on short-term rainfall available in official documents refers primarily to daily rainfall, while data on the intensities of shorter intervals is recorded for only a few cities in Montenegro, based on observation of daily rainfall. Taking into account the differing views of hydrologists and designers in the field of hydrotechnics, one can, on the basis of observation of daily rainfall, develop conclusions about characteristics of a shorter duration, which, in others' views, is considered to be a very unreliable procedure in prevailing hydrological practice.

There is therefore a need to establish in Montenegro models and mechanisms for determining the relevant characteristics of short-term rainfall at locations where there is otherwise valid data. It is immediately clear that this refers to cities that are equipped with appropriate observation equipment, i.e. urban areas.

Regardless of the projections of the future climate, which always contain a certain degree of uncertainty, it can be expected that extreme rainfall will occur more frequently on the territory of Montenegro, and in that sense the range of relevant parameters and sizes necessary for numerous analyses and calculations is expected to increase: designing all types of infrastructure – above all road and hydraulic – spatial planning, scientific research, ecology, agriculture, mining, tourism, security, etc. Increasing the frequency of the occurrence of short-term, heavy rainfall will have the effect of reducing the possibility of large-scale drainage through already constructed hydraulic structures, which are designed based on historical data on short-term rainfall intensities. In addition, it must be borne in mind that the occurrence of increasing rainfall in urban areas is primarily the result of intensive urbanization and an increase in watertight surfaces, which increases not only the total amount of swollen rainwater, due to reduced amounts of water infiltrating underground. However, in such cases the concentration times are also reduced during rainwater drainage, thus increasing the peak flow of rainwater (Walesh, 1989; Mays, 2004; Despotović, 2009; Cindrić et al., 2014).





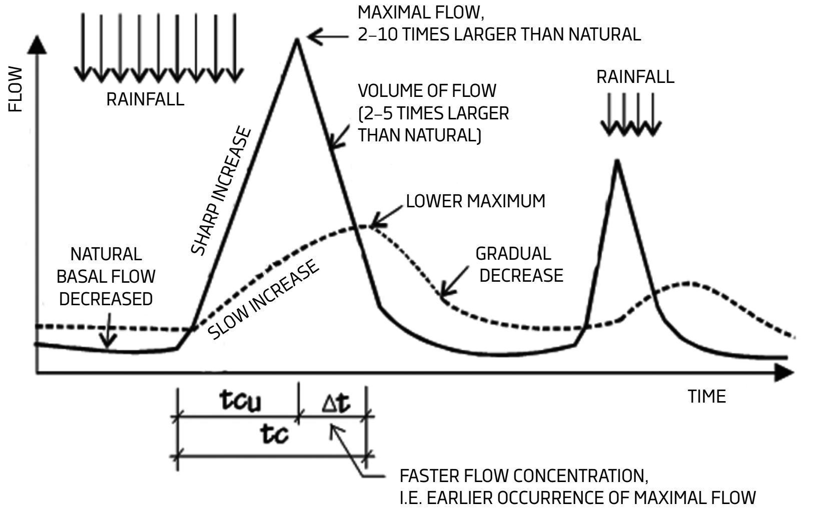


FIGURE 5.23 **Urbanization leads to major changes in rainwater runoff: Schematic diagram of the change in natural runoff**

Source: J. Despotović, J. Plavšić et al.

Understanding and predicting rainfall in a particular area is very important, especially in extreme rainfall. Heavy rains are often associated with cyclones and atmospheric fronts passing through our region. Sometimes these fronts are reinforced in the Dinaric area, but they can also be strongly influenced by local orographic conditions – conditions that characterize the terrain of Montenegro.

Most of the precipitation data is meteorological station measurement data. Unfortunately, the spatial density of these cells is insufficient, leading to difficulties in analysing spatial rainfall, especially for rainfall episodes in a restricted area. Of all types of precipitation, short-term rainfall intensity is the most variable parameter in time. A common problem that often occurs in practice is the insufficient length of a series of short-term rains at the existing stations. In addition, the available curves calculated from earlier short sets of data that have not been updated are often used for different projects, although there is data with which they could be updated. Often, estimates of expected maximum quantities for return periods that are three to four times as long as the observed input data set are often used in practice, and budgets for return periods of up to 1000 years are not uncommon. Such estimates are highly unreliable and their application is not recommended.

More recently, climate change has meant an increased number of extreme events such as floods and droughts. Increasingly, it has been emphasized in professional and scientific circles that little research to date has been conducted on short-term rainfall intensities, which play a significant role in all segments of social life. The biggest reason for this is the lack of long-standing data sets, both global and regional, that would be suitable for analysing extremes for the purpose of determining eventual change over the last century (Easterling et al., 2000).

The problems caused by the occurrence of heavy short-term rainfall in smaller catchments and urban areas are creating increasing problems and adverse consequences, both globally and in Montenegro. In part, this is due to the possible impacts of climate change that are already manifesting themselves today, which are expected to be intensified in the future. But, in large part, this is due to inadequate substrates, calculations, and the drainage solutions themselves.

All of the above points to the urgent need to carry out studies into the identified issues, which would take place under the auspices of the Hydrometeorological Service, but with the obligatory participation of representative representatives of those activities for which the intensity of short rains is of particular importance. This could also involve cooperation with regional organizations.

The study should cover:

- An analysis of the quality of existing rainfall data in Montenegro, comparing estimates of expected short-term maxima from two shorter periods: 1961–1990 and 1991–2019;
- Analysis of the precipitation regime of short-term, heavy rainfall in pilot areas in Montenegro, selected by regional distribution, quality of available data and most commonly used for hydrological substrates in water abstraction calculations;
- Selection of methodological procedures for the necessary comprehensive analysis of short-term heavy rainfall in Montenegro, with the obligation to analyse the problems of climate change, as well as to determine the conditions for continuous checking and updating of Intensity, Duration, Frequency (IDF) curves;

- Establishing conditions for issuing (publishing) a guide or an official document of another format that would serve all potential users of short-term rainfall data in the future. Of course, this would only apply at this stage of the study to those pilot areas where sufficiently long sets of adequate data are available and where quantification of the material analysed is possible.

TABLE 5.4:
List of identified adaptation measures for the water sector

Type of adaptation measure	ADAPTATION MEASURES	Increased temperature	Decreased precipitation	Heavy rainfall
POLICY AND INSTITUTIONAL STRENGTHENING MEASURES	Improve coordination between the government, the Environment Protection Agency and the Institute of Hydrometeorology and Seismology in order to ensure the development of a system of quality national water archives to store and make available data	•	•	•
	Apply an integrated approach to water resources and systems management and strengthen cross-sector planning and activities	•	•	•
	Harmonize data set standards and define responsibilities and "ownership" regarding specific sets of data, as well as defining procedures for controlling data versions managing data exchanges between institutions	•	•	
	Form multidisciplinary expert commissions for the preparation of the Watershed Protection Zone Projects, according to the established methodology and under the auspices of the competent state institution			•
	Harmonize the relevant laws, regulations and guidelines on the protection of water sources.	•	•	•
	Define clear and effective protocols for compliance with designated sanitary protection zones and prescribed conditions for those territories.	•	•	•
	Surface water monitoring and implementation of the spatial plan.		•	•

TECHNICAL MEASURES	Strengthen the network of hydrometeorological stations for monitoring and generating climate information	•	•	•
	Construct new and upgrade the existing water and utility infrastructure of the system		•	•
	Increase the capacity of water storage		•	
	Explore the potential of groundwater in Montenegro using GIS mapping of hydrogeological boundaries of groundwater used to supply water under the climate change scenario		•	
	Develop new methodologies and design watershed protection zone projects at all water sources integrating climate change aspects	•	•	•
INFORMATION AND CAPACITY-BUILDING MEASURES	Strengthen the research and management capacities to assess the occurrence and risk of adverse impacts of climate change and adaptation of freshwater systems	•	•	•
	Upgrade the water information system considering options for the implementation of a better software information system for a water cadastre (e.g. WaterWare, WISYS or WISKI)	•	•	•
	Raising awareness about the structure of the link between the karst system and rainfall regime is necessary as an enabling factor to strengthen conservation measures and improve assessment of groundwater vulnerability.	•	•	•

Additional investment-oriented measures could include measures such as:

- Improvement of wastewater and water distribution systems in urban areas
- Water saving/distribution measures linked to agriculture and forestry, such as irrigation, micro-reservoir development, and water supply development (wells, larger reservoirs)
- Hydroelectric dam development which incorporates climate change risks into its planning.

As mentioned, these measures are likely also to be useful but have not yet been properly scoped.

FORESTRY

Vulnerability and climate impacts in the forestry resources

The direct and indirect impacts of climate change affect not only current developmental processes and growth, but usually have both carry-over and cumulative effects that can last for the lifetime of a tree. The greatest risk is to forests located in the coastal and central regions, where high air temperatures during the summer period and the typical vegetation create the necessary preconditions for forest fires to start. July and August are critical in terms of the occurrence of fires (a very low level of precipitation, or often no precipitation), as are the months of February and March (in the case of dry and warmer winters) (REC, 2015). Table 5.5 shows a summary of the potential climate impacts in the forestry sector in Montenegro.

TABLE 5.5:
Summary of climate change impacts in the forestry sector

Climate variability and hazards	POTENTIAL IMPACTS
Increases in CO_2 concentrations	– Increase in long-term net primary productivity (NPP) of most trees. Differential species impacts that could affect the competition and succession, particularly in mixed forests. – Increased soil acidity and heavy metal concentration.
Changes in the precipitation regime	– Drainage and deterioration of the hydrological balance of the habitat. – More frequent and intense occurrence of forest fires.
Increase in temperature	– NPP response depends on where forest species are in relation to their temperature ranges. In the short-run, warming can lengthen growing seasons. Where temperatures are limiting, the impact on NPP will be negative. – Species can adjust by migration, naturally or managed, but at some point, higher temperatures become limiting to growth over large areas. – Differential species impacts could impact the competition and succession, particularly in mixed forests. – Complex effects on other stressors, such as insects and diseases, can interact to limit or enhance CO_2 fertilization. – More intense mushroom development and more frequent occurrence of harmful insects due to temperature increase. – More intensive drying of forests and individual tree species, which could result in their dying, migration and/or adaptation. – Increases in vulnerability to forest fires. – Less frequent onset of frost due to reduced number of frosty days.
Increases in magnitude and frequency of extreme events	– Long-term increases in droughts and floods will probably have a negative impact on NPP. – Increasing risk of erosion.

Vulnerability of forests to diseases and pests

The data of the National Monitoring of the Health Condition of Forests shows that there are negative trends in terms of lower resistance to forest pests, although the general condition of forests is deemed to be at a satisfactory level. The process of inspecting trees identified the common insects and fungi that cause degradation (Table 5.6).

TABLE 5.6:
The most frequent pests and diseases in Montenegrin forests

Type of forest	Host	Pests and diseases
Beech forest	*Fagus moesiaca*	*Rhynchaenus fagi, Mikiola fagi, Cryptococcus fagisuga, Operophtera brumata, Nectria spp., Fomes fomentarius, Trametes versicolor*
Oak forest	*Quercus spp.*	*Altica quercetorum, Scolytus intricatus, Lymantria dispar, Operoptera brumata, Fomes fomentarius, Micosphaera alphitoides*
Spruce forest	*Picea abies*	*IpIps typographus, Pitiogenes chalcographus, Heterobasidion annosum, Fomitopsis pinico - la, Chrysomyxa abietis, Lophodermium piceae, Herpotrichia nigra*
Silver fir forest	*Abies alba*	*Melampsorella caryphyllacearum, Armillaria mellea*
Pine forest	*Pinus spp.*	*Diprion pini, Ips sexdentatus, Heterobasidiono annosum, Phellinus pini, Mycosphaerella pini, Cenangium ferruginosum*

Source: ICP, 2011.

Pests and diseases are very sensitive to any changes in the environment. Increased temperatures and variability of rainfall will likely provide favourable conditions for the increase in populations and their impacts on forests.

Climate change is also expected to cause an increase in the growth of fungal organisms as well as an increased level in reproduction capacity. It is expected to bring about changes in infections and in wintering. Changes in the physiological condition of hosts are expected to have an indirect impact on the lifecycle of fungi, on their spread and, of course, on the distribution of primary and secondary hosts. Certain local host populations will exhibit reduced resilience to pathogens.

Impacts on forests from forest fires

With the expected increase in the frequency and severity of droughts as a result of climate change, the risk of fire increases in the future especially in the southern forest areas, which are spread in the coastal and karst areas (FAO, 2018). There is a risk of fire in these areas due to high air temperatures in the summer and certain types of vegetation. In particular, during the months of July and August, when the amount of rainfall is very low, as well as during the months of February and March in the case of dry and warmer winters.

Besides direct impacts, fires can also cause indirect damage that can result in the degradation of the environment, a reduction in the resistance of forests to pests and diseases and the destruction of authentic landscapes and soil structures.

Impact of climate change on the distribution and growth of forests

A vulnerability assessment of forests by the UNECE (2015), shows that no major changes in the natural tree composition of forests will take place up until 2030, but from then until the end of the century, distribution of the habitats of the main tree species (oak, beech, spruce, fir, and white pine) would change geographically and forests would also tend to spread to higher altitudes.

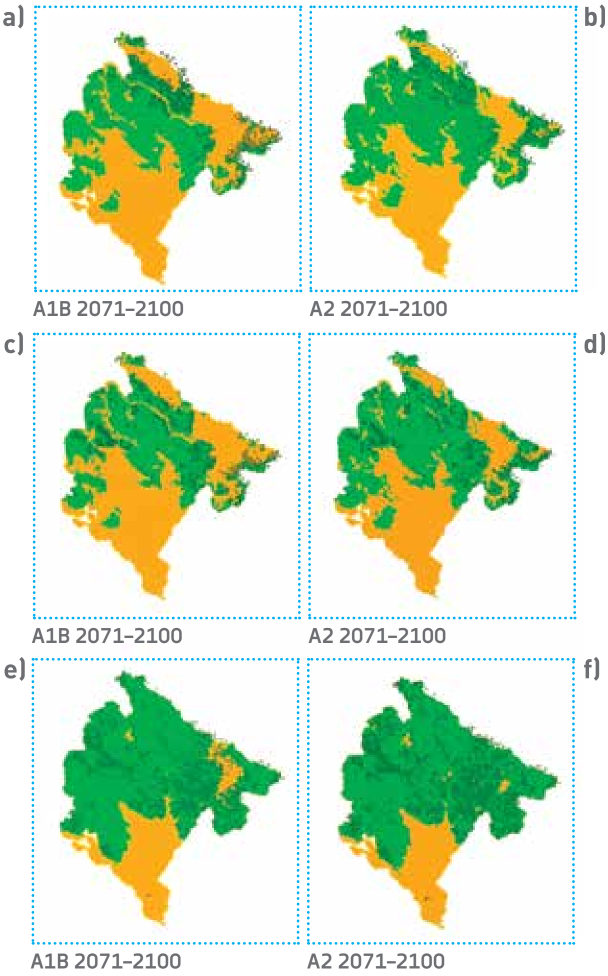
Quality and quantity of wood volume, i.e. the level of vitality and resilience of forests to negative impacts directly depends on their structure and on the types of trees and on optimum mixes in mixed forests. These are the key parameters for the vulnerability of individual trees and ecosystems, as well as for the intensity of reactions to negative impacts caused by physical moves and extent to which certain tree types have spread.

The SNC indicated that climate change is expected to have a negative impact on the distribution of most of the key tree types in Montenegro (Figure 5.22). This primarily refers to the distribution of ***spruce*** (Figure 5.22 – a and b), ***silver fir*** (Figure 5.22 – c and d), and ***Aleppo pine***. It can be expected that climate change will have a negative impact on the distribution of these types of trees on larger surfaces, primarily in the furthest eastern part of Montenegro, in the territory of Lower Prokletije, Mokra Planina, Hajla, Suva Planina, Mokra Gora, and in all the mountain areas north of Berane and Rožaje. It is also likely that these species will become endangered in larger lower mountain areas around Pljevlja.

Conversely it is possible that certain tree types will spread, such as: spruce, silver fir, and Aleppo pine in the mountain pasture areas of the high mountains (Maglić, Volujak, Bioč, Planina Pivska, Durmitor, Ljubišnja, Sinjavina, Maganik, Bjelasica, Komovi, Prokletije, Hajla, and Mokra Planina).

Projections show that beech will preserve the largest part of its current area, with the exception of some border habitats, such as the areas of Rumija, the coast, and Polimlje (Figure 5.22 – e and f). There is a moderate likelihood that beech will spread into the mountain pasture areas of the high mountains where other conditions are favourable, primarily the quality of the soil.

Notably, black pine and certain oak species are expected to become endangered in small parts of their current coastal habitats (black pine in the entire area, and oaks in the region north-west of Ulcinj). Conversely, it is possible that they will spread to cover broader regions of the continental part of Montenegro and may well dominate over beech, spruce, silver fir, and Aleppo pine.



a) Spruce spread estimate (2071–2100 A1B)

b) Spruce spread estimate (2071–2100 A2)

c) Silver fir spread estimate (2071–2100 A1B)

d) Silver fir spread estimate (2071–2100 A2)

e) Beech spread estimate (2071–2100 A1B)

f) Beech spread estimate (2071–2100 A2)

FIGURE 5.24 **Distribution projections of tree species as a result of climate change for the period 2071–2100 with the baseline 1961–1990**

The adaptive capacity of the forest sector is considered low due to the lack of an expert advisory body on vulnerability and adaptation and insufficient level of cooperation between the research sector and decision makers. Additionally, the lack of funding for research programmes in the field of vulnerability and adaptation, as well as to support the work of expert and advisory bodies in this field are barriers to adaptation.

Adaptation measures for the forestry sector

Adaptation measures for the forestry sector need to focus on promoting sustainable management of forests and strengthening the information and monitoring systems. Adaptation measures described in this National Communication are based on a combination of those which are still relevant and included in the Technology Needs Assessment (TNA) from 2012, the Second National Communication, as well as new analysis for this Communication.

The TNA has estimated that the forestry sector may require €1.4 million for adaptation measures (Government of Montenegro, 2012) but this focuses on "soft measures" and not "hard measures" involving investment. Many of the adaptation measures identified in the TNA are still relevant at the time of this National Communication though additional options have been added. Possible adaptation measures in the forestry sector include planning and capacity-building measures, while others more technology and information-oriented responses (Table 5.7) but have not yet included "hard" investment measures in the forestry sector which are likely also to be useful but have not yet been properly scoped.

TABLE 5.7:
List of identified adaptation measures for the forestry sector

Type of adaptation measure	ADAPTATION MEASURES	Increase in temperature	Extreme events	Increases in CO_2 concentrations
POLICY AND INSTITUTIONAL STRENGTHENING MEASURES		•	•	•
	Establishment of cross-sector monitoring of forest ecosystem status (including databases for sectors) as a prerequisite for informed planning and implementation of adaptation measures	•	•	•
		•	•	•
TECHNICAL MEASURES	Improvement/update of early warning systems for fires and hydrometeorological hazards		•	
	Improvement of forest management (especially in karst forests) considering: – Promoting tree species that are naturally present or suitable for habitat – Increasing species richness in forests and promote mixed forest communities – Promoting indigenous tree types in afforestation – Encouragement of a mixed forest stand, particular attention should be given to the preservation of selected stands of beech, silver fir, and spruce (stands of various ages) – Maintain and increase genetic variation within tree species – Promote natural forest regeneration – Avoid clear cutting.	•	•	
	Promoting afforestation, landscaping and protection of forests, and production of seedlings	•	•	
		•	•	•

RESEARCH, INFORMATION AND CAPACITY-BUILDING MEASURES	Adequate reporting and forecasting services for forest protection, establishment of ecological indicators indicating current changes in forest ecosystems.	•	•	•
	Identification of species and provenance of forest trees that are genetically best-adapted to the influence of climate change and are of economic significance	•	•	•
	Support for cooperation for research and inter-institutional and international agencies.	•	•	•
	Capacity building in sustainable forestry through continuous learning and training	•	•	•

Additional investment-oriented measures could include those below under agriculture which also are linked to land degradation (see Table 5,10).

While forest inventories have been well developed within the forestry sector to support a broader aspect of continuous monitoring, the problems of a non-integrated cross-sector approach and insufficient information coverage of the intensification of biotic and abiotic impacts caused by climate change have been identified. A prerequisite for the smooth functioning of permanent monitoring is the existence of an integrated information system and integrated, integrated, participatory, and adaptive planning of sustainable forest management in national parks, as a whole at the national level.

Some of the institutional and capacity constraints identified in vulnerability assessment and adaptation measures are:

- an unsatisfactory level of information exchange between institutions
- the lack of an expert advisory body on vulnerability and adaptation
- an unsatisfactory level of cooperation between the research sector and decision makers
- lack of funding for research programmes in the field of vulnerability and adaptation, as well as to support the work of expert and advisory bodies in this field
- insufficient international cooperation in order to minimize environmental and economic damage.

AGRICULTURE

The most important categories of land use (land cover) in Montenegro are: pastures and meadows; forests; and then: agricultural land; groups of arable land; water areas; orchards and vineyards; agricultural land with significant natural vegetation; artificial land; wetlands; and bare rocks. Agricultural land in Montenegro covers 37.4% of the total area (as of 2011) and is an important economic factor in the country. Arable land, orchards and vineyards occupy only 62,154 ha or 12% of the total agricultural area, while the dominant categories of agricultural use are pastures and meadows.

The agricultural sector is highly vulnerable to climate change due to its dependence on specific temperature conditions and water availability, and it is also exposed to climate hazards such as droughts or floods. A large part of the agricultural areas in Montenegro are located in the lowlands, which makes them particularly prone to regular floods.

Vulnerability and climate impacts in the agriculture sector

The warm conditions of the daytime are important for crop growth cycles. However, there are upper heat thresholds beyond which crop productivity is reduced or stalled. This threshold is different for each crop type. Also, due to agriculture's high dependence on rainfall (irrigation systems cover only 1% of arable land), extreme temperatures and frequent and intense drought adversely impact the quality and quantity of the yield, revenue, costs of plant culture due to diseases, insects and weeds, and the irrigation rate (FAO, 2018). Table 5.8 shows a summary of the potential impacts of climate change on the agricultural sector.

TABLE 5.8:
Key climate variability and hazards that will affect the agricultural sector and potential impacts

Climate variability and hazards	POTENTIAL IMPACTS
Increase in temperature	– Shift of vegetation periods towards the beginning of the year – Sharp interruptions in the vegetation process cause losses in yield, particularly in fruit-growing cultures, due to frost – Increases in crop yields (and land productivity) up to a point, followed by decreases – Increases in productivity of livestock up to a point, followed by decreases – Complex effects on weeds and insects – Heat stress affects livestock and milk production, gains in muscle mass and reproduction
Decrease in precipitation	– Decreases in crop yields (and land productivity) – Decreased irrigation water supply – Increased irrigation water demand
Droughts	– Limited plant growth, and therefore substantial reduction in yields – A decrease in the content of organic matter in soils – Increasing dependency on insufficiently developed irrigation systems – Reduction in the production of fodder for livestock feed
Floods	– Loss of crop yield – Increased plant diseases and weeds – Increase in crop damage – Loss of livestock due to difficulty of evacuation

Land degradation

The IPCC Special Report on Climate Change and Land (2019) shows with high confidence that climate change creates additional stresses on land and in particular on already degraded land by exacerbating the existing risks to food systems. Land degradation in Montenegro makes agricultural production more sensitive to climate change impacts. The assessment of Land Degradation Neutrality (LDN) is required to understand the level of land degradation in the country.

Land Degradation Neutrality

Montenegro ratified the United Nations Convention to Combat Desertification (UNCCD) in 2007 and is actively involved in the Land Degradation Neutralization Task Force (LDN-TSP) programme. In 2017 a national task force was formed consisting of 25 members from 15 institutions. The meetings of the working group held so far presented the process of establishing tasks in land degradation and the work plan, a national map of the LDN critical areas (hotspots) with analysis at the catchment level, as well as a SWOT analysis of LDN in terms of the National Adaptation Plan.

LDN can be defined as a condition in which the quantity and quality of land resources necessary to support ecosystem functions and services, and to ensure food security, remain stable or increase within a certain temporal and spatial frame. The percentage of degraded land compared to the total land area was determined as an indicator by which progress in the achievement of LDN would be monitored. This indicator contains three sub-indicators:

1. **Land cover** – changes in land use patterns indicate changes in vegetation cover and changes in habitat conditions.
2. **Soil productivity** – the biological productive capacity of land as a source of nutrients and building materials, fuels, and food. It is determined by total above-ground net primary production (NPP), most commonly by vegetation indices.
3. **Organic above-ground and ground organic carbon stocks** – soil organic carbon (SOC) is used as a measure of carbon stock assessment.

These sub-indicators, combined with other nationally relevant indicators, are used to define the LDN benchmark and assess the trends in land degradation in Montenegro over a 10-to-15-year period. Degradation is thought to occur when negative trends in any of the three indicators emerge.

Based on land cover data from the European Space Agency (ESA), data on soil productivity dynamics from the Joint Research Centre of the European Union (JRC), soil organic carbon data from the International Land Reference and Information Centre (ISRIC) and field data, 15 potentially critical areas in Montenegro were identified. According to data on the dynamics of land productivity in Montenegro, 5.44% of land is potentially degraded (64,107 ha in the categories of "decrease", "initial signs of decrease", and "stable but under stress"). Degradation has occurred on 8.5% of the total agricultural area and on 7.33% of the succession areas of forest vegetation, grassland, and areas with thinned vegetation (Figure 5.25).

Based on the data analysed[2], 15 potentially critical areas were identified. It was concluded that the River Morača basin is the most degraded with a surface area of 31,041 ha, and most common type of land degradation in Montenegro is biological degradation caused by fires.

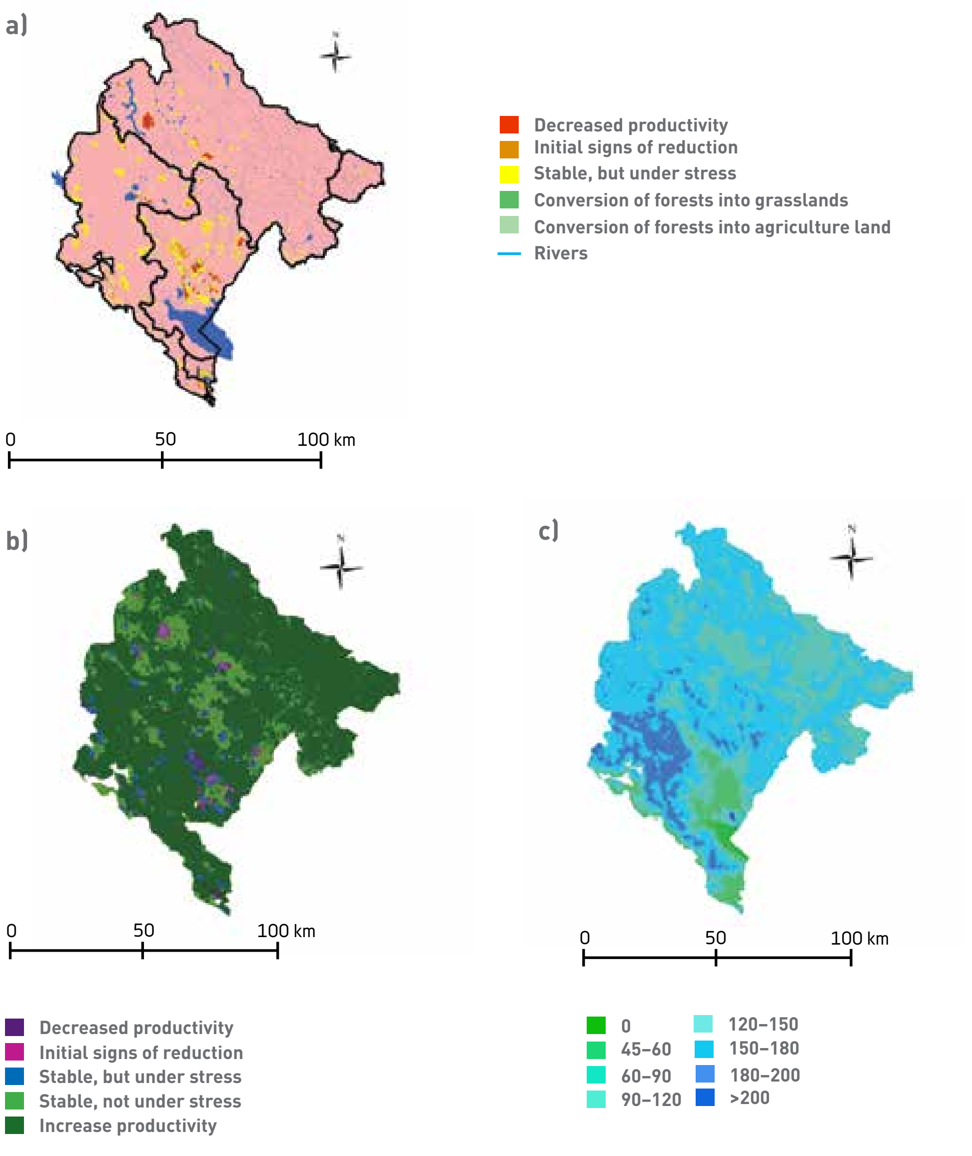


FIGURE 5.25 Maps of soil productivity dynamics (a), organic carbon stock (b), and degraded areas (c) according to the LDN approach in Montenegro obtained from global databases

[2] The analysis was based on global datasets; however, it should be taken into consideration that the datasets do not accurately represent the situation in Montenegro. The SOC reserves are overestimated due to the fact that a very large part of the territory of Montenegro is covered with rocks, and many grassland areas that have high SOC values are classified as agricultural land.

The average content of organic carbon (SOC) in the soil for the territory of Montenegro in 2000 was 125.1 t/ha. SOC stocks are highest in forests (129.9 t/ha), followed by successions of forest vegetation, grasslands, and areas with thinned vegetation (124.9 t/ha) and agricultural land with (124.3 t/ha). However, estimates from global datasets do not represent the real situation on the ground. The SOC reserves in these databases are overestimated due to the fact that a very large part of the territory of Montenegro is covered with bare rocks and has a pronounced rockiness, that is, a lot of lithosols, as well as shallow and/or extremely skeletal soils. In addition, within the ESA land cover database, many grasslands that have high SOC values are classified as agricultural land. Due to the aforementioned deficiencies, the map of organic carbon stocks of the soil of Montenegro should be corrected using quality national data. National SOC data is available in the databases of the University of Montenegro's Biotechnical Faculty, via the content of humus in the soil. This data is often very old and rarely georeferenced, and the SOC estimation procedure does not match the methodological approach of the LDN. Therefore, it is necessary to systematize the national SOC inventory data so that it is reliable and presented spatially.

Drought

An assessment of the vulnerability to droughts for the agriculture sector identified potential areas with a high risk of drought focusing. The three key agriculture areas, i.e. the River Zeta Valley, the Bjelopavlići Plain and the coastal area are slightly-to-moderately vulnerable, with some areas demonstrating high vulnerability to drought (Figure 5.26). This is due to the sharp inclination of the terrain (very steep mountain slopes along the coast) and exposure to solar radiation and wind erosion of the soil.

Project Drought Management Center for South Eastern Europe (DMCSEE)

Within the DMCSEE project, the WINISAREG model for irrigation planning was applied, and the project also included an assessment of the impact of climate change on irrigation within the context of the future climate. For Montenegro, tests were carried out for Podgorica and Berane in the short term and in the long term for growing certain types of corn. The results of the 30-year simulation in the Podgorica region indicate that irrigation would be necessary for both types of corn. It would also be possible to move the short corn-growing season to early spring to avoid the long-term summer dry period. Relative yields have increased over the last 30 years for both long-term and short-term cultivars in the Podgorica region. On the other hand, in the Berane region they are declining. Thus, climate change has different effects depending on the climate type – Mediterranean or continental.

The project also included an assessment of the monitoring of droughts in Montenegro through remote detection. The results show that remote monitoring is very volatile. The key factor is the inclination of the mountains rather than their height. The best results were obtained for the coastal region, the Zeta–Bjelopavlići Plain, and Ulcinj Field, where the use of satellite drought monitoring was recommended. It is also worth noting that these are also the three key agricultural areas in Montenegro.

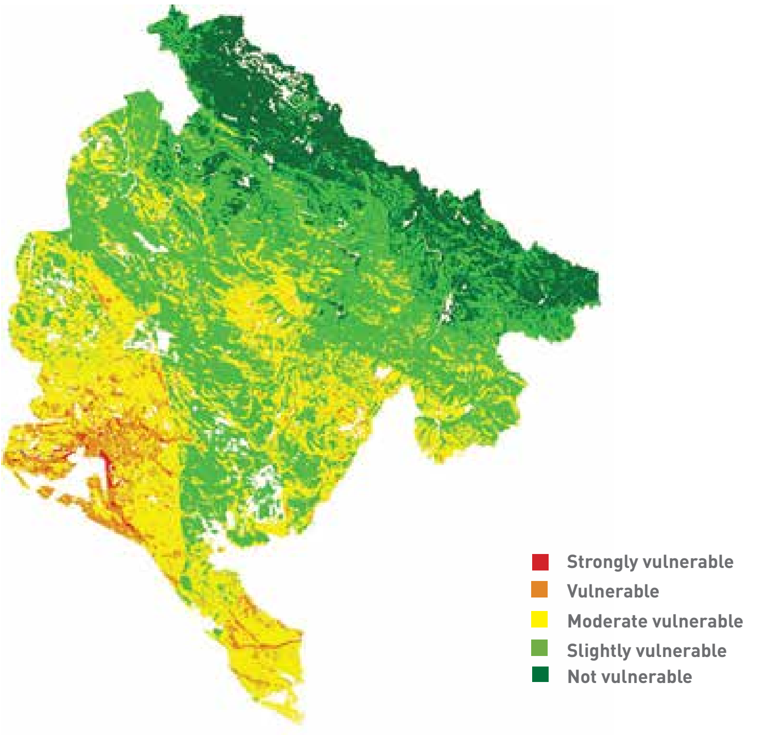


FIGURE 5.26 **Vulnerability of agricultural areas to drought during the period observed (1971–2000)**

Source: Institute of Hydrometeorology and Seismology

The potential impacts of climate change on agriculture are also assessed using two variables: (i) soil temperature regime up to 1 m deep and (ii) the phenological stages of some of the most represented and significant agricultural crops in Montenegro.

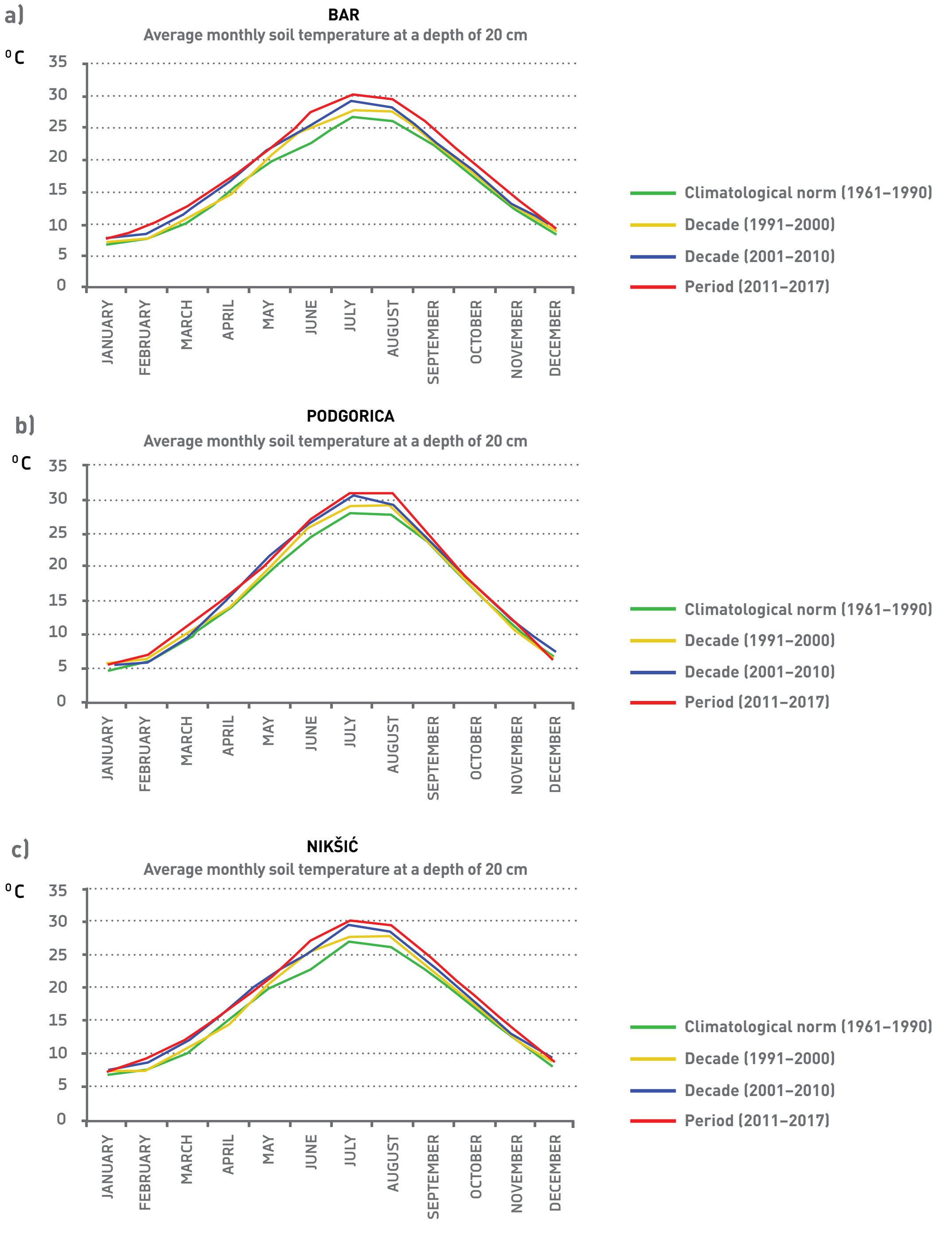
Soil temperature mode

As part of preparation for this National Communication, soil temperatures were analysed.[1] The analysis concludes that the temperature of the soil at all depths in recent decades has been steadily increasing with a constant trend at all stations. For illustration, the average monthly soil temperatures at a depth of 20 cm are shown for the Podgorica, Bar, and Nikšić stations for the climatological norms in the period 1961–1990, the decades 1991–2000 and 2000–2010, and the period 2011–2017 (Figure 5.27 – a, b, c). At all the stations, the mean monthly soil temperature at a depth of 20 cm was warmer than normal for all decades, with the largest deviation being precisely for the most recent period 2011–2017. The rise in soil temperature is less significant during the winter and more significant during the spring and autumn, and most intense during the summer months.

[1] Soil temperature has been measured at the Institute of Hydrometeorology and Seismology of Montenegro (ZHMS) since 1951 at standard depths of 2, 5, 10, 20, 30, 50, and 100 cm. The measured data at 11 meteorological stations across the country is in the CLIDATA database. The disadvantages of this database are reflected in the lack of complete data, especially for greater depths (50 and 100 cm) and during the winter months, when frost, ice, and other factors cause glass geothermometers to easily break and break. In addition, individual stations have repeatedly changed their location, thus impairing the homogeneity of the measured dataset.

On the basis of soil temperatures at depths of 5, 10 and 20 cm, the mean date of occurrence of the temperature threshold of 10° C was determined for the period of climatological normal in 1961–1990 and the period 2011–2017 (Figure 5 25, right). This information determines the optimal sowing time of crops. In recent years the temperature threshold of 10° C occurs a few days earlier in relation to the climate norm at all observed depths, which also indicates intense soil warming.

Given that the climate projections in Montenegro show a further increase in temperature and changes in the amount and distribution of rainfall, it is expected that the trend of increasing soil temperature at all depths will continue in the coming period.



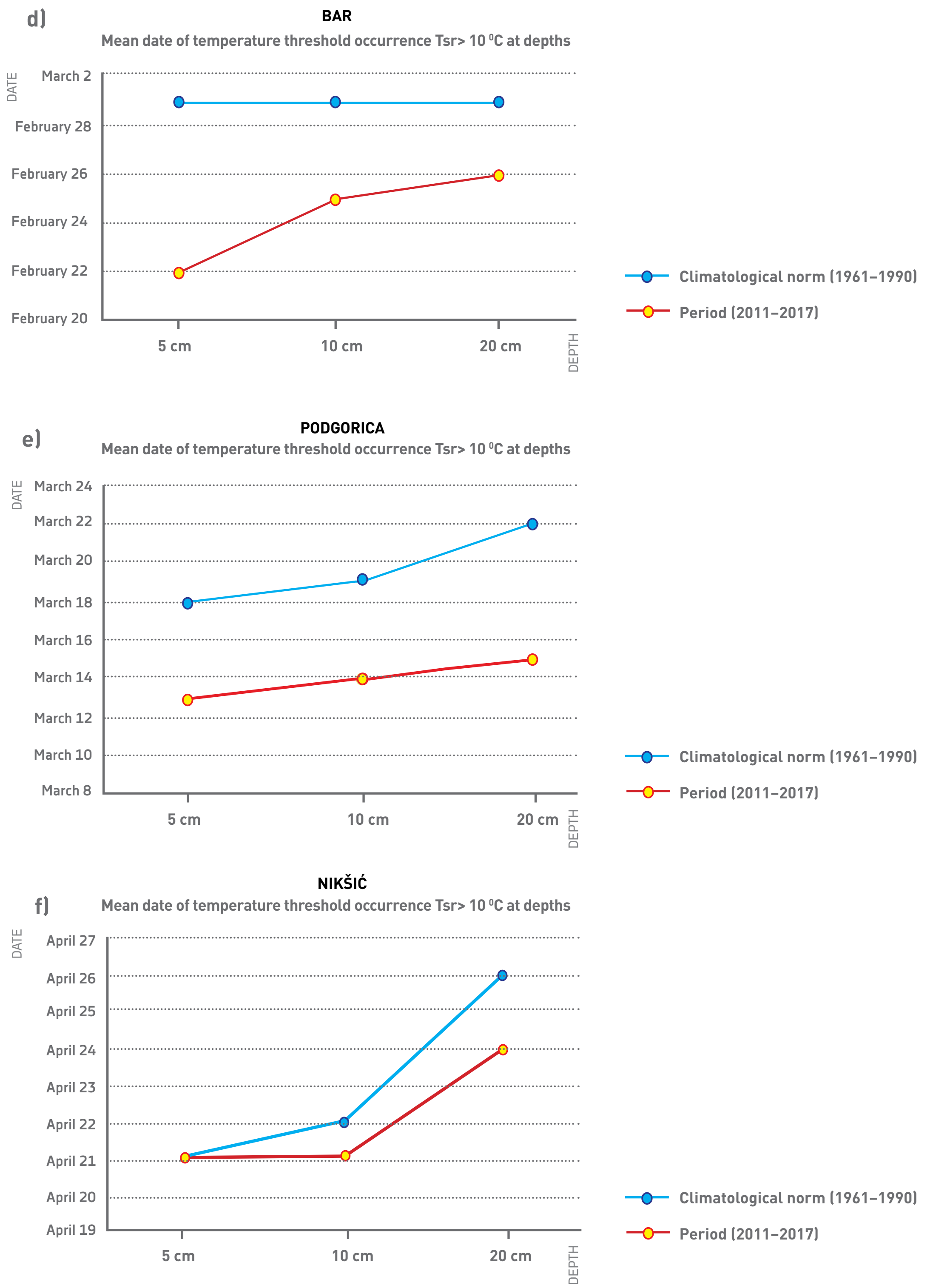


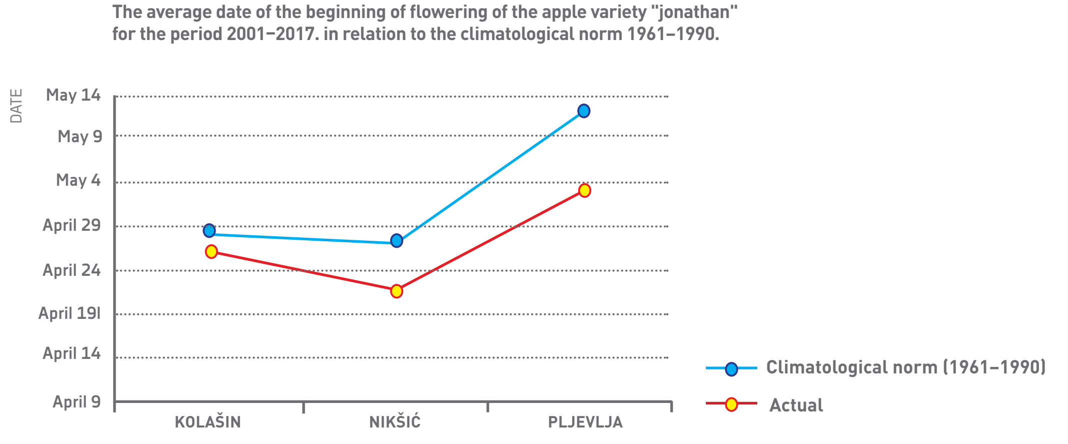
FIGURE 5.27 Mean monthly soil temperatures (° C) at a depth of 20 cm (a, b, c) and the mean date of occurrence of a temperature threshold of 10° C at depths of 5, 10, and 20 cm (d, e, f) for the 1961–1990 climatological norms and the periods 1990–2000, 2000–2010, and 2011–2017 for Bar, Podgorica, and Nikšić

Phenological observations

The phenological database[1] contains data broken down into seven basic categories: fruit crops, vines, arable crops, forest trees, plant diseases and pests, beekeeping, and general field work. The methodology for monitoring phenophases is highly dependent on the human factor and is subject to subjective errors. Therefore, it is necessary to establish data control, modernize the collection of phenological data using online forms, and expand the network of stations and observers, all in order to maintain the continuity and reliability of data.

Today, phenological observations are being carried out at seven phenological stations in Montenegro with the aim of increasing their numbers, as well as restoring the International Phenological Garden in Bar and its inclusion in the European Phenological Network. Montenegro is participating in the Pan-European Phenological database project, which aims to promote and facilitate phenological research by adopting a complete European phenological database with open, unrestricted access to data for science, research, and education.

On the basis of phenological data, it has been established that in the last years in Montenegro the beginning of flowering of the apple of the Jonathan variety occurs 2 to 9 days earlier in relation to the 1961–1990 climatological norm. At the same time, the beginning of flowering of the Požegača plum variety occurs 4 to 7 days earlier in relation to the reference period (Figure 5.28)



[1] Phenology studies the individual stages of plant development during their growing season, with the aim of determining the dynamics of their appearance, as well as their dependence on environmental factors. Phenological observations are an integral part of observations at agrometeorological stations in all member countries of the World Meteorological Organization. At the Institute for Hydrometeorology and Seismology of Montenegro, phenological observations have been carried out since 1951. The data collected from 19 phenological cells is in the phenology database (Access database). However, as the monitoring in Montenegro was not carried out continuously at all stations, the database is not complete for the stated period.

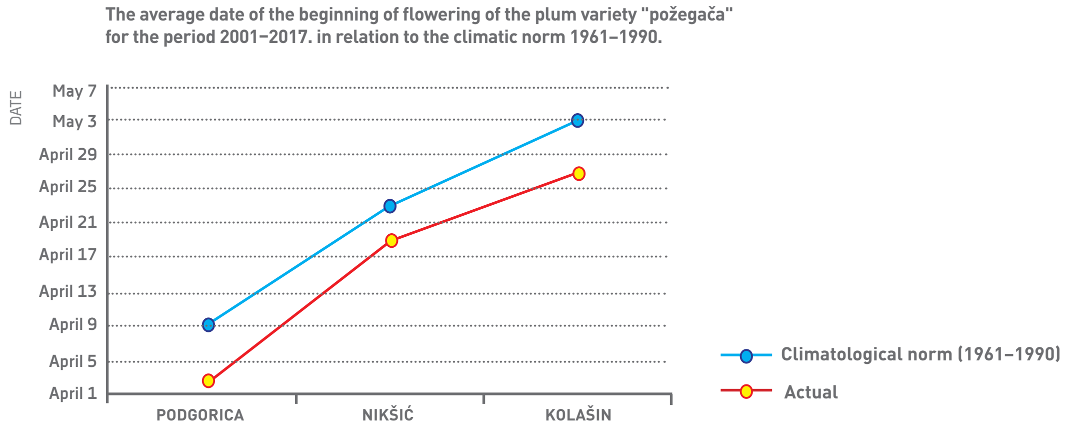


FIGURE 5.28 **Mean start date of flowering of the Jonathan apple variety and the Požegača plum variety for the period 2001–2017 and the 1961–1990 climatological norm**

On the coast of Montenegro, spring phenophases of vines are starting 2 to 3 days earlier per 10 years. The stages of full maturity and grape harvesting in the continental regions show a much earlier start. On the coast, the period from the beginning to full ripening of the grapes has shortened on average by about a week. At the same time, changes in olive vegetation have been observed. It has been observed that on the coast olives have been moving the period of blooming by 2 to 3 days per 10 years. In addition to early flowering, there is an early ripening of olive fruits. Phenological observations clearly show a trend of early vegetation in spring, while no significant extension of vegetation in the fall has been observed everywhere. This is attributed to a larger observed increase in mean daily air temperature in spring than in autumn.

The results of future climate projections for Montenegro show that a further increase in temperature, changes in the amount and redistribution of precipitation, and intensification and increase in the frequency of weather and climate extremes can be expected. Due to the increase in temperature, a further extension of the vegetation period is expected. The smallest changes are expected in the north, wherein the end of the century vegetation could last from 11 to 18 days longer, while on the coast the coastal vegetation period could last almost the entire year.

The expected higher number of consecutive dry days, especially in the northern areas, as well as shorter rainy periods, is expected to lead to more arid conditions throughout the territory of Montenegro. Rainfall, especially during the summer months, combined with the increased number of days with high daytime temperatures, makes Montenegro, as well as the entire region of Southeast Europe, very vulnerable to droughts. As the movement of the vegetation period is expected to be larger towards the beginning than towards the end of the year, there is a risk that the movement of the vegetation period to an earlier time will expose the plant to a greater risk of late spring frosts. Due to the early onset of vegetation, the shortened duration of some phenophases, the ripening of crops in months with a higher average temperature, and a higher risk of extreme weather events, a decrease in the yield and quality of some crops can be expected. Due to the changing climatic characteristics of areas where some varieties have traditionally been grown, they will become unfavourable, while in some new ones the optimal climatic conditions for their cultivation will be created.

Agrometeorological information

In the face of increasing climate change, modern agricultural production, in addition to the monthly and decadal agrometeorological analyses, requires specific real-time information and warnings. Therefore, it is necessary to modernize and expand the existing network of meteorological stations, and also to expand the range of agrometeorological information available to users.

The existing network of stations in Montenegro is not adequate due to: the low coverage of the territory of Montenegro, the inadequate choice of locations of stations, and their lack of specific sensors. By expanding the existing network of meteorological stations with upgraded agrometeorological stations, equipped with sensors for soil temperature and humidity, leaf humidity, and sunshine length, it would be possible to provide important information and recommendations to agricultural producers in a timely manner. For optimal effectiveness, the upgraded network needs to contain at least three agrometeorological stations per municipality, depending on the municipality's surface area, the number of climatic micro-localities, orography, land type, and type of agricultural production.

An excellent example from practice is the promotion of agrometeorological observation through the established network of reporters within the IPA project "Risk of droughts in the Danube region" – DriDanube, (http://www.interreg-danube.eu/approved-projects/dridanube). The network of reporters consists of agricultural producers (Pljevlja, Nikšić, Žabljak) employed in Durmitor National Park, Biogradska Gora and Lovćen, meteorological experts (Bar, Kolašin), as well as agricultural engineers (AD Plantaže). Reporters at selected agricultural and forest locations monitor and report weekly on soil moisture, crop and forest cover relative to humidity, These reports enable the creation of multiple types of maps for the territory of Montenegro and the DriDanube region.

In addition to the use of data monitored in the field, the ability to use satellite and data obtained from numerical models is of great importance (http://www.droughtwatch.eu).

In a changing climate, support for crop production would also be the introduction into the operational agrometeorological work of models to simulate crop yields (plant time model), as well as models for predicting plant diseases.

Adaptation measures for the agriculture sector

The adaptation measures described in this National Communication are based on a combination of those which are still relevant and included in the Technology Needs Assessment (TNA) from 2012, the Second National Communication, as well as new analysis for this Communication.

The Technology Needs Assessment (TNA) has estimated that the agriculture sector may require €2.1 million for adaptation measures (Government of Montenegro, 2012). Many of the adaptation measures identified in the TNA are still relevant at the time of this National Communication, although additional options have been added. Possible adaptation measures in the agricultural sector include planning and capacity-building measures, while others more technology- and information-oriented responses (Table 5 9), but this list does not yet include "hard" investment measures in the forestry sector which are likely also to be useful but have not yet been properly scoped.

TABLE 5.9:
List of identified adaptation measures for the agriculture sector

Type of adaptation measure	ADAPTATION MEASURES	Increase in temperature	Decrease in precipitation	Droughts	Floods
POLICY AND INSTITUTIONAL STRENGTHENING MEASURES	The development of a comprehensive plan of response/ adaptation to droughts should focus on existing schemes for drought control measures			•	
	Cooperation between scientists, decision makers, and stakeholders needs to be strengthened	•	•	•	•
	Establish a national network of reporters as part of the agrometeorological observations, reporting on soil moisture and crop conditions	•	•	•	•
TECHNICAL MEASURES	Expansion of a range of user-friendly agrometeorological information such as satellite data and numerical model results	•	•	•	•
	Improvement of the agroforestry sector by cultivating new plantations of hazelnuts, wild pomegranates, or other perennial species in areas exposed to frequent fires	•		•	
	Building/upgrade of irrigation and drainage systems to ensure water access in drought period	•	•	•	
	Adequate conditions for growing fodder in new climate conditions should be ensured and new technology should be used	•	•	•	

	Promoting of sustainable use of mountain pastures and support sustainable use of manure	•		•	
	Building of micro-reservoirs to cope with fires and water shortages in livestock and crop production	•	•	•	
	Implementation of models for simulating crop yields (plant time) and models for predicting plant diseases in operational agrometeorological work	•	•	•	•
	Introduction of new varieties of agricultural crops that are more resistant to warmer climates and more frequent occurrence of extreme events	•		•	•
	Sustainable use of mountain pastures and support sustainable use of manure				•
	Production and use biochar in sustainable land management and study its impact on land	•	•	•	•
	Establish a network of agrometeorological stations and equip them with adequate sensors (for soil temperature and humidity, leaf humidity, sunshine length, etc.)	•	•	•	•
RESEARCH, INFORMATION AND CAPACITY-BUILDING MEASURES	Improvement of the phenological database, modernization of the data collection system through an online form and expand the observer network	•	•	•	•
	Research on the impact of climate change on livestock breeding and on which regions are best for certain breeds and types of livestock	•		•	
	Systematic collection of existing data on soil organic carbon and other soil fertility parameters and formation of an integrated database	•		•	
	Generation of agrometeorological information, reporting on soil moisture and crop conditions	•	•		

In addition to the measures described above, a number of potential measures related to climate change have been identified within Montenegro for implementation to address land degradation as part of the Land Degradation Neutrality (LDN) Target Setting Programme. These are described in Table 5.10.

TABLE 5.10:
Measures in the LDN Target Setting Programme which are directly related to addressing climate change vulnerability

Number from the LDN TSP	PROGRAMMES, ACTIONS, AND MEASURES	USD	Responsible institution
5	Building micro-reservoirs to cope with fires and water shortages in agriculturei	1,500,000	MPRR
6	Production and use of biochar in sustainable land management and study of its impact on land	1,200,000	MORT, MPRR, UCG-BTF
9	Improvement of the agroforestry sector by cultivating new plantations of hazelnuts, wild pomegranates, or other perennial species in areas subject to frequent fires	1,200,000	MPRR
10	Collecting all existing data related to soil organic carbon and other soil fertility parameters into one integrated database	650,000	UCG-BTF
15	Support for investments in water supply (wells, reservoirs)	2,000,000	MPRR
18	Sustainable use of mountain pastures	1,375,000	MPRR
19	Support for the sustainable use of manure	650,000	MPRR
21	Afforestation, landscaping, and protection of forests and production of seedlings	4,100,000	MPRR
22	Raising of economic forests on private land (change of land use)	200,000	MPRR
23	Determination of the Fire Weather Index – FWI	80,000	ZHMS, MORT
Total		**28,910,000**	

SEA ECOSYSTEMS AND FISHERIES

The fisheries sector is important for the national economy and livelihoods of coastal communities in Montenegro. According to the most recent fish assessment, 407 fish species and subspecies were recorded in the Adriatic Sea (Jardas, 1996). In the meantime, that number has increased to 449, accounting for more than two-thirds of the species and subspecies represented in the Mediterranean Sea. There are 46 foreign fish species in the Adriatic, while seven new fish species and two decapod crustacean species have been recorded in Montenegro so far. This number is expected to increase steadily throughout the 21st century.

Vulnerability and climate impacts in the fisheries sector

The Adriatic Sea has experienced increasing temperature in the last decade. The temperature is estimated to have increased by approximately 0.3° C since 1990 (Dulčić and Dragičević, 2013). In the last 20 years, there have been quantitative and qualitative changes in the Adriatic ichthyofauna, which are a consequence of climate change, i.e. changes in precipitation, salinity, the pH of water, and oxygen availability in marine ecosystems. The greatest impact of the changes is reflected in the increase in temperature that favours the distribution, spread, abundance, and impact of invasive species.

The assessment of the climate sensitivity of the marine ecosystem due to the rise in temperature of the Adriatic Sea was carried out on the basis of data collected during monitoring. The assessment shows the vulnerability of natural (indigenous) populations of marine organisms that inhabit the Adriatic Sea. Changes in temperature have resulted in changes to populations that are occurring due to the appearance of new species. The key impacts for the marine ecosystem include:

- Changes in the composition of natural communities, an increase in the number of certain species, and a decrease in or complete disappearance of some other species
- Breeding of new species of marine organisms because they lack natural predators and are not competing for food and space
- Impacts on local communities in the coastal area, such as the reduction of fish catches, damage to fishing gear, and the emergence of highly toxic puffer fish, dangerous to human health

Results from the monitoring of the fisheries sector show that five new fish species have been recorded: the brushtooth lizardfish *Saurida undosquamis*, marbled spinefoot *Siganus rivulatus*, peacock wrasse *Iniistius pavo*, and two barracuda species *Sphyraena viridensis* and *Sphyraena chrysotaenia*. In addition, data on native species shows that some species have disappeared completely (e.g. the Adriatic sturgeon Acipenser naccarii, monkfish Squatina squatina, Mediterranean dealfish *Trachipterus trachypterus*, and meagre *Argyrosomus regius*), and other native species have reduced their numbers (e.g. brown wrasse *Labrus merula* and brown meagre *Sciaena umbra*).

Although the degree of vulnerability of marine ecosystems cannot be determined with certainty, the problem of new and invasive species should be treated as belonging to the category "very vulnerable". The emergence of new species causes disruption throughout the ecosystem, as they are species that do not have natural predators in the new ecosystem that would regulate their abundance through the food chain and, through competition for food and habitat, affect the existing native species. Table 5.11 shows a summary of the key climate impacts for the fisheries sector.

TABLE 5.11:
Summary of climate change impacts in the fisheries sector

Climate variability and hazards	POTENTIAL IMPACTS
Increase in temperature	– Changes in the composition of natural communities, increase in the number of certain species, and decrease in or complete disappearance of some other species – Breeding of new species of marine organisms because they lack natural predators and are not competing for food and space – Impacts on local communities in the coastal area, such as the reduction of fishermen's catches, material damage to fishing gear, and the emergence of highly toxic puffer fish, dangerous to human health.

Adaptation measures for the fisheries sector

The adaptation measures to be taken relate primarily to the controlled capture of certain species that are new to the Adriatic Sea or have drastically increased their abundance and examined the possibility of exporting new species to areas where they are valued as food. In order to implement these measures, capacity building at the level of management units (competent ministries) and professional (scientific) institutions is needed, the establishment of a national monitoring centre for alien and invasive species, as well as educating the local population and fishermen on the measures and procedures to be implemented. in the case of finding a new species and new fishing techniques. Possible adaptation measures in the fisheries sector include planning and capacity building measures, while others more technology and information-oriented responses (Table 5.12).

TABLE 5.12:
List of identified adaptation measures for the fisheries sector

Type of adaptation measure	ADAPTATION MEASURES	Temperature rise
POLICY AND INSTITUTIONAL STRENGTHENING MEASURES		•
	Establishment of a national monitoring centre for alien and invasive species	•
	Adoption of the Law on Alien and Invasive Species and drawing up of a plan of measures and activities to be implemented in the case of new species	•
TECHNICAL MEASURES	Reduction of the abundance of certain species that are new to the Adriatic or have drastically increased their abundance by controlling catches	•

RESEARCH, INFORMATION AND CAPACITY-BUILDING MEASURES	**Capacity building for local fishermen regarding new fishing techniques that will be used to catch new species and decrease the population of invasive species**	•
	Research on new species in areas where they are valued as food and where there is a culture of their consumption	•
	Preparation of awareness raising materials on the species to be monitored and registered, with information to be notified when a new species is found, in order to educate fishermen and the local population	•
	Capacity building of competent ministries and professional (scientific) institutions	•

COASTS AND COASTAL AREAS

The Coastal Area Management Programme (CAMP) defines that the coastal zone of Montenegro covers the administrative boundaries of six coastal municipalities (Herceg Novi, Kotor, Tivat, Budva, Bar, and Ulcinj, excluding parts of Lake Skadar National Park and Lovćen National Park) with a total area of 1,591 km^2, as well as inland waters and the territorial sea of Montenegro with an area of about 2,500 km^2. The coastal area is the densest and most developed part of Montenegro.

Coastal areas in Montenegro are exposed to sea level rises. Rising sea levels will be particularly significant in terms of flooding, the erosion of the coast, and the loss of flat areas of karst such as Ada Bojana in the extreme south-eastern area of the Montenegrin coast.

Vulnerability and climate impacts in forestry resources

Predicted climate change, and above all increases in temperature, frequency of the occurrence of storms, as well as an increase in the frequency, intensity, and length of droughts, are expected to lead to an increase in evapotranspiration, a decrease of flows and groundwater levels, rises in sea level and the spread of seawater along river beds, and more frequent floods. All of the above is expected lead to a deterioration of the hydrological conditions in the coastal area, a reduction in water supplies, and considering the projected population growth in this area, it will affect demand for water. The expected changes will additionally have a negative impact on the coastal ecosystems. Adverse changes in the habitats of these ecosystems can result from rising water temperatures, weakening of thermohaline circulation, and the increased erosion of sandy beaches. It is therefore necessary to maintain a good water status and reduce flood risks.

Tourism is one of the most economically important sectors in Montenegro. In 2017, tourism contributed 23.7% to the total gross domestic product (GDP). In recent years, there has been a steady increase in the number of tourists and their overnight stays, as well as an increase in the number of cruise ships and their passengers sailing into the port of Kotor. According to the World Tourism Council projection, tourism will contribute almost 30% of GDP to the national economy over the next 10 years.

According to the Tourism Development Strategy of Montenegro until 2020, almost 70% of the total number of overnight stays in the last years is recorded during July and August, and nearly 90% in the period June–September. Such a time distribution of visits throughout the year makes tourism revenue very sensitive to climate change, as coastal tourism in southern Europe is projected to decline due to high daily temperatures. In this respect, the vulnerability of coastal tourism cannot be assessed with certainty, since it must be taken into account that tourists may adapt to climate change. Although a further increase in air temperature in the main seasonal period could lead to a fall in the number of tourists, an improved offer of tourist activities in the pre- and post-season periods could increase the number of tourists.

Table 5.13 has a summary of the potential impacts from climate change on coasts and coastal areas.

TABLE 5.13:
Summary of climate impacts in the coastal area

Climate variability and hazards	POTENTIAL IMPACTS
Increase in temperature	– Increased temperature of sea water – Reduction of the functions of coastal ecosystems – Increased demand and pressure on the water system especially in the summer season when water demand increases due to tourism – Eutrophication and multiplication of aquatic plants – Insufficient adaptation of tourism offers in line with climate change
Decrease in precipitation	– Reduction of the amount of water available – Reduction of water levels in coastal wetlands
Storm winds and storms	– Exacerbated soil erosion, damage to power lines, buildings, and structures. – Increased mid-sea levels, while strong winds create high waves that can cause damage to ships, coasts, and coastal infrastructure, as well as disrupt maritime traffic
Floods	– Loss of attractiveness of the coastal area – Loss of economic assets – Decrease in tourist visits – Intensified erosion processes – Loss of attractiveness of the coastal area – Direct loss of income and weakening of the national economy
Sea level rise	– Infiltration of salt water into water systems – Flooding in low-lying areas – Erosion of coastal zones and beaches

The rise in sea level could also increase the probability of storm waves, the penetration of salt water into the land and posing threats to human lives, infrastructure, tourism, coastal ecosystems, and marshlands. Due to the rise in seawater temperature, changes in the amount, intensity, and frequency of rainfall, as well as due to the more frequent occurrence of storms, a rise in the sea level is predicted. Increasing this can lead to the more frequent occurrence of floods, intensifying the erosion process and leading to the penetration of salt water into the mainland and its mixing with drinking water sources. An increase in the relative sea level enables waves to approach the coast, thereby increasing the load and stress on coastal infrastructure. Estimates of the rise in Adriatic Sea levels by 2100, according to various sources, range from 32 to 65 cm. Since the Montenegrin coast of the Adriatic Sea is mostly rocky and relatively steep, it can be said that the vulnerability of the coastal area from rising sea levels is not very high. Sandy beaches in low-lying coastal areas covered with alluvial or flysch deposits could be endangered, and the most vulnerable area is Ada Bojana. The zones that could be flooded coincide with the zones of flooding caused by storms.

Storms increase mid-sea levels, while strong winds create high waves that can cause damage to ships, coasts, and coastal infrastructure, as well as disrupt maritime traffic. There are two types of strong winds in Montenegro during the winter: the southern wind and the bora, with gusts that can reach speeds of over 115 km/h. During the summer, strong winds are generally associated with the local weather. The estimated vulnerability to storm winds in the coastal area of Montenegro currently varies from low at the mouth of the River Bojana estuary to very high in the Herceg Novi area. On the other hand, in the area of Ulcinj Beach, Ada Bojana Beach, and the mouth of the River Bojana, the most pronounced impact is that of storms due to the sandy and low coastline and the shallow depth of the sea. Six zones have been identified that could be flooded due to the effects of storms, as well as flooding surfaces:

- Mouth of the River Sutorina, Bay of Kotor (51,936.2 m^2),
- Solila, Bay of Kotor (147,183.5 m^2)
- Jaz Cove (29,202 m^2)
- Buljarica Bay (159,562 m^2)
- Čanj Bay (61,734.3 m^2)
- Ulcinj Beach (863,726.8 m^2)
- Ada Bojana Beach (228,192.7 m^2)

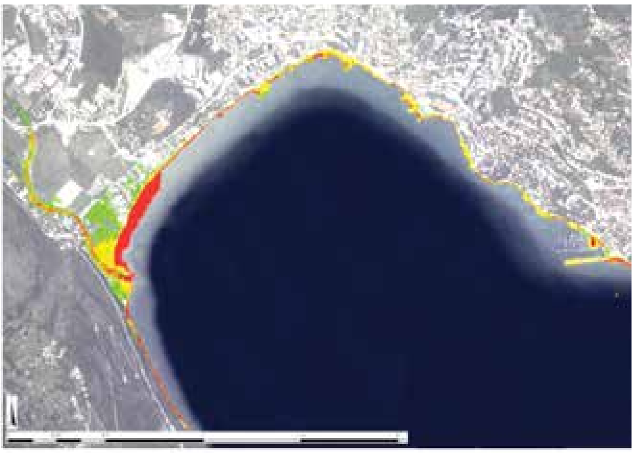
Within the framework of the MedPartnership sister project: "Integration of Climatic Variability and Change into national strategies to implement the ICZM Protocol in the Mediterranean", a vulnerability assessment of coastal areas in Montenegro was conducted in 2013 (MedPartnership, 2013). The assessment used four scenarios for sea level rise by 2100 considering the sea level rise that has already happened in the period 1978–2013:

- Scenario 1 – 0.62 m on DTM = 0.27 m (height correction) + 0.35 m (sea level rise)
- Scenario 2 – 0.96 m on DTM = 0.27 m (height correction) + 0.15 m (sea rise 1978–2013) + 0.54 m (sea level rise)
- Scenario 3 – 1.46 m on DTM = 0.27 m (height correction) + 0.15 m (sea rise 1978–2013) + 1.04 m (sea level rise)
- Scenario 4 – 1.96 m on DTM = 0.27 m (height correction) + 0.15 m (sea rise 1978–2013) + 1.54 m (sea level rise)

The following maps show the most exposed coastal areas in Montenegro especially for Scenarios 1 and 2 – the Igalo area, Morinj area, Krtole/Polje Bay area, and the River Bojana. The values used in legend correspond to values on DTM (and have therefore added the vertical correction of +0.27 m). In the case of the predicted sea-level rise of 35 cm by the year 2100 (Scenario 1), the areas in red will be endangered with sea floods. The orange areas (Scenario 2) will be endangered in case of a global sea level rise of 54 cm (and with consideration of the worst-possible global sea-level rise between 1978 and 2012). The same areas are already endangered during certain extreme meteorological events (excluding short-period wave action). Scenario 3 is marked in yellow and Scenario 4 in green. In blue are the areas that appear below 0 m on the DTM. They are significant in the hinterlands of the mouth of the River Bojana and are particularly vulnerable as they represent the lowest parts of the terrain and will be endangered according to all scenarios.

- Igalo Bay shows a high exposure in the western part where water could progress through the channel and should therefore be considered and discussed from a hydrotechnical point of view (Figure 5.29 – a).
- The Morinj area exhibits elevations below 62 cm not only directly next to the sea but also in the area on south-west of the bridge, about 150 m or more from the shore, which is connected to the sea by some sort of channel. This area would be significantly affected already in the case of Scenario 1. In the case of Scenario 2, the aforementioned exposed area would progress further to the west and east. Water would also cover almost the entire part of the land on the seaward side of the road, except of the elevated residence area (Figure 5.29 – b).
- Krtole/Polje Bay and the saltpan natural reserve would be significantly flooded already in Scenario 1 (westwards to the first crossing road). In case of Scenario 2, water would also flood the area between the two crossing roads and progress significantly more to the east and north (towards the airport). Tivat Airport would, however, stay above the water in all four scenarios (Figure 5.29 – c).
- In the River Bojana area it can be observed that the saltpans are vulnerable already in the case of the Scenarios 1 and 2. The island of Ada Bojana with its very low elevations – more than half of it is below 62 cm, is likely to be significantly underwater already in Scenario 1 and almost completely in Scenario 2 (Figure 5.29 – d).

a)



Between 1.46 m and 1.96 m
Between 0.96 m and 1.46 m
Between 0.62 m and 0.96 m
Between 0 m and 0.62 m
Values below 0 m

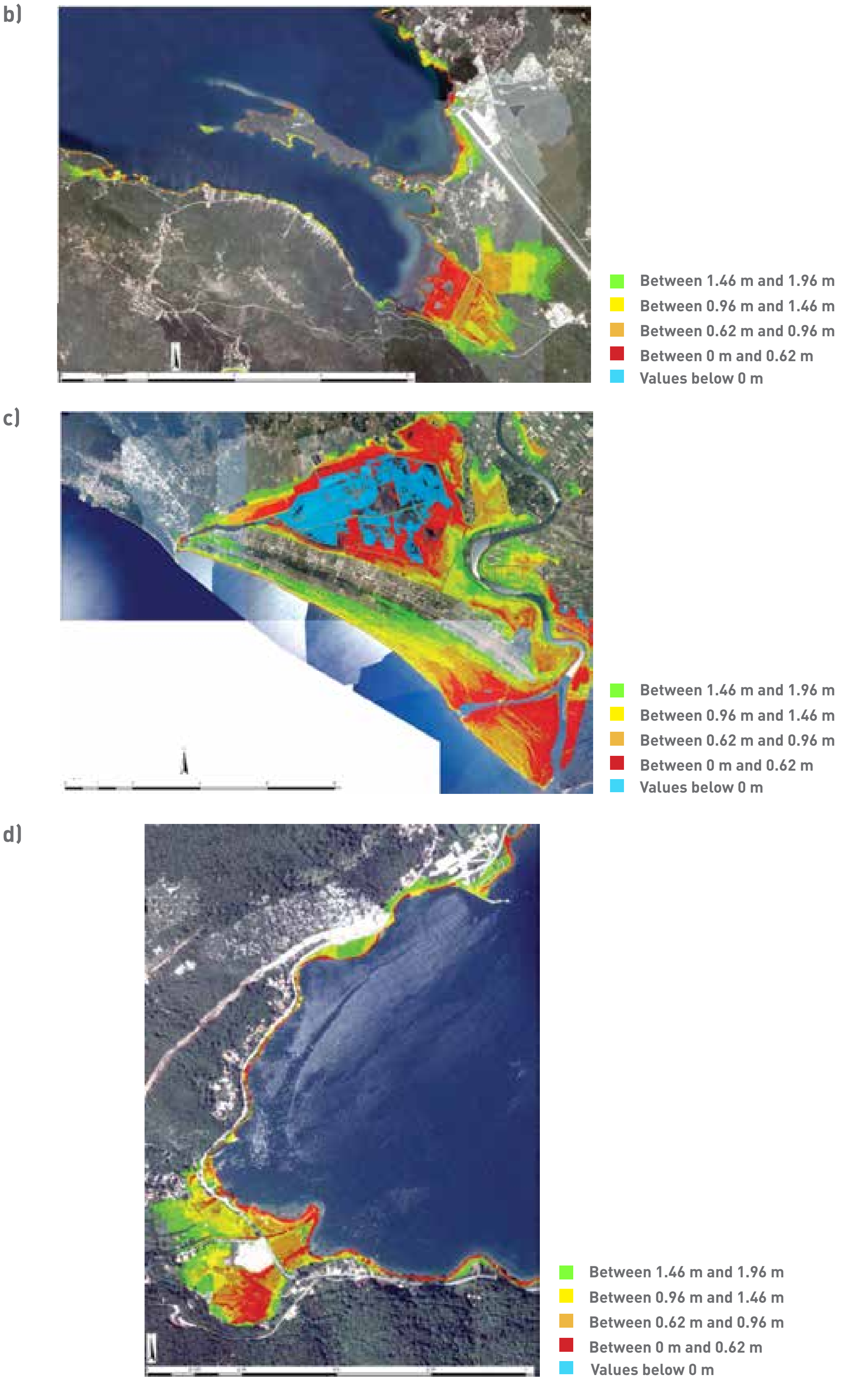


FIGURE 5.29 Map of exposed areas to coastal flooding: a) Igalo Bay; b) Krtole/Polje Bay; c) the Morinj area; and d) the River Bojana

During the project of the Integrated Coastal Area Management Programme of Montenegro (CAMP CG), an analysis of the sea level rise was carried out, but the effects of storms and storm waves were not taken into account, and the data obtained could not be fully considered relevant. According to the programme, two scenarios are relevant:

- Scenario 1: An expected sea level rise of 96 cm (based on measurements at Marae Station in Bar),
- Scenario 2: Sea levels will raise the sea level by 62 cm.

The study defines the level of vulnerability into five categories, where 'very low vulnerability' is rated as 1 and 'very high vulnerability' as 5 (Table 5.14). It also defines a wide range of prevention measures, some of which are relevant to this section and many of which are already included in relation to other sectors.

TABLE 5.14
Summary of results from the CAMP CG vulnerability analysis and adaptation measures

		Winter	Spring	Summer	Autumn	RECOMMENDED PREVENTION MEASURES
DROUGHT	A1B (2001–2030)	2–3	2–3	5	2–3	HOUSEHOLDS: – reducing the use of water in toilets and showers – commercial car washing with recycled water – collecting water TOURISM: – education in tourism – application of water conservation technologies – use of water from air conditioners and heating systems, – water management in swimming pools INDUSTRY: – application of water conservation technologies – treatment and alternative use of contaminated water AGRICULTURE: – improvement of the water supply system – more efficient irrigation (night-time irrigation, choice of irrigation scheme and irrigation system) – terraced slopes – strategic afforestation to shade exposed areas on sloping terrain – use of drought-resistant varieties – cultivation of forest protection belts – protection of agricultural land – improvement of the quality of individual ecosystem components – establishment of an early warning system for droughts
	A1B (2071–2100)	3–4	3	5	4–5	
	A2 (2071–2100)	2–3	3	5	4–5	
FOREST FIRE	A1B (2001–2030)	1	2	5	3	– provide support for an early warning system – carry out activities before, during, and after fires – controlled ignition in the presence of firefighters – carry out ongoing campaigns to inform the general public about the importance of forest resources – raise awareness of the general public about the dangers of forest fires
	A1B (2071–2100)	1	2	5	5	
	A2 (2071–2100)	1	2	5	5	

HEAVY RAIN	A1B (2001–2030)	3–5	3	1	5	– afforestation of low-productivity degraded areas – protection against torrents – protection against the harmful effects of water – performing anti-erosion works and measures – prohibit devastation in erosion areas, as well as deforestation and deforestation
	A1B (2071–2100)	3	3	1	1–2	
	A2 (2071–2100)	4–5	2–3	1	4–5	
STRONG WINDS AND STORMS	A1B (2001–2030)	2–4	2–4	1	2	– implementation of anti-erosion measures – afforestation of land – introduction of an early alert system making maps of maximum wind speeds by zone – development of municipal infrastructure for wastewater management
	A1B (2071–2100)	3–5	3–4	2	2	
	A2 (2071–2100)	4–5	4–5	2–3	2–3	
SEA LEVEL RISE	A1B (2001–2030)					– installation of new mareographical stations with a GNSS system for monitoring tectonic plate movements and measuring tides (sea levels) – installation of a waveform for measuring the parameters of waves, currents, surface sea temperature, tides (sea levels) – improving the impact assessment and damage from rising sea levels using more accurate modelling data
	A1B (2071–2100)					
	A2 (2071–2100)					

Adaptation measures for the coastal areas

The adaptation measures described in this National Communication are based on a combination of those which are still relevant and included in the Technology Needs Assessment (TNA) from 2012, the Second National Communication, and new analysis for this Communication.

The adaptation measures in the coastal areas need to focus on strengthening the hydrometeorological monitoring in order to better understand the potential impacts of climate change and to inform management plans and strategies – which may be changed to address climate change. On the other hand, the preservation of the natural environment and the coastal area will have the greatest impact by addressing coastal erosion risks and will improve tourism sites. The TNA has estimated that the coastal areas may require €1.9 million for the adaptation measures (Government of Montenegro, 2012) but these focus on "soft measures" and not "hard measures" involving investment. Many of the adaptation measures identified in the TNA are still relevant at the time of this National Communication, although additional options have been added. Possible adaptation measures related to the coast/coastal areas include planning and capacity-building measures, while others include more technology- and information-oriented responses (Table 5.15), but these have not yet included "hard" investment measures in the coast/coastal areas which are likely also to be useful but have not yet been properly scoped.

TABLE 5.15
List of identified adaptation measures for the coast/coastal areas

Type of adaptation measure	ADAPTATION MEASURES	Drought	Floods	Coastal erosion	Sea level rise
POLICY AND INSTITUTIONAL STRENGTHENING MEASURES	Integration of climate change impact and risk assessment into all future coastal strategic documents		•	•	•
	Strengthening of cross-sector coordination in the coastal areas	•	•	•	•
	Improvement of the protection of areas that have the status of a special nature reserve.	•	•	•	•
	Monitoring changes in coastal tourism, developing and implementing plans to adapt the tourist sector	•	•	•	•
	Promotion of new and sustainable tourist destinations and activities	•	•	•	•
	Introduction of regulations to restrict construction near shorelines		•	•	•

TECHNICAL MEASURES	Improvement/upgrade of early warning for coastal floods and storm surges		•		•
	Development and use of geographical information systems	•	•	•	•
	Promotion of erosion control measures, such as dune regeneration and restoration of coastal areas		•	•	
	Mapping of surfaces endangered by high waters is needed, as well as an analysis of options enabling the hydrological service of IHSM and the relevant municipal services to organize and monitor networks in priority watercourses		•		•
	Moving of communal infrastructure, such as treatment plants and pumping stations to higher altitudes, to reduce the risk of coastal flooding and vulnerability to coastal erosion		•		•
	Building of flood barriers to protect critical infrastructure, including embankments and wave defences		•		•
RESEARCH, INFORMATION AND CAPACITY-BUILDING MEASURES	Research into the impacts of climate change on all sectors of the coastal zone, as well as the development of new impact models	•	•	•	•
	Further analyses of high waters in watercourses in the Montenegrin coastal regions				•
	Research on the erosion control potential of the preservation of beaches in the Montenegrin coastal region			•	

HUMAN HEALTH

Good public health depends on safe drinking water, sufficient food, secure shelter, and good social conditions, which may all be affected by a changing climate – and are particularly important in the context of economies in transition, such as Montenegro.

Vulnerability and climate impacts in the health sector

Climate change has a range of complex interlinkages with health. These include direct impacts, such as temperature-related illness and death, and the health impacts of extreme weather events. It also includes other impacts that follow more indirect pathways, such as those that give rise to water- and food-borne diseases; vector-borne diseases; or food and water shortages. It can also include wider effects on health and wellbeing (Table 5.16).

TABLE 5.16:
Summary of climate change impacts on human health

Climate variability and hazards	POTENTIAL IMPACTS
Increase in temperatures	– Increase in transmission of food-borne diseases such as salmonella infections – Increase in the transmission of vector-borne diseases, such as tick-borne encephalitis, Lyme disease, and Leishmaniasis
Floods	– Direct physical effects (drowning and injuries) – Effects on wellbeing (e.g. mental illnesses from the effect of flooding and displacement) – Potentially increased risk of food- and water-borne diseases
Extreme temperatures	– Increase of occurrence of mortality due to heat waves and extreme low temperatures

There is no reliable data on the impact of climate change on human health, as this data has not been integrated with compulsory health records. However, there are efforts to strengthen this capacity and plans to introduce bio-forecasting in order to quantitatively assess the impact of weather and climate on human health in Montenegro.

It is important to establish such a system of bio-forecasting and this is supported by both direct indicators (e.g. more frequent heat waves, floods, droughts, and forest fires) and indirect indicators (increased frequency of food- and water-borne diseases, allergies, and other respiratory tract diseases caused by pollen, particularly in children; and more frequent heart attacks and strokes due to low air pressure, large fluctuations in temperature, and sultry days).

The aim is to prevent and adapt to changes in the climate; with the support of a bio-meteorological forecasting system, Montenegro will establish a database which provides data on the impact of weather and climate on morbidity and mortality in Montenegro. Two ways of collecting data have been defined: using questionnaires with questions about reactions to meteorological-related events and using a list of specific diseases that are affected by the weather. All of the collected data will be archived and analysed by the Public Health Institute of Montenegro (PHI). At the beginning, data collection and research will only be carried out for the capital city of Montenegro, Podgorica.

It is important to consider that climate change could affect the capacity of health services to deal with emergencies. Therefore, planned and proactive adaptation can reduce climate impacts in different ways. It may reduce the population's exposure to climatic stimuli (e.g. through urban planning and design); it may reduce the population's sensitivity (e.g. through vaccination programmes); it may modify non-climate risk factors (e.g. control of disease vectors); or it may reduce the direct impact of disease (e.g. through early notification and treatment).

Adaptation measures for the health sector

Adaptation measures in the health sector should focus on the strengthening of existing institutional capacities, information dissemination, and monitoring systems to better understand the impacts of climate change on human health in Montenegro. Possible adaptation measures include planning and capacity building measures, while others include more technology- and information-oriented responses (Table 5.17).

TABLE 5.17:
List of identified adaptation measures for the health sector

Type of adaptation measure	ADAPTATION MEASURES
POLICY AND INSTITUTIONAL STRENGTHENING MEASURES	Development of strategic documents related to climate change adaptation planning
	Improvement and strengthening of the health system's ability to adapt to climate change to health
TECHNICAL MEASURES	Development and improvement of early warning systems for the population with health problems
	Strengthen health monitoring systems related to the potential impacts of climate change
	Implementation of bio-meteorological forecasting is necessary in order to ensure early warning about the favourable or unfavourable impact of weather on human beings, particularly on people with chronic diseases
RESEARCH, INFORMATION AND CAPACITY-BUILDING MEASURES	Strengthening the competence of the health system in terms of climate change impacts on health
	Strengthening the competence of the health system as a response during future adaptation

URBAN AREAS

Urban areas in Montenegro are constantly expanding with many people migrating from nearby rural areas in search of better opportunities. Due to land conversion around urban settlements into industrial and residential zones, population migration from the northern regions of Montenegro to its central and coastal areas has increased. The municipalities with the largest migration, primarily Podgorica, Budva, and Bar, have the greatest pressures on urban areas due to inadequately designed infrastructure, especially when it comes to the capacity and maintenance of rainwater, drainage, sewage infrastructure, air quality, and environmental impact.

These aspects increase the vulnerability of urban areas to climate change damage, both from the sociological, infrastructural, and environmental aspects. For the purpose of climate vulnerability assessment, Montenegro is divided into three regions according to climate characteristics: the north, the centre, and the coast. As the vulnerability increases even more as the population grows, the demographical characteristics were analysed in addition to the climatic characteristics, starting with the number of inhabitants and the population density, through to their migration within Montenegro. The climatic characteristics were analysed on the basis of data from meteorological stations located in urban areas, namely: Žabljak, Pljevlja and Kolašin for the northern region; Podgorica and Nikšić for the central region; and Herceg Novi, Bar, and Ulcinj for the coastal region. The basic administrative, demographical, economic, and climatological characteristics of these regions are shown in Table 5.18.

TABLE 5.18:
Montenegro's urban areas and characteristic climate variability

	NORTH	CENTRE	COAST
Administrative unit	MUNICIPALITIES: Andrijevica, Berane, Bijelo Polje, Gusinje, Kolašin, Mojkovac, Petnjica, Plav, Pljevlja, Plužine, Rožaje, Šavnik and Žabljak	MUNICIPALITIES: Podgorica, Cetinje, Danilovgrad and Nikšić	MUNICIPALITIES: Bar, Budva, Herceg Novi, Kotor, Tivat and Ulcinj
Demography	– It occupies 52.8% of the territory in which one-third of the total population lives. – The lowest population density is in the northern municipalities of Šavnik and Plužine (4 inhabitants/km^2), Žabljak (8 inhabitants/km^2) and Kolašin (9 inhabitants/km^2). – The migration balance at the regional level is negative and amounts to 1,882 people.	– Population density in the capital Podgorica is 129 inhabitants/km^2. – The region-wide migration balance is positive and highest. It amounts to 990 people	– The highest population density is Tivat (309 inhabitants/km^2), then Budva (153 inhabitants/km^2), and Herceg Novi (131 inhabitants/km^2). – The migration balance at the regional level is positive and amounts to 892 people.
Economy	– The least developed region in the country, which is home to most natural resources, the proper use and management of which can help bring Montenegro closer to the EU average. – Smaller urban settlements: Žabljak, Plužine, and Šavnik. – Urban and semi-urban settlements in the valleys of the Rivers Lim, Ibar, Tara, and Ćehotina.	– In the area of the Lake Skadar basin there are: urban settlements with agricultural fields, orchards and vineyards, industrial zones, storage and service areas. – In the area of the karst part of the central region are: · the city of Nikšić as an urban settlement · suburban settlements with agricultural fields · industrial zones · storage and service areas, quarries.	– In the coastal region there are: olive groves, traditional agricultural fields, coastal urban and suburban settlements, semi-urban settlements, industrial zones, storage and service areas. – Devastated areas are quarries and landfills.

Climate	ŽABLJAK: mountainous climate, with minimum rainfall from April to July and maximum in November. The warmest months are July and August, and the coldest January. PLJEVLJA: temperate continental climate. The primary maximum rainfall occurs in June and the secondary in November, with precipitation almost uniform in months. The warmest months are July and August, and the coldest is January. ROŽAJE: similar precipitation regime as in Pljevlja, but the total precipitation is higher.	NIKŠIĆ: modified mountain climate, with maximum rainfall in November and minimum in July. The warmest month is July and the coldest January. PODGORICA: modified maritime (Mediterranean) climate. The highest rainfall is in November, the second in January and the third in April. The summer months see minimal rainfall, and during July the climate is arid. The warmest month is August and the coldest January.	BAR: maritime climate. The highest mean monthly temperature is in August and the lowest in January. The average monthly rainfall reaches a maximum in November, a secondary maximum in January and then in April. There is a minimum of rainfall during the summer months and arid conditions occur in July.

The municipalities with the largest positive migration balance, primarily Podgorica, Budva, and Bar, have the greatest pressures on urbanism due to inadequately designed infrastructure, especially when it comes to the capacity and maintenance of the water supply, drainage, sewage infrastructure, air quality, and environmental impact. In addition, in the last 10 years, the method of heating has moved more towards firewood and away from electricity which is reflected in the quality of air and human health.

With the increased number of people in the central and coastal regions, land redevelopment, and urban infrastructure development, exposure to dangerous natural disasters is increasing due to greater material damage and the loss of human lives and natural resources.

Climate projections also indicate that with regard to the movement of the total population and the direction and intensity of changes, much more significant differences can be expected in each region. While population inflows are foreseen in the coastal and central regions, a significant population decrease is expected in the northern region. An analysis of the vulnerability of the economy, population, infrastructure, and natural resources in urban areas to changes in climate extremes and mean values of temperature and precipitation is presented in Table 5.19.

TABLE 5.19:
Observed and projected impacts of climate change in urban areas of Montenegro (Žabljak, Pljevlja, Kolašin, Nikšić, Podgorica, Herceg Novi, and Bar)

Climate variables	EVIDENCE OF PRESENT IMPACTS OR VULNERABILITIES	OTHER PROCESSES OR PRESSURES	FUTURE IMPACTS OR VULNERABILITY TO PROJECTIONS AND SCENARIO RCP8.5	AFFECTED ZONES OR GROUPS
Heat and cold waves	Effects on human health; increased energy and water consumption; infrastructure	Social opportunities; institutional capacity; building design and internal temperature control	Increased vulnerability of the population; effects on human health; changes in energy requirements	The elderly, pregnant women and children, and the very poor; agriculture, greenhouses due to high internal temperatures

Drought	Water availability; energy production, water supply	Plumbing systems; energy demand; problem in water supply, inadequate forest fire protection system	Searching for sources in affected areas; additional investments for water supply	Poor part of the population, poor areas; areas with water shortages as a result of human activities; forest fires
Extreme rains, river flooding	Erosion, landslides; flooding of land; interruption in transport	Drainage infrastructure	Drainage infrastructure	Infrastructure (transport, water supply, sewage system), agriculture, natural resources (water resources and quality)
Thunderstorms	Flood and wind victims; economic damages; transport, tourism; infrastructure (energy transfer); insurance	Land use, population density in flood plains and flood-prone areas; flood protection; institutional capacity	Increased vulnerability of storm-prone shores; possible impact on settlements, health, tourism, economy, and transport	Coastal area, population, and areas with limited capacities and resources; insurance companies
Changes in mean values temperature	Energy demand and costs; air quality; tourism	Demographic and economic change; land conversion; air pollution Demographic and economic change; land conversion; air pollution Institutional capacity	Changing energy demand; deterioration in air quality; impacts on settlements and infrastructure	High vulnerability of the population with limited capacity and resources for adaptation
Changes in mean values precipitation	Effects on agriculture; water infrastructure; tourism; energy supply	Water resource allocation	Floods; rainfall deficit	Poor part of the population
Sea level rise	Flood risk; water infrastructure; use of coastal land	Coastal development trends, settlements and land use	Increasing vulnerability of lower coastal areas in the long term	Poor population and adaptation resources

The increased frequency of extreme events observed in all three regions of Montenegro has a negative impact on the economy, infrastructure, society, and environment of urban areas. Table 5.20 shows a summary of the climate impacts for urban areas.

TABLE 5.20:
Impacts of extreme events on water and natural resources, human health and infrastructure

Extreme events observed	EXPOSURE TO THE URBAN AREAS (ECONOMIC, INFRASTRUCTURAL, SOCIOLOGICAL, AND ENVIRONMENTAL DIMENSIONS)			
	Water resources	Human health	Infrastructure	Natural resources
Fewer cold days and nights; more frequent very warm days and night		Reducing the risk of frost mortality due to less of a cold day and night	Reduced heating requirements and increased cooling requirements; reduced transport interruptions due to snow and ice	
Heatwave frequency increase in all regions	Increasing the need for water; water quality problem; significant impact on the water aquifers of the coasts so that water is unusable in the summer because of the high concentration of chlorine ions	Increased risk of heat-related mortality in the elderly, chronic patients, pregnant women, children, socially vulnerable groups (Roma, displaced persons, outdoor workers, i.e. those who do not have adequate accommodation)	Power supply system crash due to higher power consumption; inadequate building materials/ insulation	The problem of irrigating urban greenery and parks causes them to dry up; Low yields in agriculture
Drought			Water shortage; reduction of hydroelectric power potential	Land degradation; yield reduction and damage; livestock mortality, reduced milk production; increased risk of fire followed by a decrease in air quality
Heavy rains leading to sudden flooding; increase in frequency and intensity in all regions	Adverse impacts on surface and ground water quality; water shortages can be mitigated	Respiratory problems; increased risk of mortality and infection, from injury	Difficult work or out of operation of the water supply and sewage system; interruptions in the regular functioning of transportation; insufficient sewerage capacity; increasing the risk of flooding	Yield damage; inability to cultivate land; increasing the risk of water erosion, especially in the area of torrential flows

The Climate Action Plan for Podgorica (2015)[1] has conducted a comprehensive analysis of the urban vulnerability to climate change for different groups and services (Secretariat for Spatial Planning and Environmental Protection, 2015). This is included in the box below.

[1] The Climate Adaptation Plan for Podgorica was prepared as part of the GIZ project Climate Change Adaptation in the Western Balkans (CCAWB). Available at: Climate Change Adaptation in the Western Balkans (CCAWB).

Vulnerability Assessment and Adaptation Action Plan in Podgorica

The Climate Action Plan of Podgorica (2016) presents a robust methodology for vulnerability of urban areas, which can be replicated in other urban areas. The vulnerability assessment was based on the combination of observed climate trends and hazards with climate projections. It identified which are the most vulnerable groups to climate hazards and their level of vulnerability. Particularly vulnerable groups (the young and old, the sick, workers who work outdoors), as well as the majority of socially vulnerable groups (Roma, displaced persons), have a high vulnerability to heat waves (especially in city centres) and heavy precipitation (accompanied by floods).

TABLE 5.21:
Assessment of climate vulnerability classes in Podgorica

Population	Heat wave	Extreme cold	Drought	Heavy precipitation/ Floods	Storm
Public health/ vulnerable groups	High	Medium	Low	High	Niska
Social infrastructure	High	Medium (Roma)	High	High	High (Roma)

The assessment as well evaluated the level of vulnerability of urban services. The electricity distribution system is very vulnerable under conditions of all extreme weather events, and so are social infrastructure facilities. Water supply systems and waste water channelling systems are particularly vulnerable in the case of heavy rainfall. The same situation is valid for transport, which has interruptions of regular functioning in the case of torrential rains and floods.

TABLE 5.22:
Assessment of the climate vulnerability of urban services in Podgorica

Infrastructure	Heat wave	Extreme cold	Drought	Heavy precipitation/ Floods	Storm
Transport	Medium	Medium	Medium	High	/
Electricity services	High	High	High	High	High
Sanitation services	Low	Low	Medium	High	Low
Water supply services	Low	Low	Low	High (Mareza)	Low

Droughts can have many effects on urban environments, including water and electricity shortages due to insufficient water in hydroelectric plants, diseases caused by poor water quality, and higher food costs. City parks, block and linear greenery, and forest parks are already highly vulnerable to droughts and heat waves with low adaptive capacity due to underdeveloped irrigation systems.

The impact of more frequent hot days and nights are expected to amplify the effects of heat islands in cities, which can cause health problems, increase air pollution, and increase energy demand for cooling (IPCC, 2014). Conversely, a fall in the number of cold days will reduce energy demand for heating purposes. Particularly vulnerable groups are the elderly, children, pregnant women, and socially disadvantaged groups.

Urban areas are particularly vulnerable to short-term heavy rains, which lead to sudden flooding and affect the infrastructure (e.g. bridges) and related services, such as transport, the electricity supply, sewerage, and the water supply, as well as the possible flooding of the shores of Lake Skadar. The data on short-term rainfall available in official documents refers primarily to daily rainfall, while the data on the intensities of shorter intervals has been produced for only a few cities in Montenegro. This makes it difficult to inform planning and management activities to adapt the urban water management system and services. Extreme rainfall is expected to occur more frequently in Montenegro, which would have multiple implications, for example for the design of different types of infrastructure, above all road and hydraulic, and spatial planning. The increased frequency of short-term heavy rainfall events will affect the capacity of large-scale drainage systems to effectively function. Many of the drainage systems were designed based on historical data on short-term rainfall intensities. The intensive and inadequately planned urbanization contributes to the increased risks of floods due to short-term heavy rain episodes. Urban pavement and infrastructure impedes the infiltration of rainwater run-off, which, combined with insufficient drainage system, results in the increased water in certain urban areas. (Walesh, 1989; Mays, 2004; Despotović, 2009; Cindrić et al., 2014).

Heat waves, on the other hand, have caused increased heat stress in the population, with a particularly negative impact on the health of vulnerable groups (the elderly, children, people with cardiovascular and heart diseases, and the mentally ill). In addition, a decrease in labour productivity, especially in agriculture, infrastructure, and construction, a reduction of other economic activities (trade, utilities), and increased consumption of electricity and water consumption have been recorded. Podgorica experienced several heat waves on an annual basis between 2003 and 2007, and then again between 2011 and 2014. During these periods, several records in maximum daily temperature at the national level were recorded (42.2° C in August 2003; 44.8° C in August 2007; and 44° C in August 2012). Also, during 2011 and 2012 the number of tropical days and tropical nights was higher than the climatological normal.

Adaptation measures for the urban areas

Urban areas need to increase their adaptive capacity and search for mechanisms to effectively adapt to climate hazards in the short, medium, and long term.

An analysis of the observed climate impacts shows that infrastructure development (including improving drainage and sewerage systems), improving city services, promoting long-term mitigation, adaptation, and poverty reduction are the most important factors to increase adaptation capacity in urban areas. Cooperation between the three regions needs to be developed through the exchange of experience in implementing adaptation measures in the field of urban management, control in planning and land use, strengthening the resilience of houses and buildings, and the use of domestic and foreign investment.

A key role in the planning and implementation of adaptation measures should be played by the local government. Tools such as Climate-ADAPT could be used in the planning process. This includes a wealth of information and data that is essential for adapting urban areas to climate change. Within Climate-ADAPT, there are also two tools specifically designed to assist in the decision-making process. One of them is focused on decision making (Urban Adaptation Support Tool – UAST) and the other involves maps with extreme events and their impact on Europe (Urban Adaptation Map Viewer).

Possible adaptation measures in the urban areas include planning and capacity-building measures, while others include more technology- and information-oriented responses (Table 5.23). This list does not yet include much detail on "hard" investment measures related to urban environments which are likely also to be useful but have not yet been properly scoped.

TABLE 5.23:
List of identified adaptation measures for urban areas

Type of adaptation measure	ADAPTATION MEASURES	Extreme temperature	Flood	Drought
POLICY AND INSTITUTIONAL STRENGTHENING MEASURES	Developing cooperation between the three regions through the exchange of experience in implementing adaptation measures	•	•	•
	Support local government in planning and implementing adaptation measures	•	•	•
TECHNICAL MEASURES	Improvement and development of infrastructure, above all drainage and sewerage systems		•	•
	Development of models and mechanisms for determining relevant characteristics of short-term rainfall for urban areas to support decision making and planning of water management structures supporting urban services.		•	

	Promote green infrastructure to decrease exposure to heat waves and floods	•	•	•
RESEARCH, INFORMATION AND CAPACITY-BUILDING MEASURES	An analysis of the quality of existing rainfall data in Montenegro, comparing estimates of expected short-term maxima from two shorter periods: 1961–1990 and 1991–2019		•	
	Analysis of the precipitation regime of short-term heavy rainfall in pilot areas in Montenegro, selected by regional distribution, quality of available data, and most commonly used for hydrological substrates in water abstraction calculations		•	
	Selection of methodological procedures for a comprehensive analysis of short-term, heavy rainfall in Montenegro, with focus on analysing climate change risks and impacts in the urban areas and considering the conditions for continuous checking and updating of ITP curves (rainfall–duration–return period)		•	
	Guidelines on the use of climate information such as projected short-term rainfall data.	•	•	•

CONSTRAINTS AND GAPS: TECHNOLOGY, FINANCIAL AND CAPACITY-BUILDING NEEDS AND SUPPORT RECEIVED

6

Montenegro has demonstrated progress in climate mitigation and adaptation, continuing such efforts to move towards meeting its obligations under the UNFCCC, which entail additional investments, technology, and capacity. While these needs can be partially covered by national resources (public and private), for Montenegro, as a country in transition, contributions from international cooperation are essential.

6.1 Climate finance

The need to prioritize climate financing in Montenegro arises, to a greater extent, from the scarcity of public and/or private resources to develop and support specific projects needed to comply with adaptation and mitigation targets under the UNFCCC. In addition to national budget funds, there is a range of funding sources that address climate change, such as international funds, grants, and loans that have low interest rates. Public institutions and organizations and local governments need support in accessing these funds to move towards a competitive, sustainable, low-carbon, and resilient economy, as stipulated in the National Climate Change Strategy.

To date, Montenegro has received support from the international community via different financial mechanisms, but predominantly in the form of loans and grants. Financial support from international organizations and knowledge transfer with other countries has enabled Montenegro to implement a series of climate change projects. Between 2014 and 2017, the state received Official Development Assistance (ODA) of more than €200 million from a number of partners for climate-change-related initiatives (OECD, 2017). The EU has been the principal source of donations, with a contribution of approximately 60% of all project funding. Together, the UN and GEF also contributed approximately 30% of the total funding through programmes and donations.

Investments in mitigation actions are far higher than investment for adaptation actions. Estimated financial investments for climate change projects between 2014 and 2017 are approximately €13 million on adaptation for the water, forestry, and agriculture sectors (see Figure 6.1), while for mitigation projects the investments have reached up to €187 million in the energy sector, transport and storage as well as banking and financial services (OECD–DAC, 2017)[1]. The majority of these funds come as loans or grants.

[1] Note that investments in the banking and financial services sector are often then lent on to customers of the banks for mitigation measures. The OECD–DAC statistics are available at: http://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm.

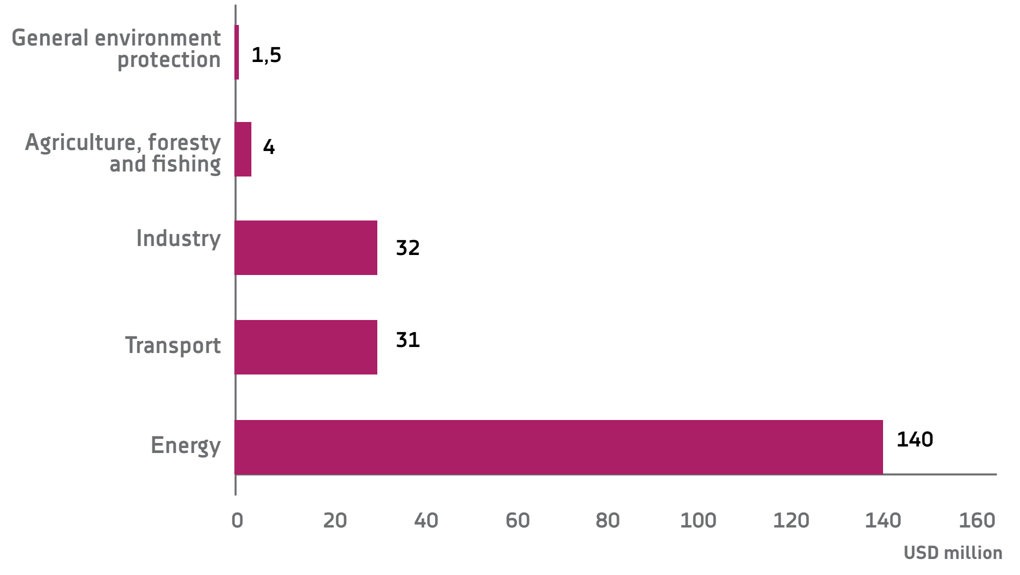


FIGURE 6.1 **Climate-related development finance for Montenegro (2014–2017)**

Source: OECD–DAC, 2017

Public debt stood at around 65% of GDP in 2017[2]and a recent round of bond issuance led to an interest rate on 10-year bonds of 2.55%[3]. This borrowing cost makes a number of investments feasible, although the relatively high debt-to-GDP ratio indicates that the authorities should be cautious about borrowing.

The Montenegro's Climate Change Strategy encourages the state to have a strong support for climate change financing through both providing financial incentives and participation in project financing, as well as through adequate policy making and implementation. Local governments are also in a position and need to contribute, within the limits of their competencies.

The mobilization of financial resources in the private sector is extremely important and can be implemented through, for example, public–private partnerships and through the creation of favourable investment conditions. The International Climate Funds and bilateral assistance are another channel for gathering some of the necessary to use climate change technologies. There are a number of private-sector investments in mitigation in particular which are occurring/have occurred in Montenegro. These are itemized in the chapter on mitigation.

[2] See http://www.mf.gov.me/ResourceManager/FileDownload.aspx?rId=308569&rType=2

[3] See https://www.bankar.me/2019/09/27/crna-gora-emitovala-500-miliona-eura-obveznica-na-medunarodnom-trzistu/

6.2 Technology transfer and needs

In Chapters 4 and 5, Montenegro lists the proposed and planned adaptation and mitigation actions, many of which require technologies (needs for new equipment, techniques, practical knowledge and skills, approaches, etc.). These technology needs require additional investments and capacity to support and accelerate their transfer and implementation in accordance with UNFCCC.

Article 4.5 of the UNFCCC urges developed country parties and Annex-II parties to take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other parties, particularly to developing countries, to enable them to implement the provisions of the Convention. As a non-Annex-I country, the Republic of Montenegro is eligible to use 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.

Montenegro's strategic framework envisages further investment in the continuous development of the energy infrastructure including pipelines, new transmission system facilities, upgrades of the existing transmission and distribution systems, support for entrepreneurship in the energy sector, and reductions in technical and technological losses in electricity generation and transmission/distribution. The BUR (2019) highlighted that investments in energy generation related to the hydroelectric potential of rivers could potentially ensure energy security and mitigate the effects of climate change. Furthermore, large investments in solar power and solar water heaters are envisaged as a part of the Technology Needs Assessment (see below).

Regarding energy efficiency, a number of activities have been launched through the Montenegro Energy Efficiency Projects (MEEP). In the area of energy efficiency technology, there is a need for further support for a reduction in energy consumption through the widespread use of 'smart' systems in consumption management and network technology.

6.3 Capacity-building needs

Montenegro's national strategic and legal frameworks make only limited reference to climate-change-related aspects. Sector-level policies and plans only loosely integrate climate risk considerations. The few sectors that have incorporated climate change into planning have only considered mitigation.

In its second Biennial Update Report (BUR) from 2019, Montenegro identified the main constraints as being the lack of a permanent and binding system for gathering and processing the data needed for its National Communications (NCs) and BURs and the lack of a system to sustainably monitor and support decision makers with regard to GHG trends, progress and options for mitigation actions. The absence of a national system for MRV also hinders the development of effective systems for coordinating and registering Nationally Appropriate Mitigation Actions (NAMA) and developing projects that present strong cases for investment. Thus, further limiting opportunities for Montenegro to seek action funding. Furthermore, given developments in processes and agreements under the Convention, the party needs to constantly improve its capacity, expertise, and skills to meet its national obligations. Montenegro is also encountering technological, financial, and capacity constraints when implementing its identified actions.

A 'Stocktaking Report' carried out a rapid capacity assessment in 2017, identifying the required capacity needs based on the United Nations Development Programme (UNDPs) and United Nations Institute for Training and Research (UNITARs) capacity development frameworks[4] (See Table 6.1).

TABLE 6.1:
Key capacity-building needs in Montenegro

SECTOR-SPECIFIC (TECHNICAL)	CORE ORGANIZATIONAL FUNCTIONS
ENABLING ENVIRONMENT	
– There is a need to strengthen the climate-related knowledge base and monitoring systems for sector-level implementation activities – Lack of awareness about climate change adaptation and linkages with existing programmes and activities	– Lack of clarity for institutional and operational arrangements for the working group on adaptation – The existing administrative/technical capacity for reporting to the UNFCCC is insufficient – Level of understanding of sector-based climate impact and vulnerability
ORGANIZATIONAL	
– Almost no awareness of adaption fundamentals – Limited understanding of current capacities and climate change adaptation needs at the local level – Insufficient information about sector-specific climate impacts and their economic implications as well as an apparent deficit in climate-related economic analysis, including damage and loss analysis, especially at the local level	– The climate-related participatory decision making and stakeholder input processes for managers and decision makers are unclear – There is no platform for information sharing regarding climate change and adaptation in Montenegro – Fragmented and outdated vulnerability and risk assessments – Limited cross-sector collaboration on climate adaptation programming at the national and sub-national levels

[4] UNDP (2008) UNDP Capacity Assessment Methodology User's Guide. UNDP: NY, USA; UNDP. 2010. Capacity Development – Measuring Capacity. UNDP: NY, USA; and Mackay A. et al. 2015. Skills Assessment for National Adaptation Planning – How Countries Can Identify the Gap. UNITAR: Geneva, Switzerland.

– There is no climate-related focal person (or department) in each sector – There is a need for ToT programmes in climate change fundamentals for national training institutions and selected sector staff to improve sector-level capacities	– A strong need to harmonize techniques for climate related data collection, analysis, and documentation and to improve utilization processes – Limited collaboration mechanisms within and between sectors at all levels – There is a need for university-level climate-related national curriculum development to increase and sustain professional inputs across all sectors – Gaps in the availability and communication of hydrometeorological risk information, especially at the local level
INDIVIDUAL	
– Language barriers prevent staff access to relatively low-cost knowledge and training; further limiting the pool of qualified staff available to attend international training	– Deficit in the required trained personnel (numbers and expertise) to meet climate-related and adaptation-related challenges and functions

Montenegro has been granted significant capacity-building and technical assistance for a number of programme, projects, and partnerships by the following donors: the European Commission, UN Agencies, the World Bank, EBRD, GEF, GCF, GiZ, EIB, KfW, LuxDev, ADA, the Governments of Italy, Germany, Luxembourg, Austria, Norway, the Netherlands, Greece, etc. (See Table 6.2 for a non-comprehensive list of assistance programmes). The greatest share has been provided by the European Commission and the UN Agencies, who have supported projects, workshops, studies, initiatives, and specific programmes of considerable impact regarding overall capacity strengthening and technical assistance.

For the preparation of this National Communication, Montenegro received support from the Global Environment Facility via UNDP. Another noteworthy technical assistance programme relevant to the National Communication itself is the Environment and Climate Regional Accession Network (ECRAN) which, from 2013 to 2015, provided support in the form of training, and of the Union for Mediterranean Climate Change Expert Group (UfMCCEG). ECRAN promoted regional cooperation between EU candidate countries on environment and climate action. Training activities attended by Montenegro under ECRAN were selected with the aim of facilitating the drafting of reports (NCs and BURs), the modelling and defining of NAMA project ideas and the drafting of climate change policies.

In 2016, the Government of Montenegro adopted the National Strategy with Action Plan for Transposition, Implementation, and Enforcement of the EU acquis on the Environment and Climate Change 2019–2023[5]. The aim of this strategy is to strengthen the capacities of relevant institutions regarding climate change.

[5] http://www.mrt.gov.me/ResourceManager/FileDownload.aspx?rId=281718&rType=2.

Montenegro is also currently part of the Regional Implementation of the Paris Agreement Project (RIPAP) which focuses on capacity building and support for participating countries for implementing the 2015 Paris Climate Agreement. Support through RIPAP includes support in preparing technical reports and documents, capacity-building activities such as workshops and seminars, and ad-hoc assistance. Outcomes include the upgrading of national greenhouse gas monitoring and reporting systems and practices and strengthening of MRV activities.

6.4 Progress towards reducing constraints

Over recent years there has been an evident increase in the volume of investment in energy infrastructure development. Recent major investments have provided support for (amongst other areas):

- Transboundary flood risk management
- Green business growth
- Reconstruction of existing hydroelectric power plants (HPPs)
- Construction of new wind power plants and HPPs
- Introduction of Best Available Technologies at KAP
- 'Smart' electricity meters

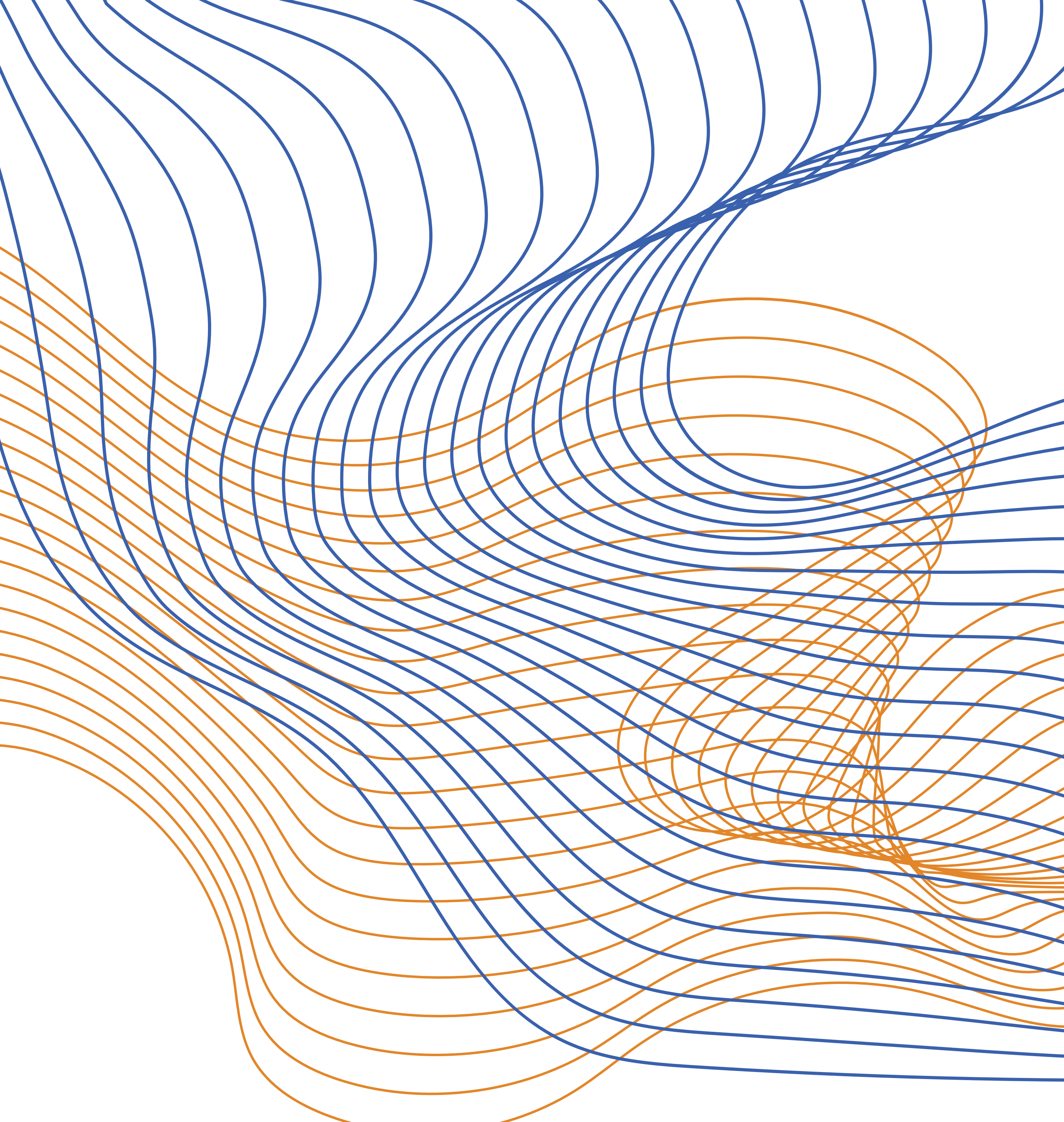
The development of renewable energy sources has been set as a priority for the forthcoming period in line with international obligations.

The total number of projects relating to climate change is likely to be higher than the number put forward in Table 6.2 below.

TABLE 6.2:
Summary of adaptation and mitigation projects in Montenegro between 2012 and 2020

NAME OF PROJECT	YEAR	IMPLEMENTING AGENCY	FUNDING AGENCY	DESCRIPTION	SECTORS
CROSS CUTTING PROJECTS					
NDA Strengthening and Country Programming support for Montenegro	2016–2017	*UN Environment*	*GCF*	The grant's objective was to prepare a country programme including Montenegro's development priorities with respect to the Green Climate Fund, consistent with the country's national environmental, waste management, industrial, agricultural and energy strategies, and the Fund's initial results management framework.	*Cross-cutting*
ADAPTATION PROJECTS					
Adaptation to Climate Change through Transboundary Flood Risk Management in the Western Balkans	2012–2021	*Ministry of Sustainable Development and Tourism /GIZ*	*BMZ*	The project's focus was on transboundary flood risk management to address climate change impacts. It works in three key areas: flood hazard and risk mapping; early warning; and institutional development.	*Water sector*

Programme for Disaster Risk Assessment and Mapping (IPA DRAM) (regional)	2016–2019		*European Commission*	The project's objective was to improve effective, coherent and EU oriented national systems for disaster loss data collection, risk assessment and mapping, and alignment and integration into the Union Civil Protection Mechanism.	*Disaster risk reduction*
Climate change adaptation in the Western Balkans	2013–2015	*GIZ*	*BMZ*	The project's objective was to offer mechanisms for increasing capacities to adapt to climate change. It resulted in the elaboration of a "Vulnerability assessment and adaptation action plan for Podgorica".	
Capacity Building for Environmental Policy Institutions for Integration of Global Environment Commitments in Montenegro	2010–2014	*Government of Montenegro /UNDP*	*GEF*	The project's focus was on developing national capacities for improved management and implementation of the three Rio Conventions by developing global environmental management indicators as part of the Montenegro's environmental governance regime.	*Infrastructure / climate risk management*
MITIGATION PROJECTS					
Energy Efficiency Project (MEEP)	2018–2023	*Ministry of Health*	*International Bank for Reconstruction and Development (IBRD)*	The project's objective is to improve energy efficiency in health-sector buildings, and to develop and demonstrate a sustainable financing model.	*Energy sector*
Towards Carbon-Neutral Tourism	2013–2017	*Ministry of Sustainable Development and Tourism /UNDP*	*GEF*	The project objective was to reduce GHG emissions from Montenegro's tourism by promoting adoption of low-carbon policies and regulation in the sector, implementing flagship investment projects in low-carbon tourism infrastructure, establishing sustainable financing mechanisms, and raising awareness among relevant stakeholders – the tourism, private, and public sectors.	*Tourist sector*
Policy, Macro-Economic Assessments and Instruments to Empower Governments and Business to Advance Resource Efficiency and Move Towards a Green Economy	2010–2015	*UN Environment*	*GEF*	The project's focus was on providing the economic case for investing in the sectors of agriculture, forest, fisheries, tourism, water, waste, renewable energy, and transport.	*Private sector*
Growing Green Business in Montenegro	2017–2020	*Ministry of Sustainable Development and Tourism /UNDP*	GEF	The project's objective is to promote private sector investment in low-carbon and green businesses via a combination of policy de-risking and financial de-risking instruments. Overall, the project will stimulate low-emission economic growth and green job creation in Montenegro.	*Investment sector*
Regional Energy Efficiency Programme (REEP)	2012–2020	*EBRD, Energy Community Secretariat*	European Commission, EBRD, CEB, EIB	REEP has had a number of support windows including currently: • Policy dialogue and project preparation support • A credit line facility window (WeBSEFF II) • A direct financing facility window (WeBSEDFF) for investment in both medium-scale renewable energy and energy efficiency improvements in industrial enterprises, and ESCO financing	*Policy and investment sectors*



ANNEXES

ANNEX 1

TABLE SUMMARIZING THE MITIGATION MEASURES

	Mitigation measures according to WEM scenario (With Existing Measures)
	Mitigation measures according to WAM scenario (With Additional Measures)

ID	NAME	SCENARIO	IMPLEMENTATION TIMEFRAME	EU ETS	BUDGET EUROS)	Potential for annual CO_2eq reduction in 2030	NOTE
Energy – stationary combustion							
1E	Eco upgrade of the thermoelectric power plant, block 1	WEM	2020–2021	Yes	€65m	221 Gg	The eco upgrade is planned to start shortly. This will entail the plant being out of operation for four months each year in 2020 and 2021. It is then envisaged that there will be a reduction in generation due to low market prices and then as a result of the ETS from 2025
2E	New renewable power plants (WEM)*	WEM	2020–2030	No	€766m	21 Gg	It is assumed that the new renewable power plants that cover the country's electricity deficit will have no impact on GHG emissions. The electricity generation from new renewable power plants will only contribute to a GHG emission decrease once there is no electricity deficit.
3E	District heating in Pljevlja	WEM	2022–2030	No	€23m	12 Gg	This measure will be implemented following the TPP eco upgrade
4E	Development and implementation of energy efficiency regulatory framework in buildings	WEM	2020–2025 (estimate)	No	Negligible	155 Gg	This measure has a major impact on the existing buildings refurbishment, as all refurbished buildings must meet the minimum requirements. The estimated energy savings are presented in the NEEAP
5E	Increased energy efficiency in public buildings	WEM	2020–2030	No	€70m	23 Gg	The goal of this measure is to improve energy efficiency and comfort conditions in selected public sector buildings. €70m will be invested in various phases starting in 2020.
6E	Financial incentives for citizens (for EE investments)	WEM	Current to 2030	No	€1.3m	4 Gg	The objective of this measure is to make financial support mechanisms available to individuals for investing in energy efficiency and renewables. It includes an introduction of dedicated state and local government support programmes.

* These include: New turbine-generator unit G8 in Perućica Hydroelectric Power Plant (HPP), reconstruction of Piva HPP, reconstruction of old small HPPs, construction of small HPPs, Gvozd Wind Power Plant (WPP), Brajići WPP, Briska Gora Solar Power Plant (SPP) and Biomass sTPP.

7E	Energy labelling and eco-design requirements for energy related products	WEM	2020–2030	No	€14 m	288 Gg	In order to provide conditions and practices for the labelling and eco-design requirements of devices, an appropriate legal framework is already in place obliging market players to place certain products on the market. The estimated energy savings are presented in the NEEAP.
8E	Establishing and implementing energy efficiency criteria in public tendering	WEM	2020–2030	No	Negligible	9 Gg	The main objective of this measure is to establish systematic mechanisms for introducing energy-efficiency criteria in the public procurement process, in order to achieve significant energy savings and achieve economic and other benefits. The implementation of this measure is one of the preconditions for meeting the requirements for environmental protection.
9E	Implementation of EE measures in public municipal companies	WEM	2020–2024	No	Approx. €5.12m	12 Gg	This includes public lighting, water supply and sewerage, and other utilities
10E	Development of transmission and distribution power grid (decrease of losses)	WEM	2020–2030	No	Approx. €704m	54 Gg	Montenegrin grid operators will invest in the grid in order to accommodate new consumers and power plants. This will result in a reduction in grid electricity losses
11E	Refurbishment of hydroelectric power plants (increased EE)	WEM	2020–2022	No	Approx. €48m	10 Gg	The energy savings corresponding to this measure are achieved by replacing existing, outdated electrical and mechanical equipment (the currently available power transformers are characterized by higher efficiency due to higher regulatory requirements).
12E	New renewable power plants (WAM)	WAM	2025–2030	Yes	Approx. €1,512m	381 Gg	This measure introduces additional renewable power plants which are not currently in the definite plans. The following are included: Morača HPP, Komarnica HPP and Velje Brdo SPP. The GHG reductions and costs include the WEM element.
Energy – mobile combustion							
1T	Electric cars (WEM)	WEM	2020–2030	No	Approx. €381m	23 Gg	It is assumed that 13,000 electric cars will replace diesel cars.
1T	Electric cars (WAM)	WAM	2020–2030	No	Approx. €622m	38 Gg	This scenario assumes 21,000 electric cars. The GHG reductions and costs include the WEM element.

Industrial processes and product use							
ID	NAME	SCENARIO	TIMEFRAME	EU ETS	BUDGET	Potential for CO_2	NOTE
1IP	Uniprom KAP: Electrolysis cells replacement and overhaul (2020–2024) and ETS (2025–2030) (WEM)	WEM	2022–2026 and impact of ETS 2025–2030	Yes	Approx. €26m	43 Gg	Currently 155 out of 264 cells are in operation, while the remaining cells have to be either overhauled or replaced by 2024, when electrolysis plant will achieve full capacity of liquid metal production. The WEM scenario has envisaged all the technological improvements on the electrolysis cells.
2IP							In the WAM scenario, decreased PFCs occur due to F-gas capturing from all cells and results in almost 100% of PFC captured and at the same time electricity consumption savings (5.5%). According to the installation business plan, they envisaged investing in PFC-capturing technology in all cells (approximately 33 cells per year), starting in 2022. In such a case, by 2030, all the cells will be covered, so zero PFCs will occur in the electrolysis plant. The estimated GHG reductions and associated costs are included the WEM element.
ID	NAME	SCENARIO	IMPLEMENTATION TIMEFRAME	EU ETS	BUDGET EUROS)	Potential for annual CO_2eq reduction in 2030	NOTE
Agriculture							
1A							
2A			2020–2030		€6m	9 Gg	The change of manure management system does not only affect the direct N_2O emissions, but also the methane emission (more anaerobic systems emit less N_2O but more CH_4). The figure provided relates to general improvements to the agriculture sector to reduce GHG emissions

Land use, land use change and forestry							
1L	Limitation of harvest amounts in state-owned and private forests	WAM	2020–2030	No	N/A	Increase of 37 kt CO_2 per year by 2030	Limitation of harvest amounts to 1,575,000 m^3/year, of which 1,195,000 m^3 are in state-owned forests and 380,000 m^3 are in private forests, or 28.6% more in 2023 than in 2010. Therefore the limit is higher than historical levels.
2L	Reduction in the area annually affected by wildfires	WAM	2020–2030	No	Not estimated	717 Gg	Wildfires are a key source of GHG emissions. Enhanced fire protection was defined as part of Objective 1 in the NŠS; however, there is no evidence of less wildfire-affected areas, while the salvage volume from post-fire periods did not change the trend over the last few years. So, efforts are still needed to implement this measure.
3L	Further increases in the share of industrial roundwood used for long-term products	WAM	2020–2030	No	Not estimated	0.06 Gg	As a consequence of increasing the harvest, it seems meaningful that there would be a 30% increase in the amount of "Industrial roundwood" used for long-term products. This means an increase from a share of 20% in total regular harvest in 2010 to 40% in 2023.
Waste							
1W	Reduce the share of bio-waste in municipal waste:	WEM	2020–2030	No	Not known	144 Gg	Projected waste treatment pathways have been developed under a WEM scenario, dependent upon the treatment pathway of biogenic waste
1W	Reduce the share of bio-waste in municipal waste + additional diversion to recycling/ composting	WAM	2020–2030	No	Not known	170 Gg	The WAM scenario assumes that there is an additional effort to divert waste, specifically to recycling and/or composting. Note, the GHG savings include the WEM element.

ANNEX 2

MONTENEGRO'S REDD+ POSSIBILITIES

Introduction

Recognizing the potential role of forests in contributing to climate change mitigation, REDD+ is a mechanism under the UNFCCC for reducing emissions from deforestation and/or forest degradation, while supporting the conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks. Under the UNFCCC, non-Annex-I countries would benefit from results-based payments. However, in the context of Montenegro, currently a non-Annex-I party but in the process of joining the European Union, it is fundamental to understand the rules where the reduction of emissions and enhancement of absorption of GHG in forests will stand in the short and medium term.

A note on terminology, the approach detailed under the UNFCCC is commonly referred to as 'reducing emissions from deforestation and forest degradation', often abbreviated as REDD+. Formally, the mechanism was originally dubbed 'reducing emissions from deforestation in developing countries' or REDD. However, this was extended to 'reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries' or REDD+. Throughout this section, the mechanism will be referred to as REDD+ for simplicity.

In its simplest form, REDD+ is a vehicle to provide technical and financial support for the reduction of emissions and enhancement of GHG removal at the national level through a host of forest management options. Since its inception in 2005 at the 11th session of the Conference of the Parties to the Convention (COP), the concepts behind REDD+ have been developed through decisions at successive COPs, ultimately leading to the formulation of the Warsaw Framework for REDD-plus, developed at COP 19.

Montenegro's REDD+ eligibility

Montenegro's eligibility for funding via results-based payments under the REDD+ mechanism is not altogether clear according to the verbiage of the legal framework outlined in the relevant decisions. The text on REDD+ mechanisms consistently refers to 'developing countries'. However, according to the UN report on the 'World Economic Situation and Prospects 2019', Montenegro is defined as a country with an 'economy in transition'. This suggests that Montenegro is not the intended recipient of such a mechanism. There is also a lack of precedent for engaging with REDD+ programmes through multilateral channels in countries outside of Africa, Asia-Pacific, Latin America, and the Caribbean. For example, the UN-REDD Programme Collaborative.

However, there is some evidence of bilateral support for REDD+ activities in countries outside of Africa, Latin America, and Asia-Pacific, including for countries with 'economies in transition'. Up to 2010, Germany allocated US$261 million through bilateral projects Workspace lists 65 partner countries, exclusively from these regions Forest Carbon Partnership Agreement (FCPA), a World Bank-led initiative, lists support for 47 developing countries located in subtropical or tropical regions across Africa, Latin America, and Asia-Pacific – with over 20 developing countries including Armenia, Azerbaijan, and Russia.

Additionally, Montenegro was recently included in a survey run by the Green Climate Fund (GCF) on countries' progress under REDD+. According to that survey, Montenegro has begun to prepare a national forest monitoring system, though it has not started to develop any of the other elements required for engagement with the REDD+ mechanism. This may also be a reason for the lack of engagement with multilateral funding channels for REDD+ activities such as the UN-REDD Programme and FCPA to date.

This suggests that whilst the remit of many multilateral channels supporting REDD+ activities focuses on tropical or subtropical countries in Asia-Pacific, Africa, Latin America, and the Caribbean, there may be opportunities for Montenegro to secure funding through other channels. Securing REDD+ funding through established multilateral channels may also hinge on the development of the elements supporting national engagement with REDD+ such as the national strategy, FRL, NFMS, and safeguarding information.

Another key factor that may play a large role in Montenegro's access to funding under REDD+ is EU accession. Given the EU's involvement in funding REDD+ opportunities, it would seem contradictory that a party could be part of the EU and receive funding under REDD+. However, no clear guidance on this matter has been found. This aspect should be further discussed as part of the EU accession negotiations should Montenegro engage with the REDD+ mechanism.

ANNEX **3**

KEY INSTITUTIONS INVOLVED IN MONTENEGRO'S MRV SYSTEM

INSTITUTION NAME	RESPONSIBILITIES
NATIONAL COUNCIL FOR SUSTAINABLE DEVELOPMENT AND CLIMATE CHANGE AND INTEGRATED COSTAL MANAGEMENT (NATIONAL COUNCIL)	The National Council should play a central role in engaging ministries in the Climate Change Action MRV system on adaptation and mitigation. The National Council can support MSDT DCC by establishing strong institutional arrangements for data gathering. It should also provide a forum for MSDT DCC to present the main findings and outputs from the MRV systems on progress with climate change action, key vulnerabilities, and risks to ministries and decision makers. This engagement can then be used for Montenegro to take on board key messages for sector-level decision making and strategies.
DIRECTORATE FOR CLIMATE CHANGE (DCC), MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM	The DCC will take the leading role in engaging wider stakeholders including the Council. The DCC will be involved in all training activities, overseeing the quality of the MRV system's data, using the MRV system's data and tools to build climate awareness and play a key role in the collection and integration of data. This includes enabling the flow of data, assumptions, and perspectives on mitigation and adaptation from sector leads. As the key managers and coordinators of the MRV system, the DCC's technical experts will be key to making the system and platform user-friendly and keeping it up to date.
NATURE AND ENVIRONMENTAL PROTECTION AGENCY (EPA)	The EPA oversees the GHG inventory development and will take the lead for the compilation of projections with data supplied by DCC. The EPA's expertise, systems, and tools will be an important part of the overall MRV system. The EPA will be responsible for designing its data collection, analysis, and QA/QC systems and for recruiting and training its own (and potentially other institutions') experts. The EPA will also contribute to the building of awareness of the National Council and other bodies on GHG trends, indicators, and reports. The new Law on Protection Against Adverse Impacts of Climate Change was adopted by the Government in October 2019, and is currently in the procedure for adoption in Parliament.

STATISTICAL OFFICE OF MONTENEGRO (MONSTAT)	MONSTAT is the institution in charge of producing Montenegro's official state statistics. MONSTAT collects, processes, and disseminates high-quality, transparent statistics in accordance with contemporary European standards*. A wide range of data and statistics is produced by MONSTAT (including GDP, the annual energy balance, and environmental surveys) which can be used by the Government, scientific research institutions, citizens, and the media. Due to its significant reach to generate data on a national level, it will be the main partner to process and supply data for GHG inventory calculations.
INSTITUTE FOR HYDROMETEOROLOGY AND SEISMOLOGY (IHMS)	The IHMS has a network of observation stations which measure meteorological, hydrological, ecological, and agrometeorological parameters. Weather stations, for example, constantly measure parameters such as air temperature, pressure, humidity, precipitation quantity, wind speed and direction, and insolation. The institute is responsible for maintaining and enhancing this network of stations and for archiving their measurements. Their research activities include analysis of the data, utilizing numerical models over short time ranges (up to 5 days) to produce weather forecasts, and the production of relevant studies (e.g. evaluation of soil, water, and air quality on the territory of Montenegro)**.
INSTITUTE FOR MARINE BIOLOGY, UNIVERSITY OF MONTENEGRO	The Institute for Marine Biology is one of three scientific research institutes at the University of Montenegro. The research conducted at this institute spans a range of sectors, including fishery biology, aquaculture, environmental protection, and sustainable development***. The researchers also have an active role in coastal adaptation projects.
DIRECTORATE FOR ENERGY AND ENERGY EFFICIENCY, MINISTRY OF THE ECONOMY	The Directorate should be the main source of official strategic assumptions on energy production and consumption in the future, as well as historical data on energy production and consumption. The Directorate will also be responsible for implementing the EU's Energy and Climate Union. This is a new regulation that will cover the five pillars of: Energy Security; Decarbonization; Energy Efficiency; Energy Markets and Electricity Connectivity; and Energy Research and Development. Strategies for this implementation will require investment in energy modelling which will need to include input material for GHG projections.

* http://www.monstat.org/eng/page.php?id=2

** http://www.meteo.co.me/.

*** http://www.ciesm.org/online/institutes/inst/Inst160.htm

	The Department for Energy Efficiency should collect detailed information on energy efficiency projects in Montenegro. This information is reported via their quarterly Implementation Plan, sent to the EU. This system collects information on energy efficiency actions including carbon savings and financial data (though not where investments are coming from). This information should be made available to the DCC and summarized (e.g. grouping projects such as individual hydroelectric plants under one action) in order to allow DCC to present it in the climate change action MRV system and its reports. The Ministry of the Economy should share (where possible) reports and data related to the progress of their projects and to engage the DCC in the design and use of the data collection systems it will be using.
DIRECTORATE FOR INDUSTRY AND ENTREPRENEURSHIP, MINISTRY OF THE ECONOMY	The Directorate for Industry and Entrepreneurship oversees the country's industrial policy and will be important in designing industrial policy and innovative responses to GHG mitigation and adaptation challenges. This Directorate will need to contribute to and review assumptions on future industrial consumption, production, and economic trends and projections. It may also provide information on the performance of industry to date and statistics on industrial production and consumption. It will also oversee industry's response to the GHG mitigation needs of the NDC and other national GHG mitigation targets. This Directorate is also likely to oversee the expected emissions from facilities under the EU's Industrial Emissions Directive and be able to provide information on industry's expected response to this directive.
DIRECTORATE FOR AGRICULTURE, MINISTRY OF RURAL DEVELOPMENT AND AGRICULTURE	The Directorate for Agriculture oversees the country's agricultural policy and will be important in designing agricultural policy and responses to GHG mitigation and adaptation challenges. This Directorate will need to contribute to and review assumptions on future agricultural production and economic trends and projections. It may also provide information on the performance of agriculture to date and statistics on agricultural production and consumption. It will also oversee agriculture's response to the GHG mitigation needs of the NDC and other national GHG mitigation targets. The Ministry of Agriculture and Rural Development is responsible for sector-level agriculture policies that are the subject of the Effort Sharing Decision.

DIRECTORATE FOR FORESTRY, MINISTRY OF RURAL DEVELOPMENT AND AGRICULTURE	The Directorate for Forestry, of the Ministry of Rural Development and Agriculture, oversees the country's forestry policy and will be important in designing forestry policy and responses to GHG mitigation and adaptation challenges. This Directorate will need to contribute to and review assumptions on future forestry production and economic trends and projections. It may also provide information on the performance of forestry to date and statistics on forestry production and consumption. It will also oversee forestry's response to the GHG mitigation needs of the NDC and other national GHG mitigation targets. The Directorate for Forestry and the Ministry of Agriculture and Rural Development are responsible for the sector-level agriculture policies that are the subject of the EU's upcoming LULUCF Regulation.
DIRECTORATE FOR WASTE MANAGEMENT AND COMMUNAL DEVELOPMENT, MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM	The Directorate for Waste Management and Communal Development, which oversees the country's waste policy, will be important in designing waste policy and responses to GHG mitigation and adaptation challenges. This Directorate will need to contribute to and review assumptions on future waste disposal strategies, including the regulation of solid and liquid waste facilities under the EU's Industrial Emissions Directive. It will also oversee waste response to the GHG mitigation needs of the NDC and other national GHG mitigation targets. The Directorate for Waste Management and Communal Development also provides the Ministry of Finance with all financial information for its waste projects.
DIRECTORATE FOR EU INTEGRATION AND INTERNATIONAL COOPERATION, MINISTRY OF SUSTAINABLE DEVELOPMENT AND TOURISM	The Directorate for EU Integration and International Cooperation oversees the country's climate change finances, including GEF and GCF, and acts as the focal point of the Adaptation Fund. It will be important in understanding the financial flows necessary to implement GHG mitigation and adaptation options. This Directorate will help to indicate if certain GHG mitigation actions will receive funding and their implementation status for consideration in the projections.
MINISTRY OF FINANCE	The Ministry of Finance also has relevant data on budget spending from the national budget. This Ministry has information on the amount of funding available for climate change projects and can open dedicated accounts for individual projects.
MINISTRY OF TRANSPORT AND MARITIME AFFAIRS AND MINISTRY OF INTERNAL AFFAIRS	Ministry of Transport and Maritime Affairs and the Ministry of Internal Affairs are responsible for sector-level transport policies that are the subject of the Effort-Sharing Decision and policymaking and legislation, regulating terms and conditions for the placement and use of cars and vans.

	These will be important inputs for the GHG inventory and projections, and need to be considered in combination with the projected energy demand balances for transport which will be the responsibility of Directorate for Energy, of the Ministry of the Economy.
THE ACCREDITATION BODY OF MONTENEGRO	The Accreditation Body of Montenegro is Montenegro's competent body for accreditation and for bilateral and multilateral agreements on mutual recognition and the recognition of foreign licences. The Accreditation Body of Montenegro is responsible for the accreditation of laboratories to measure fuel quality and measurement related to ozone layer protection and fluorinated gases. This body will be important for defining and supporting Montenegro's measurement activities and the generation of country-specific emission factors for its GHG inventory.
INSTITUTE FOR PUBLIC HEALTH (IPH)	The institution in charge of public health will be important in gathering, managing, and sharing information on the health-related impacts of climate change and the positive and potentially negative impacts of climate change actions. The IPH's experts will need to be trained in data quality improvement, evaluation, monitoring, and reporting of adaptation actions relating to public health. This includes working with the IHMS on early warning systems and strengthening links between climate change action and air quality. The institute sees a need to educate the media to communicate climate change and, broadly, environmental issues. The Institute would like to use materials such as leaflets that have already been produced and used as an example in the UK. The Institute of Public Health will start to share data on health-related impacts and actions with the DCC and IHMS.
DIRECTORATE FOR EMERGENCY SITUATIONS, MINISTRY OF INTERNAL AFFAIRS	The Directorate has reporting obligations related to the SDGs and the Sendai Framework. It is working to classify climate-related hazards and related data that can be useful for tracking action. The Disaster Risk Reduction Strategy Action Plan was approved in March and will provide some material relevant to climate adaptation actions. In 2018, the Directorate will be working on a database on damage and loss, with UNDP support. This database will be useful for the MRV of climate change impacts and should be incorporated into and summarized by the MRV system.

DIRECTORATE FOR EMERGENCY SITUATIONS, MINISTRY OF INTERNAL AFFAIRS	The Directorate has reporting obligations related to the SDGs and the Sendai Framework. It is working to classify climate-related hazards and related data that can be useful for tracking action. The Disaster Risk Reduction Strategy Action Plan was approved in March and will provide some material relevant to climate adaptation actions. In 2018, the Directorate will be working on a database on damage and loss, with UNDP support. This database will be useful for the MRV of climate change impacts and should be incorporated into and summarized by the MRV system.

ANNEX 4

ADDITIONAL INFORMATION FROM THE GREENHOUSE GAS INVENTORY

A4.1 Emissions from the energy sector

GHG EMISSIONS FROM ENERGY SECTOR BY GAS

TABLE A4.1:
CO_2 emissions from energy sectors and subsectors for 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995
1 – Energy	2214.38	2334.02	1685.36	1462.80	1323.82	709.34
1A – Fuel combustion	2214.38	2334.02	1685.36	1462.80	1323.82	709.34
1A1 – Energy industries	1406.22	1365.23	1069.17	973.74	808.90	164.62
1A2 – Manufacturing industries & construction	275.61	392.60	256.13	193.49	204.39	199.98
1A3 – Transport	337.58	389.85	245.55	190.25	212.10	227.77
1A4 – Other sectors	176.44	164.64	105.13	99.05	92.17	107.57
1A5 – Non-specified	18.53	21.70	9.40	6.26	6.26	9.40
CATEGORY	1996	1997	1998	1999	2000	2001
1 – Energy	1730.22	1749.95	2161.77	2230.59	2325.19	1928.40
1A – Fuel combustion	1730.22	1749.95	2161.77	2230.59	2325.19	1928.40
1A1 – Energy industries	1094.73	1092.19	1386.25	1367.48	1489.66	1156.80
1A2 – Manufacturing industries & construction	238.82	198.65	180.69	177.33	174.17	186.82
1A3 – Transport	280.89	296.30	416.49	507.94	508.30	442.06
1A4 – Other sectors	106.38	141.83	149.29	153.13	124.88	123.93
1A5 – Non-specified	9.40	20.98	29.04	24.71	28.19	18.79

CATEGORY	2002	2003	2004	2005	2006	2007
1 – Energy	2410.14	2305.68	2290.60	2089.36	2225.84	2175.99
1A – Fuel combustion	2410.14	2305.68	2290.60	2089.36	2225.84	2175.99
1A1 – Energy industries	1687.39	1596.94	1530.82	1117.62	1267.04	1000.30
1A2 – Manufacturing industries & construction	187.87	159.99	169.47	437.25	426.21	456.49
1A3 – Transport	360.49	376.73	427.26	400.53	425.10	519.85
1A4 – Other sectors	145.26	143.83	141.36	105.77	85.85	171.16
1A5 – Non-specified	29.13	28.19	21.70	28.19	21.65	28.19
CATEGORY	2008	2009	2010	2011	2012	2013
1 – Energy	2772.76	1859.80	2588.11	2624.73	2543.61	2283.94
1A – Fuel combustion	2772.76	1859.80	2588.11	2624.73	2543.61	2283.94
1A1 – Energy industries	1523.15	820.91	1724.03	1763.47	1763.19	1505.30
1A2 – Manufacturing industries & construction	452.90	169.61	83.19	51.90	42.89	74.78
1A3 – Transport	593.58	692.24	606.02	653.38	631.32	603.67
1A4 – Other sectors	178.07	148.85	143.54	149.73	99.94	28.85
1A5 – Non-specified	25.05	28.19	31.32	6.24	6.26	71.34
CATEGORY	2014	2015	2016	2017		
1 – Energy	2191.65	2332.61	2141.52	2241.78		
1A – Fuel combustion	2191.65	2332.61	2141.52	2241.78		
1A1 – Energy industries	1458.72	1524.30	1224.37	1259.48		
1A2 – Manufacturing industries & construction	145.89	178.33	188.40	211.21		
1A3 – Transport	525.85	562.63	663.50	713.14		
1A4 – Other sectors	61.19	67.35	65.25	57.94		
1A5 – Non-specified	0.00	0.00	0	0		

TABLE A4.2:
CH_4 emissions from energy sectors and subsectors for 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996
1 – Energy	4.19	3.60	3.67	4.22	3.27	3.74	3.42
1A – Fuel combustion	2.34	2.04	2.13	2.30	1.64	1.84	1.79
1A1 – Energy industries	0.02	0.02	0.02	0.01	0.01	0.01	0.01
1A2 – Manufacturing industries & construction	0.01	0.02	0.01	0.01	0.01	0.01	0.01
1A3 – Transport	0.11	0.12	0.08	0.06	0.06	0.07	0.08
1A4 – Other sectors	2.19	1.88	2.01	2.21	1.55	1.75	1.68
1A5 – Non-specified	0.00	0.00	0.00	0.00	0.00	0.01	0.00
1B – Fugitive emissions from fuels	1.85	1.56	1.54	1.92	1.63	1.90	1.63
1B1 – Solid fuels	1.85	1.56	1.54	1.92	1.63	1.90	1.63
CATEGORY	1997	1998	1999	2000	2001	2002	2003
1 – Energy	4.15	3.94	4.08	4.07	3.46	5.52	4.76
1A – Fuel combustion	2.74	2.54	2.67	2.71	2.30	3.24	3.36
1A1 – Energy industries	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1A2 – Manufacturing industries & construction	0.01	0.01	0.01	0.01	0.01	0.01	0.01
1A3 – Transport	0.09	0.13	0.15	0.13	0.11	0.08	0.10
1A4 – Other sectors	2.60	2.38	2.48	2.54	2.15	3.11	3.21
1A5 – Non-specified	0.01	0.01	0.01	0.01	0.01	0.01	0.02
1B – Fugitive emissions from fuels	1.41	1.39	1.42	1.36	1.16	2.28	1.41
1B1 – Solid fuels	1.41	1.39	1.42	1.36	1.16	2.28	1.41
CATEGORY	2004	2005	2006	2007	2008	2009	2010
1 – Energy	3.52	3.21	3.46	3.22	3.61	3.03	3.91
1A – Fuel combustion	2.06	1.96	2.02	2.09	2.10	2.20	2.22
1A1 – Energy industries	0.02	0.01	0.01	0.01	0.02	0.01	0.02
1A2 – Manufacturing industries & construction	0.01	0.02	0.02	0.02	0.02	0.01	0.00
1A3 – Transport	0.10	0.10	0.11	0.11	0.11	0.14	0.12
1A4 – Other sectors	1.92	1.81	1.85	1.85	1.86	1.95	2.05
1A5 – Non-specified	0.01	0.01	0.03	0.09	0.09	0.09	0.03

1B – Fugitive emissions from fuels	1.46	1.25	1.44	1.14	1.52	0.83	1.69
1B1 – Solid fuels	1.46	1.25	1.44	1.14	1.52	0.83	1.69

CATEGORY	2011	2012	2013	2014	2015	2016	2017
1 – Energy	4.03	3.88	3.68	3.60	3.96	4.00	4.12
1A – Fuel combustion	2.31	2.33	2.20	2.15	2.20	2.17	2.13
1A1 – Energy industries	0.02	0.02	0.02	0.01	0.02	0.01	0.01
1A2 – Manufacturing industries & construction	0.01	0.01	0.01	0.02	0.02	0.02	0.03
1A3 – Transport	0.10	0.10	0.07	0.09	0.10	0.10	0.11
1A4 – Other sectors	2.18	2.20	2.08	2.03	2.07	2.03	1.98
1A5 – Non-specified	0.00	0.00	0.02	0.00	0.00	0.00	0.00
1B – Fugitive emissions from fuels	1.72	1.55	1.47	1.44	1.76	1.83	1.99
1B1 – Solid fuels	1.72	1.55	1.47	1.44	1.76	1.83	1.99

TABLE A4.3:
N_2O emissions from energy sectors and subsectors for 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996
1 – Energy	0.07	0.07	0.06	0.06	0.05	0.04	0.06
1A – Fuel combustion	0.07	0.07	0.06	0.06	0.05	0.04	0.06
1A1 – Energy industries	0.02	0.02	0.02	0.01	0.01	0.00	0.02
1A2 – Manufacturing industries & construction	NO	NO	NO	NO	NO	NO	NO
1A3 – Transport	0.02	0.02	0.01	0.01	0.01	0.01	0.01
1A4 – Other sectors	0.03	0.03	0.03	0.03	0.02	0.02	0.02
1A5 – Non-specified	NO	NO	NO	NO	NO	NO	NO
1B – Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO
1B1 – Solid fuels	NO	NO	NO	NO	NO	NO	NO
CATEGORY	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1 – Energy	0.05	0.06	0.07	0.07	0.06	0.07	0.07
1A – Fuel combustion	0.05	0.06	0.07	0.07	0.06	0.07	0.07
1A1 – Energy industries	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1A2 – Manufacturing industries & construction	NO	NO	NO	NO	NO	NO	NO
1A3 – Transport	0.02	0.02	0.03	0.03	0.02	0.02	0.02
1A4 – Other sectors	0.02	0.02	0.02	0.02	0.02	0.02	0.03
1A5 – Non-specified	NO	NO	NO	NO	NO	NO	NO
1B – Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO
1B1 – Solid fuels	NO	NO	NO	NO	NO	NO	NO
CATEGORY	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1 – Energy	0.07	0.07	0.08	0.07	0.09	0.08	0.09
1A – Fuel combustion	0.07	0.07	0.08	0.07	0.09	0.08	0.09
1A1 – Energy industries	0.02	0.02	0.02	0.01	0.02	0.01	0.03
1A2 – Manufacturing industries & construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1A3 – Transport	0.02	0.02	0.02	0.03	0.03	0.04	0.03
1A4 – Other sectors	0.03	0.02	0.02	0.03	0.03	0.03	0.03

1A5 – Non-specified	NO	NO	NO	NO	NO	NO	NO
1B – Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO
1B1 – Solid fuels	NO	NO	NO	NO	NO	NO	NO

CATEGORY	2011	2012	2013	2014	2015	2016	2017
1 – Energy	0.09	0.09	0.08	0.08	0.08	0.08	0.09
1A – Fuel combustion	0.09	0.09	0.08	0.08	0.08	0.08	0.09
1A1 – Energy industries	0.03	0.03	0.02	0.02	0.02	0.02	0.02
1A2 – Manufacturing industries & construction	NO	NO	NO	NO	NO	NO	NO
1A3 – Transport	0.03	0.03	0.03	0.03	0.03	0.03	0.04
1A4 – Other sectors	0.03	0.03	0.03	0.03	0.03	0.03	0.03
1A5 – Non-specified	NO	NO	NO	NO	NO	NO	NO
1B – Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO	NO
1B1 – Solid fuels	NO	NO	NO	NO	NO	NO	NO

TABLE A4.4:
CO_2 emissions from transport for 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996
1A3 – Traffic	337.58	389.85	245.55	190.25	212.10	227.77	280.89
1A3b – Road traffic	330.30	383.52	239.22	183.93	205.78	221.45	274.57
1A3c – Rail transport	4.11	3.16	3.16	3.16	3.16	3.16	3.16
1A3d.ii – Domestic aviation	3.16	3.16	3.16	3.16	3.16	3.16	3.16
CATEGORY	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
1A3 – Traffic	296.30	416.49	507.94	508.30	442.06	360.49	376.73
1A3b – Road traffic	289.66	407.98	501.95	499.14	427.60	338.56	352.94
1A3c – Rail transport	3.48	3.48	2.53	3.80	3.48	3.16	3.16
1A3d.ii – Domestic aviation	3.16	3.16	2.53	4.11	5.06	5.69	6.01
CATEGORY	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1A3 – Traffic	427.26	400.53	425.10	519.85	593.58	692.24	606.02
1A3b – Road traffic	417.77	377.25	403.52	502.76	575.55	674.84	583.88
1A3c – Rail transport	3.80	6.33	6.58	6.33	6.96	6.96	9.49
1A3d.ii – Domestic aviation	5.69	9.49	10.33	10.76	11.07	10.44	12.65
CATEGORY	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
1A3 – Traffic	653.38	631.32	603.67	525.85	562.63	663.50	713.14
1A3b – Road traffic	644.04	615.76	591.17	516.73	553.82	655.58	713.14
1A3d.ii – Domestic aviation	9.34	15.56	12.49	9.12	8.81	7.93	0.00

TABLE A4.5:
CH_4 emissions from transport for 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996
1A3 – Traffic	0.11	0.12	0.08	0.06	0.06	0.07	0.08
1A3b – Road traffic	0.11	0.12	0.08	0.06	0.06	0.07	0.08
CATEGORY	1997	1998	1999	2000	2001	2002	2003
1A3 – Traffic	0.09	0.13	0.15	0.13	0.11	0.08	0.10
1A3b – Road traffic	0.09	0.13	0.15	0.13	0.11	0.08	0.10
CATEGORY	2004	2005	2006	2007	2008	2009	2010
1A3 – Traffic	0.10	0.10	0.11	0.11	0.11	0.14	0.12
1A3b – Road traffic	0.10	0.10	0.11	0.11	0.11	0.14	0.12
CATEGORY	2011	2012	2013	2014	2015	2016	2017
1A3 – Traffic	0.10	0.07	0.09	0.10	0.10	0.11	0.10
1A3b – Road traffic	0.10	0.07	0.09	0.10	0.10	0.11	0.10

TABLE A4.6:
N_2O emissions from transport for 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996
1A3 – Traffic	0.02	0.02	0.01	0.01	0.01	0.01	0.01
1A3b – Road traffic	0.02	0.02	0.01	0.01	0.01	0.01	0.01
CATEGORY	1997	1998	1999	2000	2001	2002	2003
1A3 – Traffic	0.02	0.02	0.03	0.03	0.02	0.02	0.02
1A3b – Road traffic	0.02	0.02	0.03	0.03	0.02	0.02	0.02
CATEGORY	2004	2005	2006	2007	2008	2009	2010
1A3 – Traffic	0.02	0.02	0.02	0.03	0.03	0.04	0.03
1A3b – Road traffic	0.02	0.02	0.02	0.03	0.03	0.04	0.03
CATEGORY	2011	2012	2013	2014	2015	2016	2017
1A3 – Traffic	0.03	0.03	0.03	0.03	0.03	0.03	0.04
1A3b – Road traffic	0.03	0.03	0.03	0.03	0.03	0.03	0.04

ACTIVITY INDICATORS AND EMISSION FACTORS

The 2006 Intergovernmental Panel on Climate Change's Combined Approach 1 and 2 (*Tiers-1* and *2*) methodology (IPCC 2006). This methodology includes a combined approach to the use of the default and national emission factors, i.e. lower thermoelectric power and specific carbon emissions in fossil fuels. An oxidation factor of 1 was used for the entire time series. The emission factors of fossil fuels and the type of biomass used are given in the tables below.

TABLE A4.7:
Lower heating value and carbon contents of fuels and non-energy oil derivatives

FOSSIL FUEL	LOWER HEATING VALUE	UNIT
Brown coal	16.75	MJ/kg
Lignite	9.21	MJ/kg
Wood and wood waste	9.17	MJ/m^3
Charcoal	35	MJ/kg
Other solid biomass	12.05	MJ/kg
Liquified natural gas	44.00	MJ/MJ
Liquified petroleum gas	46.89	MJ/kg
Motor gasoline	44.59	MJ/kg
Jet kerosene	43.96	MJ/kg
Diesel fuel	42.71	MJ/kg
Fuel oil	42.71	MJ/kg
Fuel oil – fuel oil, S <1%	40.19	MJ/kg
Fuel oil – fuel oil, S ≥ 1%	40.19	MJ/kg
Lubricants	33.50	MJ/kg
Bitumen	33.50	MJ/kg
Petrol coke	31.00	MJ/kg
Other petroleum products	40.19	MJ/kg

TABLE A4.8:
National CO_2 emission factors for fossil fuels

FOSSIL FUEL	CO_{2e} mission factor (kg/TJ)
Dark coal	94,145
Lignite	99,176
Wood and wood waste	107,440
Liquified petroleum gas	630,366
Motor gasoline	69,300
Jet fuel	71,500
Diesel fuel	74,066
Fuel oil	77,366
Petrol coke	98,817

Source: MONSTAT Statistics Office and the Environmental and Environmental Protection Agency

TABLE A4.9:
Default CO_2 emission factors for fuels

FOSSIL FUEL	CO_2 emission factor (kg/TJ)
Wood and wood waste	107,440
Charcoal	112,000
Other solid biomass	100,000
Jet kerosene	70,785

To calculate the N_2O and CH_4 emissions, the default emissions factors from the IPCC methodology were used.

TABLE A4.10:
CH_4 and N_2O emissions factors

SUBSECTOR	Fossil fuel	CH_4 emission factor (kg/TJ)	N_2O emission factor (kg/TJ)
1A1a – Energy and heat production	Brown coal	10	1.5
	Lignite	10	1.5
1A2 – Manufacturing industries and construction	Wood and wood waste	30	4
	Liquified petroleum gas	3	0.1
	Diesel oil	3	0.6
	Motor gasoline	3	0.6
	Light distillate oil	3	0.6
	Petroleum coke	3	0.6
	Other solid biomass	30	4
	Charcoal	200	4
1A3ai – International aviation (international bunkers)	Jet kerosene	0.5	2
1A3aii – Domestic aviation			
1A3b – Road transportation	Motor gasoline	33	3.2
	Diesel oil	3.9	3.9
	Liquified petroleum gas (LPG)	62	0.2
1A3c – Railways	Diesel oil	4.15	28.6
1A3di – Domestic water-borne navigation	Motor gasoline	7	2
	Diesel oil	7	2
	Light distillate oil	7	2
1A4cii – Off-road vehicles and other machinery	Motor gasoline	10	0.6
	Diesel oil	10	0.6
	Light distillate oil	10	0.6
1A4ci – Stationary	Light distillate oil	10	0.6
1A4b – Residential	Light distillate oil	10	0.6
	LPG	5	0.1
	Brown coal	300	1.5
	Lignite	300	1.5
	Other solid biomass	30	4
	Charcoal	300	4

1A4a – Commercial/ institutional	Light distillate oil	
	LPG	
	Lignite	
	Other solid biomass	
	Charcoal	
	Wood and wood waste	
1A5biii – Mobile (other)	Diesel oil	

TABLE A4.11:
Emission factors for CH_4 – Fugitive emissions

SUBSECTOR Fugitive emissions	CH_4 emission factor (m^3/t)	N_2O emission factor (kg/TJ)
1B1ai1 – Coal mining – underground mines	18	-
1B1ai2 – Post-mining seam gas emissions	2.5	-
1B1aii1 – Coal mining – surface mines	1.2	-
1B1aii2 – Post-mining seam gas emissions	0.1	-

The table below shows the fossil fuel consumption data used to calculate emissions from the energy sector, following Common Reporting Format (CRF) categories.

TABLE A4.12:
Fossil-fuel consumption in energy sector for 1990–2017 (Gg)

CRF category	Fuel (Gg)	1990	1991	1992	1993	1994	1995	1996	1997
1A1ai – Production of electricity	Fuel oil	4.6	4.4	1.9	1.6	1.4	0	1.8	2.4
	Lignite	1185	1204	996	930	739	36	1054	970.3
1A1aiii – Heating plants	Fuel oil	95.05	76	46	35	38	39	37	61.2
	Lignite	7	9	8	8	9	8	9	2
1A1ci – Manufacture of solid fuels	Diesel fuel	2.4	2.3	1	1	1	1	1	2
1A2a – Iron and steel	LPG	NO	NO	NO	NO	NO	NO	NO	NO
	Fuel oil	26.8	40	25	21	20	19	22	14.1
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	0.8
	Lignite	25	21	19	16	16	17	21	34
1A2b – Non-ferrous metals	Diesel fuel	4.9	3	2	1	1	1	1	2.1
	Fuel oil	31.2	60	35	23	30	28	27	16.6
	LPG	0.2	NO	NO	NO	NO	NO	NO	NO
1A2c – Chemicals	LPG	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
1A2d – Pulp, paper, and printing	Dark coal	NO	NO	NO	NO	NO	0	9	12
	Lignit	NO	NO	NO	NO	NO	NO	NO	NO
1A2e – Manufacture of food, beverage and tobacco	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
	LPG	0.5	0.5	NO	NO	NO	NO	NO	0.8
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	0.8
	Dark coal	1	NO	1	1	1	1	1	1
	Lignite	1	NO	1	1	1	1	2	1
1A2f – Non-metallic minerals	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
1A2i – Mining (except fuel) and quarries	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
1A2j – Wood processing	LPG	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
	Wood and wood waste	NO	NO	NO	NO	NO	NO	NO	NO
1A2k – Construction	Fuel oil	4.8	NO	NO	NO	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO

1A2l – Textiles and leather	Dark coal	NO	NO	NO	1	1	2	2	2
	Lignite	19	15	14	11	11	11	15	8
1A2m –Other industry	Fuel oil	0	5	5	4	2	3	4	
	LPG	1.1	1	0	0	0	0	0	1.1
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	2	2	2	2	1	1	1	2
	Lignite	15	15	13	10	10	9	15	15
1A3ai – International air carriers (bunkers))	Jet fuel	12.5	14.3	2	1	1	1	1	0.5
1A3aii – Domestic air traffic	Jet fuel	NO	NO	NO	NO	NO	NO	NO	NO
1A3b –Road traffic	Gasoline	68.4	76	50.8	37	41	43	52	57.6
	Diesel fuel	37.6	47	26	22	25	28	36	35.3
	LPG	NO	NO	NO	NO	NO	NO	NO	NO
1A3c – Rail transport	Diesel fuel	1.3	1	1	1	1	1	1	1.1
1A3dii – Domestic maritime transport	Gasoline	NO	NO	NO	NO	NO	NO	NO	NO
	Diesel fuel	1	1	1	1	1	1	1	1
	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
1A4a – Services/ institutions	Fuel oil	17.5	16	9	11	9	12	7	12.1
	LPG	1.7	NO	NO	NO	NO	NO	NO	0.1
	Lignite	40.9	36	31	22	21	22	32	48.1
	Wood and wood waste	NO	NO	NO	NO	NO	NO	NO	NO
1A4b – Households	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
	LPG	8.5	11	1	1	0	1	2	0.5
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	0.5
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	25	23	22	21	21	20	26	32
	Wood and wood waste (TJ)	7001.5	5986.8	6477.8	7140.4	4929.5	5599.2	5316.3	4808.8
1A4ci – Stationary sources	Fuel oil	1	1	1	1	1	1	1	1
1A4cii – Off-road machinery and construction machinery	Gasoline	NO	NO	NO	NO	NO	NO	NO	NO
	Diesel fuel	8	7	6	5	6	7	6	7.2
	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO

1A5biii – Mobile sources (Other)	Diesel fuel	5.8	6	3	2	2	3	3	6.7
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	NO
1A1ai –Generation of electricity	Fuel oil	3.1	3.2	3.5	2.5	1.3	1.6	1.3	2.2
	Lignite	1302	1258	1381.4	1000.8	1598.4	1479.9	1394	1200.2
1A1aiii – Heating plants	Fuel oil	55.7	63.2	63.4	71.8	67.9	71.4	77.6	0
	Lignite	2	2	2	2	3	4	4	4.1
1A1ci – Manufacture of solid fuels	Diesel fuel	3.9	3.2	5.7	3.1	3	4.6	2.7	3.4
1A2a – Iron and steel	LPG	0.9	1	1	1	1	NO	NO	1
	Fuel oil	12.9	9.8	7.3	9.9	6.7	4.8	12.2	9.6
	Petrol coke	0.9	NO	NO	NO	NO	NO	NO	NO
	Lignite	27	32	26	22	33	33	28	25
1A2b – Non-ferrous metals	Diesel fuel	1.5	1.8	2.8	3	2.3	2	2.2	NE
	Fuel oil	16	16.7	26.4	27.1	29.8	29.5	27	95.8
	LPG	0.2	NO	NO	NO	NO	NO	NO	NO
1A2c – Chemicals	LPG	NO	NO	NO	NO	NO	NO	NO	NO
	Mrki ugalj	NO	NO	NO	NO	NO	NO	NO	2
	Petrol coke	1	NO	NO	NO	NO	NO	NO	NO
	Mrki ugalj	NO	2	NO	NO	1	NO	NO	NO
	Lignite	28	22	23	19	13	7	6	6
1A3ai – International airlines (bunkers)	Jet fuel	4.4	13	12.9	14	10.6	8.3	7.3	13
1A3aii – Domestic air traffic	Jet fuel	0.6	0.3	0.4	1.9	4.2	4.7	NE	2.4
1A3b – Road traffic	Gasoline	79	91.7	78.2	65.9	50.4	61.5	61.6	52
	Diesel fuel	51.8	69.1	81.4	70.8	57.7	51.4	71.8	65.7
	LPG	NO	NO	NO	NO	0.1	0.1	0.1	3
1A3c – Rail transport	Diesel fuel	1.1	0.8	1.2	1.1	1	1	1.2	2
1A3dii – Domestic maritime transport	Gasoline	NO	NO	NO	NO	NO	NO	NO	NO
	Diesel fuel	1	0.8	1.3	1.6	1.8	1.9	1.8	3
	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
1A4a – Services/ institutions	Fuel oil	12.7	13.4	15.4	15.3	17.6	17	17.9	15.7
	LPG	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	48.7	53.2	30	30	35	32.5	27	12
	Wood and wood waste	NO	NO	NO	NO	NO	NO	NO	NO

1A4b – Households	Fuel oil	0.7	0.7	0.8	0.9	1	1.1	1.2	2.4
	LPG	1.1	NO	NO	NO	0.9	2	3	NO
	Petrol coke	1.1	0.5	NO	NO	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	35.3	41.8	24	26.7	34	33	29	18
	Wood and wood waste (TJ)	4358.6	4522.6	4736.2	3964.1	5775.7	5962.8	6079.5	5840.1
1A4ci – Stationary sources	Fuel oil	1.1	0.5	NO	NO	NO	NO	NO	NO
1A4cii – Off-road machinery and construction machinery	Gasoline	0.3	NO	1	NO	NO	NO	NO	NO
	Diesel fuel	6.7	6	6.1	5.9	6	6	6	6
	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
1A5biii – Mobile sources (other)	Diesel fuel	8	7.4	9	6	9.3	9	6	9
	Petrol coke	1.3	0.5	NO	NO	NO	NO	NO	NO

CRF category	Fuel (Gg)	2006	2007	2008	2009	2010	2011	2012	2013
1A1ai – Generation of electricity	Fuel oil	1.4	3.2	2.7	1.4	3	3	3.3	NO
	Lignite	1363	1065	1636	875	1856.2	1900	1900.4	1648
1A1aiii – Heating plants	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	4	4	4	2	2	NO	NO	NO
1A1ci – Manufacture of solid fuels	Diesel fuel	4.5	4.4	5.3	4.9	5.5	5.9	5.4	NO
1A2a – Iron and steel	LPG	NO	2.1	NO	4	2	2	2	2
	Fuel oil	9.7	11.1	13.6	NO	7.6	NO	NO	3
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	22	14	16	13	9	12	12	10
1A2b – Non-ferrous metals	Diesel fuel	NO	NO	NO	NO	NO	NO	NO	NO
	Fuel oil	101.4	99.6	95.2	37.4	4.2	NO	NO	NO
	LPG	NO	NO	NO	NO	NO	NO	NO	NO
1A2c – Chemicals	LPG	NO	NO	NO	NO	NO	5	4	0
	Dark coal	1	2	1	NO	NO	NO	NO	NO
1A2d – Pulp, paper, and printing	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	1	1	2	NO	NO	NO	NO	NO
1A2e – Manufacture of food, beverages, and tobacco	Fuel oil	1,7	4,2	5,3	1,3	1,3	NO	NO	NO
	LPG	NO	NO	1	NO	NO	NO	NO	1
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	1	4	2	NO	NO	NO	NO	NO
	Lignite	NO	NO	NO	NO	NO	2	2	1

1A2f – Non-metallic minerals	Fuel oil	1	1	1	1.1	1	NO	NO	1
	Dark coal	1	2	2	NO	NO	NO	NO	NO
1A2i – Mining (except fuel) and quarries	Fuel oil	1	1	1	1.3	1	NO	NO	NO
1A2j – Wood processing	LPG	NO	NO	NO	NO	NO	NO	NO	2
	Dark coal	0	0	4	NO	NO	NO	NO	NO
	Wood and wood waste (TJ)	NO	NO	NO	NO	NO	259.07	275.74	259.13
1A2k – Construction	Fuel oil	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
1A2l – Textiles and leather	Dark coal	6.5	2	1	NO	NO	NO	NO	NO
	Lignite	NO	NO	NO	NO	NO	NO	NO	NO
1A2m – Other industry	Fuel oil	1.8	9.2	8.6	NO	NO	NO	NO	5
	LPG	7	6	8	4	7	6	4	7
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	3	7	4	3	NO	NO	NO	NO
	Lignite	7	0	0	2	2	1	1	2
1A3ai – International air carriers (bunkers)	Jet fuel	15	10.6	14	1.8	2	10	12	13
1A3aii – Domestic air traffic	Jet fuel	1.5	NO	NO	NO	NO	NO	NO	NO
1A3b – Road traffic	Gasoline	54	54	50	64	57	40	34	31
	Diesel fuel	71.5	101.4	128.5	145.2	123.1	159	155	156.6
	LPG	5	5.2	5	6.1	6.3	6	7	NO
1A3c – Rail transport	Diesel fuel	2.1	2	2.2	2.2	3	NO	NO	NO
1A3dii – Domestic maritime transport	Gasoline	NO	NO	NO	NO	NO	2	2	0
	Diesel fuel	3.3	3.4	3.5	3.3	4	1	1	1
	Fuel oil	NO	NO	NO	NO	NO	NO	2	3
1A4a – Services/ Institutions	Fuel oil	2	33	35	26	29	33	23	0
	LPG	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	27	13	11	18	NO	NO	NO	NO
	Wood and wood waste (TJ)	NO	NO	NO	NO	NO	247.18	243.57	266.86
1A4b – Households	Fuel oil	2.1	2.7	2.7	3	2.7	2	2	2
	LPG	1	NO	NO	NO	NO	NO	NO	NO
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO	NO	NO	NO	NO
	Lignite	26	15	16	22	25	14	14	11
	Wood and wood waste (TJ)	5909.6	5957.2	5957.6	6258.2	6534.6	6839.2	6925.9	6558.3

1A4ci – Stationary sources	Fuel oil	NO	4	4	NO	NO	NO	NO	NO
1A4cii – Off-road machinery and construction machinery	Gasoline	NO	NO	NO	NO	NO	NO	NO	NO
	Diesel fuel	6	7	7	7	7	8	2	3
	Fuel oil	1	NO	NO	NO	NO	NO	NO	NO
1A5biii – Mobile sources (other)	Diesel fuel	7	9	8	9	10	1	2	1
	Petrol coke	NO	NO	NO	NO	NO	NO	NO	NO

CRF category	Fuel (Gg)	2014	2015	2016	2017
1A1ai – Generation of electricity	Fuel oil	NO	NO	NO	NO
	Lignite	1597	1668.8	1259.3	1287.2
1A1aiii – Heating plants	Fuel oil	NO	NO	NO	NO
	Lignite	NO	NO	NO	NO
1A1ci – Manufacture of solid fuels	Diesel fuel	NO	NO	NO	NO
1A2a – Iron and steel	LPG	0.3	0.9	0.2	0.6
	Fuel oil	0.2	0.8	0.3	0.3
	Petrol coke	0.00	0.00	NO	NO
	Lignite	9.6	23.5	21.8	18.8
	Liquified natural gas	NO	NO	3.1	2.9
1A2b – Non-ferrous metals	Diesel fuel	0.00	0.00	0.2	0.1
	Fuel oil	0.2	0.2	2.6	2.6
	LPG	NO	NO	NO	NO
	Wood and wood waste (TJ)	0.18	0.2	1.74	NO
	Other solid biomass	0.04	NO	NO	NO
1A2c – Chemicals	Diesel fuel	0.3	0.5	0.5	0.3
	Fuel oil	0.3	1.1	1	0.7
	Wood and wood waste (TJ)	40.1	103.97	96	337
1A2d – Pulp Paper and Printing	Fuel oil	0.3	0.3	0.3	0.5

1A2e – Manufacture of food, beverage and tobacco	LPG	2.8	2.8	2.4	2.3
	Diesel fuel	6.7	4.1	4.2	
	Fuel oil	1.6	2.8	2.8	2.7
	Lignite	3.7	2.1	2.5	
	Wood and wood waste (TJ)	288.48	243.19	247	240
	Other solid biomass	0.012	0.01	0.01	0.01
	Charcoal	0.002	0.002	0.002	0.002
	Dark coal	0.00	1.1	0.8	0.8
1A2f – Non-metallic minerals	Fuel oil	0.1	0.5	0.5	0.7
	Diesel fuel	1.4	1.1	1.0	1.5
	Wood and wood waste (TJ)	6.42	6.87	7	NO
	Other solid biomass	0.00	0.04	0.04	0.059
1A2i – Mining (except fuel) and quarries	Fuel oil	0.2	4.2	NO	NO
	Diesel fuel	4.3	NO	4.5	12.4
1A2j – Wood processing	Diesel fuel	6.9	9.5	10.4	10.8
	Fuel oil	0.4	NO	NO	NO
	Motor gasoline	0.5	NO	NO	NO
	Lignite		0.9	1	1
	Wood and wood waste (TJ)	4 .96	6.46	7	7
1A2k – Construction	Fuel oil	NO	NO	NO	NO
	Dark coal	NO	NO	NO	NO
1A2l – Textiles and leather	Wood and wood waste (TJ)	3.28	3.28	5	4
	Other solid biomass	NO	0.019	0.027	0.024
	Fuel oil		0.2	0.3	0.3
	Diesel fuel	0.2	NO	NO	NO
1A2m – Other Industry	Fuel oil	0.5	3.9	3.6	3.5
	LPG	2.8	3.3	3	2.9
	Diesel fuel	10	8.6	7.9	7.6
	Motor gasoline	0.5	1.1	1	1
	Other solid biomass	0.5	0.60	0.5	0.5

1A3ai – International air carriers (bunkers)	Jet fuel	17.2	18.1	18.6	20
1A3aii – Domestic air traffic	Jet fuel	NO	NO	NO	NO
1A3b – Road traffic	Gasoline	33.4	34	35.3	38.4
	Diesel fuel	118.4	134.5	165	183.1
	LPG	6.8	8	8.3	8.3
	Fuel oil	6.2	NO	NO	NO
1A3c – Rail transport	Diesel fuel	NO	NO	NO	NO
1A3dii – Domestic maritime transport	Gasoline	NO	NO	NO	NO
	Diesel fuel	1.9	2	1.7	NE
	Fuel oil	1	0.8	0.7	
1A4a –Services/ Institutions	Fuel oil	0.3	2.1	2.2	2.3
	LPG	1.2	1.4	1.5	1.1
	Diesel fuel	5.8	4.9	5.1	5.3
	Lignite	5.9	6.8	7.1	7.4
	Wood and wood waste (TJ)	169.8	184.38	176	202
	Other solid biomass	1.36	3.61	3.68	3.8
	Drveni ugalj	0.26	0.27	0.3	0.3
1A4b – Households	Gasoline	0.2	NO	NO	NO
	LPG	0.8	0.9	1	1.1
	Petrol coke	NO	NO	NO	NO
	Other solid biomass	o.8	2.46	2.65	14.63
	Lignite	13.9	14.5	19.5	10.2
	Wood and wood waste (TJ)	5994.5	6461.9	5927	5962
	Charcoal	0.54	0.54	0.60	0.6
1A4ci – Stationary sources	Fuel oil	NO	NO	NO	NO
1A4cii – Off-road machinery and construction machinery	Gasoline	0.5	0.8	0.8	0.3
	Diesel fuel	4	4	4	2.8
	Fuel oil	1	1.3	1.3	NO
1A5biii – Mobile sources (Other)	Diesel fuel	NO	NO	NO	NO
	Petrol coke	NO	NO	NO	NO

A4.2 Industry sector

GHG EMISSIONS FROM THE INDUSTRY SECTOR BY GAS

TABLE A4.13:
CO_2 emissions from industrial subsectors, 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996	1997
2 – Industrial processes and product use	212.80	205.54	172.70	71.50	28.97	85.16	93.98	147.70
2A – Minerals industry	24.75	23.25	16.50	NO	NO	24.75	3.00	6.00
2A2 – Production of lime	24.75	23.25	16.50	NO	NO	24.75	3.00	6.00
2C – Metal industry	185.28	179.43	154.08	70.19	27.34	58.33	88.81	139.55
2C1 – Manufacture of iron and steel	16.61	15.71	11.42	9.22	8.95	16.61	7.09	10.59
2C3 – Manufacture of aluminium	168.67	163.73	142.66	60.97	18.39	41.71	81.73	128.96
2D – Non-energy fuel consumption and solvent use	2.21	2.21	1.62	0.98	1.18	1.52	1.67	1.67
2D1 – Use of lubricants	2.21	2.21	1.62	0.98	1.18	1.52	1.67	1.67
2F – Use of substances to replace ozone-depleting substances	NO	NO	NO	NO	NO	NO	NO	NO
2F1 – Refrigerators and air conditioners	NO	NO	NO	NO	NO	NO	NO	NO
2G – Manufacture and use of other products	0.56	0.64	0.49	0.32	0.45	0.56	0.50	0.48
2G1 – Electrical equipment	0.56	0.64	0.49	0.32	0.45	0.56	0.50	0.48
CATEGORY	1998	1999	2000	2001	2002	2003	2004	
2 – Industrial processes and product use	142.10	144.93	167.50	194.11	203.66	205.71	215.80	
2A – Minerals industry	6.00	6.00	5.33	9.74	8.34	6.10	7.94	
2A2 – Production of lime	6.00	6.00	5.33	9.74	8.34	6.10	7.94	
2C – Metal industry	133.81	136.51	159.62	181.78	193.00	197.06	205.29	

2C1 – Manufacture of iron and steel	11.32	7.04	6.78	8.78	6.63	4.72	12.01
2C3 – Manufacture of aluminium	122.49	129.47	152.84	173.00	186.37	192.34	193.28
2D – Non-energy fuel consumption and solvent use	1.77	1.77	1.82	1.87	1.87	1.92	1.97
2D1 – Use of lubricants	1.77	1.77	1.82	1.87	1.87	1.92	1.97
2F – Use of substances to replace ozone-depleting substances	NO	NO	NO	NO	NO	NO	NO
2F1 – Refrigerators and air conditioners	NO	NO	NO	NO	NO	NO	NO
2G – Manufacture and use of other products	0.53	0.65	0.72	0.72	0.45	0.63	0.60
2G1 – Electrical equipment	0.53	0.65	0.72	0.72	0.45	0.63	0.60

CATEGORY	2005	2006	2007	2008	2009	2010	2011
2 – Industrial processes and product use	206.42	216.40	219.26	202.90	114.09	137.54	157.68
2A – Minerals industry	4.51	6.09	5.32	7.38	3.37	0.63	2.59
2A2 – Production of lime	4.51	6.09	5.32	7.38	3.37	0.63	2.59
2C – Metal industry	200.79	207.78	212.68	194.29	109.68	135.96	154.08
2C1 – Manufacture of iron and steel	8.18	12.91	13.91	16.14	8.28	3.86	4.89
2C3 – Manufacture of aluminium	192.61	194.88	198.77	178.15	101.41	132.10	149.19
2D – Non-energy fuel consumption and solvent use	0.49	1.87	0.59	0.54	0.44	0.39	0.49
2D1 – Use of lubricants	0.49	1.87	0.59	0.54	0.44	0.39	0.49
2F – Use of substances to replace ozone-depleting substances	NO	NO	NO	NO	NO	NO	NO
2F1 – Refrigerators and air conditioners	NO	NO	NO	NO	NO	NO	NO

2G – Manufacture and use of other products	NO	NO	NO	NO	NO	NO	NO
2G1 – Electrical equipment	NO	NO	NO	NO	NO	NO	NO
2 – Industrial processes and product use	0.64	0.66	0.67	0.69	0.59	0.56	0.52
2A – Minerals industry	0.64	0.66	0.67	0.69	0.59	0.56	0.52
CATEGORY	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	
2 – Industrial processes and product use	122.29	79.88	74.57	76.05	62.12	67.29	
2A – Minerals industry	NO	NO	NO	NO	NO	NO	
2A2 – Production of lime	NO	NO	NO	NO	NO	NO	
2C – Metal industry	121.27	78.90	69.57	70.90	61.49	66.57	
2C1 – Manufacture of iron and steel	2.25	1.58	1.15	2.90	3.61	3.62	
2C3 – Manufacture of aluminium	119.02	77.32	68.43	68.00	57.88	62.95	
2D – Non-energy fuel consumption and solvent use	NO	NO	NO	NO	NO	NO	
2D1 – Use of lubricants	NO	NO	NO	NO	NO	NO	
2F – Use of substances to replace ozone-depleting substances	NO	NO	NO	NO	NO	NO	
2F1 – Refrigerators and air conditioners	NO	NO	NO	NO	NO	NO	
2G – Manufacture and use of other products	0.53	0.49	0.48	0.48	0.48	0.57	
2G1 – Electrical equipment	0.53	0.49	0.48	0.48	0.48	0.57	

TABLE A4.14:
CH_4 emissions from industrial subsectors, 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996	1997
2 – Industrial processes and product use	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
2C – Metal industry	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
2C1 – Manufacture of iron and steel	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001
CATEGORY	1998	1999	2000	2001	2002	2003	2004	2005
2 – Industrial processes and product use	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
2C – Metal industry	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
2C1 – Manufacture of iron and steel	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
CATEGORY	2006	2007	2008	2009	2010	2011		
2 – Industrial processes and product use	0.002	0.002	0.002	0.001	0.000	0.001		
2C – Metal industry	0.002	0.002	0.002	0.001	0.000	0.001		
2C1 – Manufacture of iron and steel	0.002	0.002	0.002	0.001	0.000	0.001		
CATEGORY	2012	2013	2014	2015	2016	2017		
2 – Industrial processes and product use	0.001	0.002	0.000	0.000	0.000	0.000		
2C – Metal industry	0.001	0.002	0.000	0.000	0.000	0.000		
2C1 – Manufacture of iron and steel	0.001	0.002	0.000	0.000	0.000	0.000		

TABLE A4.15:

PFC emissions expressed in CO_2eq from industrial subsectors, 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996	1997
2 – Industrial processes and product use	1487.90	1994.03	1242.55	453.66	91.12	344.41	879.26	1353.69
2C – Metal industry	1487.90	1994.03	1242.55	453.66	91.12	344.41	879.26	1353.69
2C3 – Manufacture of aluminium	1487.90	1994.03	1242.55	453.66	91.12	344.41	879.26	1353.69
CATEGORY	1998	1999	2000	2001	2002	2003	2004	2005
2 – Industrial processes and product use	987.79	1033.13	1359.01	1405.18	1340.23	1098.73	972.68	867.59
2C – Metal industry	987.79	1033.13	1359.01	1405.18	1340.23	1098.73	972.68	867.59
2C3 – Manufacture of aluminium	987.79	1033.13	1359.01	1405.18	1340.23	1098.73	972.68	867.59
CATEGORY	2006	2007	2008	2009	2010	2011	2012	2013
2 – Industrial processes and product use	966.34	1070.21	1222.86	339.50	496.54	422.51	223.03	115.26
2C – Metal industry	966.34	1070.21	1222.86	339.50	496.54	422.51	223.03	115.26
2C3 – Manufacture of aluminium	966.34	1070.21	1222.86	339.50	496.54	422.51	223.03	115.26
CATEGORY	2014	2015	2016	2017				
2 – Industrial processes and product use	86.60	71.80	45.40	45.22				
2C – Metal industry	86.60	71.80	45.40	45.22				
2C3 – Manufacture of aluminium	86.60	71.80	45.40	45.22				

ACTIVITY INDICATORS AND EMISSION FACTORS

In accordance with the national data available, it was possible to use the *Tier-2* approach to estimate the emissions from the aluminium industry. The assessment of other GHG emissions from industrial processes was done following the *Tier-1* approach.

TABLE A4.16:
Activity indicators for industrial processes and product use, 1990–2017

CATEGORY	UNIT	1990	1991	1992	1993	1994	1995	1996	1997
2A2 – Production of lime	t	33,000	31,000	22,000	NO	NO	33,000	4,000	8,000
2C1 – Manufacture of iron and steel	t	207,642	196,365	142,775	115,301	111,821	207,642	88,591	132,362
2C3 – Manufacture of aluminium	t	105,416.9	102,328.4	89,164.2	38,104.1	11,496.2	105,416.9	26,071.3	80,600.4
2H2 – Food and beverage industry – beer	hl	662,000	607,000	418,000	217,000	365,000	662,000	421,000	398,000
2H2 – Food and beverage industry – bread	t	NO	21,823	21,838	21,853	21,869	NO	21,884	21,914
2H2 – Food and beverage industry – wine	hl	33,230	24,166	25,222	17,261	26,788	33,230	35,374	28,759
CATEGORY	UNIT	1998	1999	2000	2001	2002	2003	2004	2005
2A2 – Production of lime	t	8,000	8,000	7,113	12,989	11,123	8,136	10,591	6,008
2C1 – Manufacture of iron and steel	t	141,445	88,002	84,789	109,757	82,832	59,036	150,165	102,247
2C3 – Manufacture of aluminium	t	76,556.7	80,916.1	95,525.7	108,122.9	116,482.4	120,212.7	120,796.9	120,379.4
2H2 – Food and beverage industry – beer	hl	453,000	594,000	675,532	675,532	301,213	553,282	491,189	515,332
2H2 – Food and beverage industry – bread	t	21,929	21,944	21,053	21,053	20,247	18,640	20,746	22,787
2H2 – Food and beverage industry – wine	hl	35,989	49,202	66,249	66,249	100,269	86,517	93,872	100,704
CATEGORY	JEDINICA	2006	2007	2008	2009	2010	2011	2012	2013
2A2 – Production of lime	t	8,118	7,089	9,839	4,497	839	3,448	NO	NO
2C1 – Manufacture of iron and steel	t	161,333	173,913	201,690	103,479	48,272	61,164	28,161	19,723
2C3 – Manufacture of aluminium	t	121,798	124,229.8	111,344.3	63,379	82,560	93,242	74,384.6	48,323.7

2H2 – Food and beverage industry – beer	hl	516,942	534,386	556,521	456,896	423,799	404,396	433,880	400,720
2H2 – Food and beverage industry – bread	t	24,166	25,229	25,246	22,733	21,596	17,858	16,335	15,407
2H2 – Food and beverage industry – wine	hl	121,701	110,158	111,381	105,916	105,586	104,436	102,966	93,011

CATEGORY	UNIT	2014	2015	2016	2017			
2A2 – Production of lime	t	NO	NO	NO	NO			
2C1 – Manufacture of iron and steel	t	14,330	36,279.81	46,167.57	45,223			
2C3 – Manufacture of aluminium	t	43,244.63	42,210.24	36,173	39,345.65			
2H2 – Food and beverage industry – beer	hl	364,511	357,804	362,625	380,355			
2H2 – Food and beverage industry – bread	t	15,229	16,210	17,185	17,344			
2H2 – Food and beverage industry – wine	hl	109,981	113,241	101,298	110,452			

TABLE A4.17:
Emission factors for industrial processes and product use, 1990–2017

INDUSTRY SECTOR	CO_2 emission factor	Unit	CH_4 emission factor	Unit
2A2 – Production of lime	0.75	t/t	NA	
2C1 –Manufacture of iron and steel	0.08	t/t	0.01	kg/t
2C3 – Manufacture of aluminium	1.6	t/t	NA	
2H2 – Food and beverage industry – beer	20	t C/TJ	NA	
2H2 – Food and beverage industry – bread	8×10^{-9}	t/t	NA	
2H2 – Food and beverage industry – wine	6.15×10^{-6}	t/t	NA	
2A2 – Production of lime	8.3×10^{-9}	t/t	NA	

TABLE A4.18:
Emission factors for PFC from 2C3 – Aluminium production (electrolysis), 1990–2017 (kg/t)

CATEGORY	1990	1991	1992	1993	1994	1995	1996	1997
PFC-14 (CF_4) emission factor	1.53/ 1.64	1.61/ 2.68	1.49/ 1.62	1.49/ 1.22	1.49	1.64/ 2.19	1.78/ 1.98	1.03/ 1.80
PFC-116 (C_2F_6) emission factor	0.18/ 0.19	0.19/ 0.32	0.18/ 0.2	0.20/ 0.18	0.18	0.20/ 0.27	0.22/ 0.24	0.12/ 0.22
CATEGORY	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
PFC-14 (CF_4) emission factor	1.18/ 1.65	1.13/ 2.0	1.09/ 1.77	1.17/ 1.40	0.90/ 1.13	0.8/ 1.0	0.79/ 0.83	0.75/ 1.01
PFC-116 (C_2F_6) emission factor	0.14/ 0.20	0.20/ 0.14	0.13/ 0.27	0.14/ 0.17	0.11/ 0.14	0.10/ 0.12	0.1/ 0.1	0.09/ 0.12
CATEGORY	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
PFC-14 (CF_4) emission factor	0.79/ 1.12	0.95/ 1.48	1.1/ 0.2	1.22/ 0.22	0.95/ 0.15	0.66/ 0.13	0.77/ 0.16	0.83/ 0.08
PFC-116 (C_2F_6) emission factor	0.10/ 0.14	0.11/ 0.18	0.13/ 0.02	0.02/ 0.15	0.12/ 0.02	0.08/ 0.02	0.09/ 0.02	0.1/ 0.01
CATEGORY	**2014**	**2015**	**2016**	**2017**				
PFC-14 (CF_4) emission factor	0.79	0.11	0.14	0.13				
PFC-116 (C_2F_6) emission factor	0.10	0.01	0.02	0.02				

A4.3 Emissions from the agriculture sector

GHG EMISSIONS FROM THE AGRICULTURAL SECTOR BY GAS

TABLE A4.19:
CH_4 emissions from agriculture and land use, 1990–2017 (Gg)

CATEGORY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
3A – Livestock	22.71	22.64	21.28	20.49	20.88	21.50	21.44	20.89	20.72	20.87	20.34
3A1 – Enteric fermentation	19.36	19.30	18.12	17.45	17.77	18.31	18.25	17.75	17.57	17.67	17.24
3A2 – Fertilizer management	3.36	3.34	3.15	3.04	3.11	3.19	3.19	3.14	3.15	3.20	3.10
3C – Cumulative and other sources of gas from the soil	0.07	0.05	0.09	0.08	0.05	0.08	0.08	0.04	0.09	0.02	0.36
3C1 – Biomass burning emissions	0.07	0.05	0.09	0.08	0.05	0.08	0.08	0.04	0.09	0.02	0.36
CATEGORY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3A – Livestock	19.94	20.39	20.09	19.44	13.85	13.44	12.56	12.29	9.84	9.69	10.33
3A1 – Enteric fermentation	16.86	17.23	16.95	16.40	11.77	11.42	10.67	10.43	8.35	8.21	8.75
3A2 – Fertilizer management	3.08	3.16	3.14	3.04	2.08	2.03	1.89	1.86	1.50	1.48	1.58
3C – Cumulative and other sources of gas from the soil	0.03	0.03	0.19	0.07	0.01	0.02	0.84	0.17	0.01	0.04	2.24
3C1 – Biomass burning emissions	0.03	0.03	0.19	0.07	0.01	0.02	0.84	0.17	0.01	0.04	2.24
CATEGORY	2012	2013	2014	2015	2016	2017					
3A – Livestock	10.17	10.53	11.03	10.56	10.64	10.30					
3A1 – Enteric fermentation	8.61	8.91	9.34	8.92	8.86	8.68					
3A2 – Fertilizer management	1.56	1.62	1.69	1.64	1.78	1.63					
3C – Cumulative and other sources of gas from the soil	0.26	0.02	0.01	0.18	0.08	0.97					
3C1 – Biomass burning emissions	0.26	0.02	0.01	0.18	0.08	0.97					

A4.4 Emissions from the waste sector

GHG EMISSIONS FROM THE WASTE SECTOR BY GAS

TABLE A4.20:
CH_4 emissions from the waste sector for 1990–2017 (Gg CH_4)

	Solid waste disposal (Gg)	Wastewater management (Gg)	Waste – total (Gg)
	6.04	0.42	6.46
1991	6.22	0.42	6.64
1992	6.40	0.42	6.82
1993	6.58	0.42	7.00
1994	6.77	0.42	7.19
1995	6.98	0.42	7.41
1996	7.22	0.43	7.65
1997	7.48	0.43	7.91
1998	7.75	0.43	8.18
1999	8.02	0.43	8.45
2000	8.29	0.62	8.92
2001	8.53	0.63	9.16
2002	8.73	0.63	9.37
2003	8.91	0.64	9.55
2004	9.05	0.65	9.70
2005	9.15	0.66	9.81
2006	9.24	0.68	9.92
2007	9.39	0.70	10.09
2008	9.49	0.72	10.21
2009	9.55	0.71	10.26
2010	9.64	0.71	10.36
2011	9.80	0.72	10.52
2012	9.65	0.72	10.37
2013	9.53	0.73	10.25
2014	9.47	0.73	10.20
2015	9.38	0.74	10.12
2016	9.31	0.75	10.06
2017	8.87	0.74	9.61

TABLE A4.21:
N_2O emissions from waste for 1990–2017 (Gg N_2O)

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Wastewater management N_2O (Gg)	0.033	0.033	0.034	0.034	0.035	0.035	0.036	0.036	0.037
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Wastewater management N_2O (Gg)	0.037	0.038	0.038	0.039	0.039	0.040	0.040	0.039	0.041
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Wastewater management N_2O (Gg)									
	2017								
Wastewater management N_2O (Gg)	0.045								

TABLE A4.22:
Total National Emissions for 2017 (Gg)

	Emissions (Gg)			Emissions CO_2 equivalents (Gg)			
CATEGORIES	Net CO_2 (1)(2)	CH_4	N_2O	HFC	PFC	SF_6	Other halogenated gases with CO_2 equivalent conversion factors (3)
Total national emissions and removals		25.01	0.35	235.91	45.22	2.99	
	2241.78	4.12	0.09	NO	NO	NO	
1A – Fuel combustion activities	2241.78	2.13	0.09	0.00	0.00	NO	
1A1 – Energy industries	1259.48	0.01	0.02				
1A2 – Manufacturing industries and construction	211.21	0.03	0.00				
1A3 – Transport	713.14	0.11	0.04				
1A4 – Other sectors	57.94	1.98	0.03				
1A5 – Non-specified	0.00	0.00	0.00				
	NO	1.99	NO	NO	NO	NO	NO
1B1 – Solid fuels	0.00	1.99	0.00				
1B2 – Oil and natural gas	NO	NO	NO				
1B3 – Other emissions from energy production	NO	NO	NO				
	NO	NO	NO	NO	NO	NO	NO
1C1 – Transport of CO_2	NO						
1C2 – Injection and storage	NO						
1C3 – Other	NO						
2 – Industrial processes and product use	67.29	0.00	0.00	235.91	45.22	2.99	0.00
2A – Mineral industry	NO	NO	NO	NO	NO	NO	NO
2A1 – Cement production	NO						
2A2 – Lime production	NO						
2A3 – Glass production	NO						
2A4 – Other process uses of carbonates	NO						
2A5 – Other (please specify)	NO	NO	NO				
2B – Chemical industry	NO	NO	NO	NO	NO	NO	NO

2B1 – Ammonia production	NO						
2B2 – Nitric acid production			NO				
2B3 – Adipic acid production			NO				
2B4 – Caprolactam, glyoxal and glyoxylic acid production			NO				
2B5 – Carbide production	NO	NO					
2B6 – Titanium dioxide production	NO						
2B7 – Soda ash production	NO						
2B8 – Petrochemical and carbon black production	NO	NO					
2B9 – Fluorochemical production				NO	NO	NO	NO
2B10 – Other (please specify)	NO	NO	NO	NO	NO	NO	NO
2C – Metal industry	66.57	0.0005	NO	NO	45.22	NO	NO
2C1 – Iron and steel production	3.62	0.0005					
2C2 – Ferroalloy production	NO	NO					
2C3 – Aluminium production	62.95				45.22		
2C4 – Magnesium production	NO					NO	
2C5 – Lead production	NO						
2C6 – Zinc production	NO						
2C7 – Other (please specify)	NO	NO	NO	NO	NO	NO	NO
2D – Non-energy products from fuels and solvent use	0.15	NO	NO	NO	NO	NO	NO
2D1 – Lubricant use	0.15						
2D2 – Paraffin wax use	NO						
2D3 – Solvent use							
2D4 – Other (please specify)	NO	NO	NO				
2E – Electronics industry	NO	NO	NO	NO	NO	NO	NO
2E1 – IIntegrated circuits and semiconductors				NO	NO	NO	NO
2E2 – TFT flat panel display					NO	NO	NO
2E3 – Photovoltaics					NO		
2E4 – Heat transfer fluid					NO		
2E5 – Other (please specify)	NO	NO	NO	NO	NO	NO	NO

2F – Product uses as substitutes for ozone-depleting substances	NO	NO	NO	235.91	NO	NO	NO
2F1 – Refrigeration and air conditioning				235.91			
2F2 – Foam-blowing agents				NO			
2F3 – Fire protection				NO	NO		
2F4 – Aerosols				NO			
2F5 – Solvents				NO	NO		
2F6 – Other applications (please specify)				NO	NO		
2G – Other product manufacture and use	NO	0	0	0	0	2.99	0
2G1 – Electrical equipment					NO	2.99	
2G2 – SF_6 and PFCs from other product uses					NO	NO	
2G3 – N_2O from product uses			NE				
2G4 – Other (please specify)	NO	NO	NO	NO	NO	NO	NO
2H – Other	0.57	NO	NO	NO	NO	NO	NO
2H1 – Pulp and paper industry	NO	NO					
2H2 – Food and beverage industry	0.57	NO					
2H3 – Other (please specify)	NO	NO	NO				
3 – Agriculture, forestry, and other land use	1612.95	11.27	0.22	NO	NO	NO	NO
3A – Livestock	NO	10.30	0.10	NO	NO	NO	NO
3A1 – Enteric fermentation		8.68					
3A2 – Manure management		1.63	0.10				
3B – Land	1612.57	NO	NO	NO	NO	NO	NO
3B1 – Forest land	1637.44						
3B2 – Cropland	–24.86						
3B3 – Grassland	NO						
3B4 – Wetlands	NO		NO				
3B5 – Settlements	NO						
3B6 – Other land	NO						
3C – Aggregate sources and non-CO_2 emissions sources on land	0.37	0.97	0.13	NO	NO	NO	NO
3C1 – Emissions from biomass burning		0.97	0				

	0.03						
	0.34						
3C4 – Direct N_2O emissions from managed soils			0.09				
			0				
3C6 – Indirect N_2O emissions from manure management			0.04				
3C7 – Rice cultivation	NO	NO	NO				
	NO	NO	NO				
3D – Other	NO	NO	NO	NO	NO	NO	NO
3D1 – Harvested wood products	NO						
3D2 – Other (please specify)	NO	NO	NO				
4 – Waste	NO	9.61	0.05	NO	NO	NO	NO
4A – Solid waste disposal	NO	8.87	NO	NO	NO	NO	NO
4B – Biological treatment of solid waste	NO	NO	NO	NO	NO	NO	NO
4C – Incineration and open burning of waste	NO	NO	NO	NO	NO	NO	NO
4D – Wastewater treatment and discharge	NO	0.74	0.05	NO	NO	NO	NO
4E – Other (please specify)	NO	NO	NO	NO	NO	NO	NO
5 – Other	NO	NO	NO	NO	NO	NO	NO
5A – Indirect N2O emissions from the atmospheric deposition of nitrogen in NOx and NH3	NO	NO	NO	NO	NO	NO	NO
5B – Other (Please specify)	NO	NO	NO	NO	NO	NO	NO
Memo Items (5)							
International bunkers	62.86	0.0004	0.0018	NO	NO	NO	NO
1A3ai –International aviation (international bunkers)	62.86	0.0004	0.0018				
1A3di – International water-borne navigation (international bunkers)	NO	NO	NO				
1A5c – Multilateral operations	NO	NO	NO	NO	NO	NO	NO

A4.5 Uncertainty calculations for the period 1990–2011

The table below provides estimates of measurement uncertainties (without sinks) for key categories of GHG emissions (1990–2017).

TABELA A4.23:
Estimates of measurement uncertainties for key categories of GHG emissions (1990–2017)

2006 IPCC category	Gas	Base year 2019 Emissions or sinks	Emissions in 2017 (Gg CO2 equivalent)	Uncertainty of activity (%)	Uncertainty of emission factors (%)	Combined uncertainty (%)	Contribution to change by category in 2017	Trend of national emission inventory for 2017 (change/ increase) compared to the base year (% of base year)	Uncertainty presented as a trend in total national emissions (%)
1 – Energy									
1A1 – Electricity production – liquid fuels	CO_2	317.44	0.00	12.25	13.71	18.38	0.00	0.00	0.02
1A1 – Electricity production – liquid fuels	CH_4	0.31	0.00	12.25	405.63	405.81	0.00	0.00	0.00
11A1 – Electricity production – liquid fuels	N_2O	0.73	0.00	12.25	526.34	526.48	0.00	0.00	0.00
1A1 – Electricity production – liquid fuels	CO_2	1088.79	1259.48	12.25	23.18	26.21	2.39	115.68	1.50
1A1 – Electricity production – liquid fuels	CH_4	0.27	0.32	12.25	357.07	357.28	0.00	116.09	0.00
1A1 – Electricity production – liquid fuels	N_2O	4.91	5.70	12.25	517.83	517.98	0.04	116.09	0.00
1A2 – Manufacturing and construction – liquid fuels	CO_2	215.97	187.94	18.03	18.38	25.74	0.01	87.02	0.01
1A2 – Manufacturing and construction – liquid fuels	CH_4	0.21	0.18	18.03	286.96	287.52	0.00	85.87	0.00
1A2 – Manufacturing and construction – liquid fuels	N_2O	0.49	0.41	18.03	729.62	729.84	0.00	84.36	0.00
1A2 – Manufacturing and construction – solid fuels	CO_2	59.63	23.27	18.03	31.25	36.07	0.00	39.03	0.00

1A2 – Manufacturing and construction – solid fuels	CH_4	0.15	0.06	18.03	466.40	466.74	0.00	39.04	0.00
1A2 – Manufacturing and construction – solid fuels	N_2O	0.27	0.11	18.03	725.91	726.13	0.00	39.04	0.00
1A2 – Manufacturing and construction – biomass	CO_2	0.00	69.01	18.03	40.29	44.13	0.00	0.00	0.00
1A2 – Manufacturing and construction – biomass	CH_4	0.00	0.46	18.03	513.31	513.63	0.00	0.00	0.00
1A2 – Manufacturing and construction – biomass	N_2O	0.00	0.74	18.03	823.22	823.41	0.00	0.00	0.00
1A3a – Civil aviation – liquid fuels	CO_2	39.41	62.86	7.07	7.07	10.00	0.01	159.49	0.00
1A3a – Civil aviation – liquid fuels	CH_4	0.01	0.01	7.07	70.71	71.06	0.00	159.49	0.00
1A3a – Civil aviation – liquid fuels	N_2O	0.33	0.52	7.07	282.84	282.93	0.00	159.49	0.00
1A3b – Road transport – liquid fuels	CO_2	330.30	713.14	5.00	5.00	7.07	0.76	215.91	0.55
1A3b – Road transport – liquid fuels	CH_4	2.67	2.67	5.00	50.00	50.25	0.00	99.82	0.00
1A3b – Road transport – liquid fuels	N_2O	4.77	10.62	5.00	200.00	200.06	0.14	222.36	0.03
1A3c – Rail transport – liquid fuels	CO_2	4.11	0.00	5.00	5.00	7.07	0.00	0.00	0.00
1A3c – Rail transport – liquid fuels	CH_4	0.01	0.00	5.00	50.00	50.25	0.00	0.00	0.00
1A3c – Rail transport – liquid fuels	N_2O	0.47	0.00	5.00	200.00	200.06	0.00	0.00	0.00
1A3d – Navigation – liquid fuels	CO_2	3.16	0.00	7.07	7.07	10.00	0.00	0.00	0.00
1A3d – Navigation – liquid fuels	CH_4	0.01	0.00	7.07	70.71	71.06	0.00	0.00	0.00

1A3d – Navigation – liquid fuels	N_2O	0.03	0.00	7.07	282.84	282.93	0.00	0.00	0.00
1A4 – Other sectors – liquid fuels	CO_2	116.25	41.87	10.00	10.00	14.14	0.00	36.01	0.00
1A4 – Other sectors – liquid fuels	CH_4	0.34	0.13	10.00	100.00	100.50	0.00	37.80	0.00
1A4 – Other sectors – liquid fuels	N_2O	0.22	0.08	10.00	400.00	400.12	0.00	39.21	0.00
1A4 –Other sectors – liquid fuels	CO_2	60.19	16.08	10.00	10.00	14.14	0.00	26.71	0.00
1A4 – Other sectors – liquid fuels	CH_4	1.82	0.72	10.00	100.00	100.50	0.00	39.63	0.00
1A4 – Other sectors – liquid fuels	N_2O	0.27	0.07	10.00	350.00	350.14	0.00	26.71	0.00
1A4 – Other sectors – biomass	CO_2	752.24	696.28	10.00	27.37	29.14	0.67	92.56	0.40
1A4 – Other sectors – biomass	CH_4	52.51	48.69	10.00	329.10	329.25	0.17	92.72	0.00
1A4 – Ostali sektori – biomasa	N_2O	8.35	7.73	10.00	507.23	507.33	0.07	92.56	0.00
1A5 – Indefinite – solid fuels	CO_2	0.37	0.00	5.00	5.00	7.07	0.00	0.00	0.00
1A5 – Indefinite – solid fuels	CH_4	0.00	0.00	5.00	50.00	50.25	0.00	0.00	0.00
1A5 – Indefinite – solid fuels	N_2O	0.00	0.00	5.00	200.00	200.06	0.00	0.00	0.00
2 – Industrial processes									
2A2 – Production of lime	CO_2	24.75	0.00	15.00	0.00	15.00	0.00	0.00	0.00
2C1 –Manufacture of iron and steel	CO_2	16.61	3.62	10.00	25.00	26.93	0.00	21.78	0.00
2C1 – Manufacture of iron and steel	CH_4	0.05	0.01	10.00	25.00	26.93	0.00	21.78	0.00
2C3 – Manufacture of aluminium	CO_2	168.67	62.95	2.00	10.00	10.20	0.01	37.32	0.01
2C3 – Manufacture of aluminium	CF_4	1240.16	37.69	2.00	30.00	30.07	0.04	3.04	13.53
2C3 – Manufacture of aluminium	C_2F_6	247.73	7.53	2.00	30.00	30.07	0.00	3.04	0.54

	CO_2	2.21	0.15	14.14	50.00	51.96	0.00	6.63	0.00
	SF_6	0.78	2.99	60.00	58.31	83.67	0.00	383.29	0.00
	CO_2	0.56	0.57	0.00	0.00	0.00	0.00	102.19	0.00
3 – Agriculture, Forestry, and Other Land Use									
3A1 – Enteric fermentation	CH_4	483.90	216.94	48.99	97.98	109.54	1.45	44.83	0.60
3A2 – Manure management	CH_4	83.92	40.68	52.92	79.37	95.39	0.04	48.48	0.02
3A2 – Manure management	N_2O	57.93	28.62	52.92	132.29	142.48	0.04	49.40	0.01
3B1a – Forests and other forest land	CO_2	1865.98	1637.44	0.00	0.00	0.00	0.00	87.75	0.00
3B2a – Crops and other land under crops	CO_2	-109.79	-24.86	0.00	0.00	0.00	0.00	0.00	0.00
3C1 – Emissions from biomass burning	CH_4	1.84	24.22	0.00	0.00	0.00	0.00	1314.91	0.00
3C1 – Emissions from biomass burning	N_2O	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3C2 – Use of lime	CO_2	0.06	0.03	0.00	0.00	0.00	0.00	43.57	0.00
3C2 – Use of urea	CO_2	0.43	0.34	0.00	0.00	0.00	0.00	80.57	0.00
3C4 – Direct N_2O emissions from managed land	N_2O	46.25	26.33	0.00	0.00	0.00	0.00	56.93	0.00
3C5 – Indirect N_2O emissions from managed land	N_2O	17.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3C6 – Indirect N_2O emissions from manure management	N_2O	23.17	11.45	0.00	0.00	0.00	0.00	49.40	0.00
4 – Waste									
4A – Solid waste disposal	CH_4	151.07	221.76	50.00	50.00	70.71	7.40	146.79	4.89
4D – Wastewater treatment and discharge	CH_4	10.39	18.57	70.71	42.43	82.46	0.02	178.68	0.01

4D – Wastewater treatment and discharge	N_2O	9.73	13.55	50.00	50.00	70.71	0.03	139.32	0.02
5 –Other									
TOTAL									
		Sum (C): 7478.19	**Sum (C): 5765.50**				**Sum (H): 13.274**		**Sum (M): 22.167**
							Total inventory uncertainty: 3.643		**Trend uncertainty: 4.708**

BIBLIOGRAPHY

- Djurdjevic V. and Krzic A., 2013. High-Resolution Downscaling of ERA40 Reanalysis with Nonhydrostatic Regional NMMB Model, International conference climate change impacts on water resources, 17–18 October 2013, Belgrade, Serbia. Available at: http://www.jcerni.org/images/stories/cciwr/poster_CCIWR_2013.pdf
- European Environment Agency, 2017. Climate change, impacts and vulnerability in Europe 2016. An indicator-based report. Luxembourg.
- FAO, 2014. Global Forest Resources Assessment: Country Report – Montenegro.
- Hawkins, E. and Sutton, R., 2009. The Potential to Narrow Uncertainty in Regional Climate Predictions. Bulletin of the American Meteorological Society, 90(8), 1095–1107. https://doi.org/10.1175/2009bams2607.1.
- IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, https://doi.org/10.1017/CBO9781107415324.
- MedPartnership, 2013. Assessment of sea-level rise for the coastal area of Montenegro.
- Moss R et al., 2008: Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts, and Response Strategies. Intergovernmental Panel on Climate Change, Geneva, 132 pp.
- Ministry of Economic Affairs, Agriculture and Innovation and the Ministry of Sustainable Development and Tourism (2012) Technology Needs Assessment for Climate Change Mitigation and Adaptation for Montenegro: National Strategy and Action Plan.
- Ministry of the Economy (2019). Industrial Policy of Montenegro 2019–2023.
- Ministry of Sustainable Development and Tourism (MSDT) (2019) Montenegro: Second Biennial Update Report on Climate Change (BUR). Available at https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/5937861_Montenegro-BUR2-1-SECOND%20BIENNIAL%20UPDATE%20REPORT%20ON%20CLIMATE%20CHANGE_Montenegro.pdf.
- Ministry of Economy (2019): Industrial Policy of Montenegro 2019–2023.
- Ministry of Economy (2019): Energy Efficiency Action Plan of Montenegro for the period 2019–2021
- Ministry of Sustainable Development and Tourism (2018): National strategy with action plan for transposition Ministry of Economy (2015): Energy Development Strategy of Montenegro by 2030. – Action Plan 2016–2020, implementation and enforcement of the EU acquis on environment and climate change 2018–2020.
- Ministry of Transport and Maritime Affairs (2019): Transport Development Strategy of Montenegro 2019–2035.
- MSDT, 2015, The second national communication on climate change of Montenegro to the United Nations Framework Convention on Climate Change.
- MSPE, 2010, The initial national communication on climate change of Montenegro to the United Nations Framework Convention on Climate Change.
- MONSTAT (2017). Electrical Energy Balance 2017.
- Nature and Environment Protection Agency (2019): State of the Environment Report for 2018
- OECD (2017) DAC Statistics. Available at: http://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm.
- Regional Environmental Center for Central and Eastern Europe (REC), 2015. Forest Fires in South Eastern Europe – A Regional Report.
- UNECE, 2015. Environmental Performance Review – Montenegro. Third Review.

TRANSLATION
Tanja Luburic
Uros Zekovic
Tamara Jurlina

PROOFREADING
Peter Stonelake

DESIGN
Suzana Pajović

UNITED NATIONS DEVELOPEMNT PROGRAMME (UNDP) IN MONTENEGRO
UN Eco Building | Stanko Dragojević b. b. | 81000 Podgorica | Montenegro

CIP – A catalogue record for this book is available
at the Central National Library of Montenegro, Cetinje

ISBN 978-9940-614-38-6
COBISS.CG-ID 14654468

ISBN 978-9940-614-38-6