FOURTH NATIONAL COMMUNICATION OF BOSNIA AND HERZEGOVINA

Under the United Nations Framework Convention on Climate Change

October, 2021

Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina

Ministry of Spatial Planning, Construction and Ecology of Republic of Srpska

Federal Ministry of Environment and Tourism

Department for Spatial Planning and Legal-Property Affairs of Brcko District

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EXECUTIVE SUMMARY

COUNTRY CONTEXT

Geographical characteristics	Bosnia and Herzegovina has a total surface area of 51,209.2 km2, consisting of 51,197 km2 of land and 12.2 km2 of sea. Of the total land area, 42% are mountains, 24% hills, 29% karst regions and 5% lowlands. The average altitude is 500 meters, and less than 8% of the surface is situated at an altitude of less than 150 m above sea level. Bosnia and Herzegovina borders the Republic of Croatia (931 km) in the north, northwest and south, and the Republic of Serbia (375 km) and the Republic of Montenegro (249 km) in the east, while in the south, in Neum, it reaches the Adriatic Sea in the length of 21.2 km.
Population trends	According to the data of internationally recognised estimates and population projections prepared by the Department of Economic and Social Affairs (Population Division) of the United Nations Secretariat, it is estimated that in Bosnia and Herzegovina in 2025 there will be 3.212 million inhabitants, and in 2050 2.685 million.
Climate	There are three dominant climates in Bosnia and Herzegovina: (i) continental and temperate continental climate in northern Bosnia and in the valleys of the middle stretches of the Una, Sana, Vrbas, Bosnia and Drina Rivers, (ii) mountain and sub-mountain climate that includes hilly-mountainous area of Bosnia and Herzegovina that stretches from the northern border to the southern border represented by a line extending from Posušje and the southern slopes of Čabulja, Velež and Bjelašnica mountains to Bileća, and (iii) Mediterranean and modified Mediterranean climate in the southwest of the country, in the territory of Herzegovina.
Economy and industry	Data from the Agency for Statistics of Bosnia and Herzegovina for 2015 show that the value of GDP amounted to BAM 28,540 million, and compared to 2014, the nominal was higher by 4.52% while the real growth was 3.03%. The average GDP per capita was BAM 7,473. During 2016, an increase in the physical volume of industrial production of 4.3% was registered in Bosnia and Herzegovina compared to 2015. This increase in the volume of production was accompanied by an increase in the number of employees within the industry of 2.5%.
Energy	The total gross production of electricity in Bosnia and Herzegovina in 2016 amounted to 17,767 GWh, which is a 14% increase compared to 2015 (15,629 GWh). Electricity production (gross) in hydropower plants amounted to 5,641 GWh, in thermal power plants it was 11,673 GWh, while in industrial power plants it amounted to 453 GWh. Own consumption in the energy sector amounted to 1,158 GWh.
Transport	The total length of the road network in Bosnia and Herzegovina is 22,976 km. Observed by category, motorways account for 172 km, main roads 3,870 km, regional roads 4,734 km, and 14,200 km other/local roads. Air traffic data show that there are 27 officially registered airports in Bosnia and Herzegovina. However, only 4 airports are registered for international traffic, namely Sarajevo, Banja Luka, Mostar and Tuzla.
Agriculture	The share of the sector of agriculture, hunting and related service activities in the structure of GDP for 2016 amounted to 6.37% or BAM 1.9 billion. Of the total area of Bosnia and Herzegovina, which amounts to 5,113 million hectares, about 47% is agricultural land. Only about 0.65% of area suitable for agriculture is irrigated.
Forestry	Forests in Bosnia and Herzegovina in 2017 cover 2.60 million hectares, which is 50.77% of the total area of Bosnia and Herzegovina. Along with the trend of increasing the area under forests and the volume of felling, there is a trend of decreasing the volume of afforestation.

Waste management	The estimated amount of municipal waste generated in Bosnia and Herzegovina in 2016 was 354 kg per capita per year, or 0.97 kg per capita per day. On average, 68% of the population utilises municipal waste disposal services.
Water management	Hydrographically, 75.5% of Bosnia and Herzegovina belongs to the Black Sea basin, with the most significant tributaries: the Una, Vrbas, Drina, Bosna and Sava Rivers, and 24.5% belongs to the Adriatic Sea basin with the most significant tributaries: the Neretva and Trebišnjica Rivers.
Tourism	In the period 2008-2018, the number of tourists at the level of Bosnia and Herzegovina grew at an annual rate of 8.7%, and the number of overnight stays at an annual rate of 7.8%. Based on official tourism statistics, the average increase since 2010 is close to 14% per year, and there is still enough room for more efficient use of tourism potential.
Healthcare	Diseases of the circulatory system and malignant diseases account for almost three quarters of all causes of death in Bosnia and Herzegovina. Among the five leading causes of death are diseases of the respiratory system.
Education	In Bosnia and Herzegovina at the beginning of the school year 2015/2016, 291,342 pupils were enrolled in 1,850 primary schools, which is 1.8% less than in the previous school year, while 133,228 students were enrolled in 311 secondary schools, which is 7.4% less than in the previous school year. There are 8 public higher education institutions and 29 private higher education institutions (including independent colleges and universities) in Bosnia and Herzegovina, which offer a total of about 500 study programs.

INVENTORY OF GREENHOUSE GAS EMISSIONS

The energy sector continues to make the largest contribution to CO_2 emissions, with a share of 76%, followed by the industrial sector of 11% and the agricultural sector of 7% and the waste sector of 6% in 2015. In 2016, the energy sector gave the largest contribution to CO_2 emissions, with a share of 79%, followed by the industrial sector of 9% and the agricultural sector of 7% and the waste sector of 5%.

Compared to 1990, there was a decrease in total CO_2 emissions by 21.03% in 2015, or 12.83% in 2016, without sinks. Compared to 2014, there is a increase in total CO_2 emissions by 3.16% in 2015, and by 13.85% in 2016 without sinks.

The assessment of the quality of the inventory as well as the accuracy of the results has not been verified by independent experts. Furthermore, indirect greenhouse gas emissions are not calculated.

VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

Climate change and increased frequency and intensity of extreme climate events have caused increased pressure in the sectors of agriculture, healthcare, forestry and tourism sectors, as well as in management of water resources and protected areas. There was an increase in variability and intensity of extreme weather conditions (heat waves, intensive rainfall, windstorms, days with hail, etc.). In the last five years, Bosnia and Herzegovina has been facing with several significant extreme climate and weather episodes that have caused substantial material and financial deficits, as well as casualties. The two most important events are drought during 2012 and flooding during 2014.

Observed climate change

As part of the preparation of this Fourth National Communication, the analysis of meteorological data covered the period from 1961 to 2016. At all meteorological stations in Bosnia and Herzegovina, the coldest month is January, with an average temperature of -3.8°C in Sokolac to 5.3°C in Mostar. The warmest month is July, with

the highest average air temperature in the eastern and southern part of the territory (Bijeljina 21.8°C, Bileća 22.1°C and Mostar 25.4°C). Of the ten warmest years in the period 1961–2016, nine years have been recorded since 2000 (only 1994 was among the ten warmest). The warmest years in the analysed period were: 2000, 2007, 2008 and 2014. The year 2014 was the warmest year in most of Bosnia and Herzegovina. In the analysed period, all indices of warm temperature extremes have positive trends, while the indices of cold temperature extremes have negative trends. However, both trends point to global warming in Bosnia and Herzegovina. In the entire territory of Bosnia and Herzegovina, there is a negative trend in the annual number of frosty days, which is statistically significant in almost all areas. Negative trend values range from 2.1 to 6.4 days per decade. The number of summer days (5.3 days in a decade), tropical days (4.8 days in a decade) and tropical nights (in Mostar 6.3 days in a decade) has a positive trend.

In the period from 1961 to 2016, most of the territory of Bosnia and Herzegovina was characterised by a slight increase in the amount of rainfall annually. Linear trends for the multi-year period from 1961 to 2016 indicate stagnation or a slight increase in the amount of rainfall on the entire territory of Bosnia and Herzegovina. Although significant variability in precipitation has not been recorded, the pluviometric regime, or the annual distribution, has been greatly disrupted. Extreme daily precipitation indices in Bosnia and Herzegovina showed mostly weak, insignificant and mixed trends. The analysis of probability density functions also confirmed that for most indices there were no significant changes in the extreme precipitation indices in the period from 1991 to 2016. compared to the period from 1961 to 1990. However, the results obtained suggest a general increase in heavy rainfall.

During the last two decades, there has been observed a trend of increasing intensity and frequency of maximum gusts of wind in Bosnia and Herzegovina.

Projections of future climate change

According to the presented results of climate projections obtained by global and regional climate models, and based on four different scenarios of future climate change, it can be concluded that in the future we can expect further temperature rise in Bosnia and Herzegovina in the range from 1°C to 6°C depending on climate scenario. The largest change is for the case of scenario RCP8.5 while the smallest is for the case of scenario RCP2.6. In the case of the RCP2.6 scenario, it can be expected that in the near future the temperature rise trend will become close to zero which would lead to some kind of stabilisation in terms of further temperature rises. Temperature changes are somewhat more pronounced in the case of maximum daily temperatures compared to mean daily and minimum temperatures.

The change in precipitation is somewhat more complex and only in the case of the RCP8.5 scenario can a significant decrease in annual mean values be expected, however all analysed scenarios show that the chances of summer precipitation loss are higher, when according to the RCP8.5 scenario this negative change can be less than -30%, which would certainly represent a significant pressure on the living world, but also certain socio-economic sectors, such as agriculture, forestry and water resources.

Finally, the analysis of climate scenarios shows a significant increase in warm extremes and a decrease in cold extremes, with changes again the largest for the RCP8.5 scenario, while in the case of extreme precipitation index results show a similar positive change, in terms of increasing intensity and frequency of these extremes. regardless of scenarios and analysed future periods. Finally, a further rise in temperature will lead to a prolongation of the vegetation period.

Agriculture

Agriculture is one of the sectors most affected by climate change in Bosnia and Herzegovina. The projected rise in temperature, combined with changes in precipitation and evaporation rates, is likely to have a significant negative impact on agricultural systems in Bosnia and Herzegovina. Climate change in the future will lead to an increase in the growing period and a shift in the onset of growing. It is expected that climate change will have a positive effect on yields and quality of winter crops due to the extended growing period. However, due to high temperatures, heat stress and lack of precipitation, there will be a reduction in the variability of yields, the quality of arable, vegetable and fruit crops, the occurrence of diseases and pests, soil degradation and other problems. Nevertheless, estimates from a number of studies covering many regions and crops show that negative impacts of climate change are more common than positive ones. Rising temperatures and droughts will certainly jeopardise fruit production, with the additional occurrence and development of diseases and pests. Climate change is increasing the spatial distribution and intensity of the development and spread of diseases, pests and invasive thermophilic weeds. The possible effects of climate change on food production are not limited to plant production only, but also have far-reaching consequences for the production of milk, meat and other animal products, primarily through the impact on animal feed production, health and reproduction of domestic animals. Fisheries are also at risk. The lack of precipitation in the spring-summer period lowers the biological minimum in all water courses, which adversely affects the process of reproduction and sustainability of the fishing ecosystem. Land degradation is one of the main problems of humanity, which is further accelerated by weather disasters.

The answer to reducing high vulnerability in the agricultural sector should focus on important issues such as human capacity building to understand this issue, increase soil water retention capacity, application of conservation tillage measures, cultivation of adequate species and varieties resistant to climate change, introduction of irrigation systems in all agricultural areas of Bosnia and Herzegovina, construction of water reservoirs and ponds for irrigation, application of anti-erosion measures and introduction of agroforestry as a measure to mitigate the effects of high temperatures, biodiversity protection and landscaping.

Water resources

Precipitation analysis in Bosnia and Herzegovina was performed for two main catchment areas, the Sava (Danube) River Basin and the Adriatic Sea Basin. Having analysed a series of annual precipitation supplemented with the values for the period 2015-2018 both for the Sava River Basin and the Adriatic Sea Basin, it can be immediately noticed that the extreme values of the total series have not changed. The value range (distribution) decreased compared to the period 1991-2014, but are still significantly higher compared to the period 1961-1990. In relation to the series of 1961-1990 in the Sava River Basin, the average annual precipitation was 46.6 mm higher in the period 1991-2018 than in the period 1961-1990, which is a slightly higher value of the increase than in the period 1991-2014. However, the average value of annual precipitation recorded in Mostar in the period 1991-2018 was 69 mm less than in the period 1961-1990, and about 15 mm lower than in the period 1991-2014.

The results show that the overall change in annual flows is small, however strong changes in the seasonal regime and extreme events are expected. Observing the seasons, the most significant change is the increase in water runoff in the winter season. This change is the result of a significant rise in temperatures, which either lead to less snow and more rainfall in the winter months or to accelerated snowmelt in early spring. This significantly reduces river flow in the spring and summer seasons.

In the last two decades, Bosnia and Herzegovina has been affected by several extreme floods (2004, 2010, 2014). In mid-May 2014, extreme floods occurred, affecting Bosnia and Herzegovina and the wider region. The floods

resulted from several days of rain (the highest precipitation ever recorded since the beginning of organised measurements, i.e. the last 120 years), which coincided with the field water saturation, which contributed to an extreme rise in water levels in an extremely short time, especially on the rivers Bosna, Sava, and Drina to a lesser extent, as well as their tributaries.

The events of recent decades show that in Bosnia and Herzegovina, more and more frequent floods are caused by heavy regional precipitation, which may even overcome the previous catastrophic floods. The danger of floods is also increased by mild winters with little snow, with the appearance of heavy rain that falls for hours, or heavy snow with extreme temperature oscillations.

Water resources are highly endangered and the threat will increase over time. Changes can be expected in terms of time of occurrence, frequency and intensity of extreme events - floods and droughts. This will result in a general reduction in the availability of water resources in the growing period, when the needs are greatest, in terms of water quantity and quality, because in low-water periods the potential danger of water quality degradation increases. A significant increase in air temperature during the winter season will result in a decrease in snowfall, i.e. a decrease in flow in most water courses in the spring months. On the other hand, the expected more frequent precipitation of higher intensity will cause greater runoff, often accompanied by floods. With the increase of time inequality, the problems related to the pronounced spatial inequality are exacerbated - the poorest are the parts with the greatest water needs, valleys where the population is the largest and where the greatest land potentials are for intensive agriculture, with the necessary irrigation.

In order to reduce the risk and impact of disasters, it will be necessary to implement a number of institutional and organisational measures that include providing information related to climate, establishing systems for meteorological and hydrological forecasts, raising awareness and establishing mechanisms for effective societal responses to extreme events. In addition, in the long run, structural measures are of great importance for water resources. The use of multi-purpose infrastructure could reduce the risk of adverse effects of climate change in the future.

Forest ecosystems

According to the available models, by increasing the average annual temperatures, fundamental changes in forestry, as well as in general land use and management, can be expected and required. This is accompanied by the burden of socio-economic and environmental consequences. The projected climate change will not have the same impact on all forest ecosystems in Bosnia and Herzegovina. A special impact that can occur as a result of climate change is "multiple stress", which at the same time brings changes in soil moisture, changes in average and extreme temperatures, as well as a change in the amount and distribution of precipitation (snow-rain, drought-flood), and thereby the number of pests and pathogens. All together it contributes to the high mortality rate of trees.

Taking into account the latest world research, the results of the impact of climate change and possible scenarios, it is very certain that the dynamics of growth and production of wood mass in the forests of Bosnia and Herzegovina in the coming period will decline and that it will be among the first and most disturbed parameters. In some parts of Bosnia and Herzegovina, an increased risk of forest fires caused by rising temperatures and changes in precipitation is expected, which calls for an expansion of fire protection capacity. All these aspects (weather, pests, pathogens, fires) can, over a long period of time, lead to reduced productivity and poorer forest health in Bosnia and Herzegovina.

In short, due to the multiple stress to which forest habitats and trees are exposed, climate change is likely to affect some more sensitive ecosystems. The ecological and economic importance of forests in Bosnia and

Herzegovina means that these impacts could cause serious consequences for the entire country. Approaches to climate change adaptation will require better information in the forest management process, in order to provide support in adaptation processes.

Biodiversity and sensitive ecosystems

Climate change has a significant impact on ecosystems and biodiversity, and thus on their capacity to provide environmental services. Ecosystems are able to cope to some extent with emerging changes. However, climate change is taking place much faster than in the past, which calls into question the ability of ecosystems to adapt.

Species that have lived at high latitudes or higher altitudes will be replaced by species whose range shifts from the south or from lower altitudes, which may lead to the extinction of certain species, especially those associated with high mountains. Vegetation models predict further ecosystem shifts at higher altitudes, meaning that the upper limit of forest ecosystems will shift to the detriment of subalpine grassland communities. Increasing the concentration of CO_2 in the atmosphere will allow more efficient use of water by plants because they will be able to absorb the same amount of CO_2 with less opening of the stoma. In this way, plant species will be able to grow in areas that were once too arid for them.

Climate change is leading to an increase in extreme events such as forest fires. Hot and dry summers and strong winds increase the risk of fires that can spread quickly and cover large areas. Five fire zones have been identified in Bosnia and Herzegovina: Low Herzegovina, High Herzegovina, Centre, West and North.

Tourism

Climate change is having an increasing negative impact on tourism development. In Bosnia and Herzegovina, climate change has a particularly negative impact on winter ski tourism, which traditionally develops in the area of the Olympic mountains of Bjelašnica and Jahorina, as well as mountains of Vlašić, Kupres, Ravna planina and many other smaller ski centres. Increasing the average daily and annual air temperatures, reducing the amount of snowfall, and the height and duration of the snow cover, already has a negative impact on the business of winter tourist centres in Bosnia and Herzegovina. High vulnerability in the tourism sector of Bosnia and Herzegovina is a direct consequence of the inadequate tourist offer to the projected climate scenarios. Winter mountain centres in Bosnia and Herzegovina should mostly work on diversifying their offer and developing tourist activities that are not related to traditional ski tourism.

Climate change will lead to various implications for tourist destinations, however not all are necessarily negative. Increasing the average annual temperature could create more favourable conditions during spring and summer, thus alleviating the current problem of mountain tourism - dependence on the winter season. Increasing summer temperatures in cities and lower regions will contribute to the attractiveness of mountain centres, as tourists will seek refreshment at higher altitudes. Mountain destinations will need to improve the offer of selective forms of tourism, develop and promote rural tourism in rural households, create a tourist offer based on natural tourist motives, active vacation (mountaineering, hiking, mountain biking, canyoning, paragliding, etc.). The tourism sector in Bosnia and Herzegovina will be forced to constantly enrich the tourist offer and create new tourist products, which will have a positive impact on the competitiveness of domestic destinations, both regionally and internationally, and on the structure of guests. In addition to existing products, Bosnia and Herzegovina will have to develop forms of tourism that do not depend on weather conditions, such as wellness and spa tourism, congress tourism, visits to museums, galleries, etc., which could attract more tourists.

Human health

The effects of climate change on human health are direct and indirect. Direct effects include: extreme heat and cold, floods and other extreme weather events, and ultraviolet radiation. Indirect effects of climate change are visible through a change in the vector image of infectious diseases, a higher incidence of cardiovascular and respiratory diseases, malnutrition due to loss of arable land, and deterioration of mental health of the affected population.

Public health is highly exposed to climate change, and the consequences can cause serious disruptions to the functioning of society as a whole. The main expected impacts of climate change that cause high vulnerability in the healthcare sector are: increased mortality and changes in the epidemiology of chronic noncommunicable diseases and acute communicable diseases, and the impact on the epidemiology of diseases associated with climatological factors (vector diseases). Diseases caused by environmental, as well as meteorological and climatological factors, significantly contribute to the burden on the health of the population and the health system itself because they lead to high costs of health care, overexploitation of key potentials, prevent optimal health and well-being, and undermine social and economic development.

Of all the extreme meteorological events, heat waves are mostly associated with population morbidity but also with a high mortality rate, and represent an important and global public health problem. Climate change and excessive heat as its consequence, mostly affect vulnerable population groups - young children and the elderly, pregnant women, the chronically ill, and people who work outdoors, such as construction and agricultural workers. The predicted rise in temperatures is expected to particularly affect patients with cardiovascular, cerebrovascular, respiratory and neurological problems, allergic reactions and other acute reactions to the effects of heat waves, as well as the elderly population. Higher temperatures may also contribute to the spread of disease vectors, resulting in an increased incidence rate of communicable diseases, especially those caused by contaminated water and food. Climate change can have a major impact on the movement of vector (transmissible) diseases, the causes of which are transmitted by mosquitoes, ticks and other insect species.

Bosnia and Herzegovina has not established a system for monitoring the movement of diseases that can be linked to climate change, nor has a clear methodology been developed to respond to the impact of climate change on the health of the population.

In the long run - preventing increased morbidity and mortality caused by extreme temperatures, atmospheric pollution, increased natural disasters, and reduced arable land - is the only way to preserve global health. Public participation is crucial in defining efficient responses to climate change adaptation. Therefore, it is necessary to continuously inform the public about the possible impact of climate change on human health. The informed public, through appropriate measures, can have a significant impact on reducing high vulnerability in the health sector.

ESTIMATING THE POTENTIAL FOR CLIMATE CHANGE MITIGATION

Given that over 50% of greenhouse gas emissions come from the power sector and that about 70% of electricity (varies depending on the annual distribution and precipitation) is produced in coal-fired power plants, which have relatively high specific emission of carbon dioxide, it is concluded that the greatest potential for reducing greenhouse gas emissions is in the power sector. The use of this potential should go in three directions:

1. construction of RES plants, especially those that can play a role in security of supply and development of other sectors of the economy in Bosnia and Herzegovina (wood biomass power plants, biogas power

plants and storage hydropower plants, which will enable the integration of larger capacities of wind and solar power plants),
2. reduction and management of electricity needs with reduction of losses in electricity transmission and distribution,
3. gradual closure of existing inefficient coal-fired power plants and replacement of a smaller part of the existing ones with new and more efficient thermal power plants, taking into account that total emissions are reduced at the target rate.

An additional potential in the power industry is the decentralisation of production, energy consumers should be enabled to become energy producers. The use of advanced networks, smart systems and energy storage will enable flexible consumption and greater integration of RES. In this part, there is a great potential of civil energy projects primarily through the construction of solar power plants and wind farms at a later stage. In order to enable such projects, a reform of the existing incentive systems in the Entities is needed.

In the context of exploiting the potential of biomass, it is necessary to emphasise the need to regulate the biomass market by introducing the principle of cascading use of wood. This would result in the use of the lowest quality biomass for energy production.

In second place in terms of emission reduction potential is the building sector. Given the current situation, which is characterised by high energy needs for heating (on average about 200 kWh/m^2 per year) and low efficiency of the heating system, it can justifiably be said that the potential in the building sector is high (highest in residential buildings), and that systemic measures by 2030 can reduce emissions by about 20% (with an annual refurbishment rate of 1%). The exploitation of this potential can be achieved by implementing measures related to:

1. reduction of thermal needs for existing buildings and construction of new highly efficient buildings (in accordance with EU standards),
2. replacement of heating energy sources with the use of certified and efficient heat production equipment (condensing boilers, heat pumps, regulation, etc.) and
3. connection of buildings to district heating with zero or low GHG emissions.

Additional potential for reducing (indirect) GHG emissions lies in the decarbonisation of domestic hot water preparation, which is currently heated predominantly by electricity from the grid. Centralised heat supply for domestic hot water heating (via district or block heating) reduces the load on the electricity network, reduces the need to build new generation capacity and allows greater integration of intermittent RES (wind and solar energy).

There is significant potential for reducing emissions in industry through increased energy efficiency and the use of RES, especially through on-site electricity generation to cover part of its own needs. The market will encourage the industry towards decarbonisation because it is a matter of competitiveness. In addition, there must be a system of incentives by the state (e.g. net metering or net billing, energy efficiency education, models for financing measures, etc.). However, in the period until 2030, no significant reduction in emissions from industry is expected because energy efficiency measures and the application of RES will be largely compensated by increasing the volume of industrial production.

In transport, the greatest potential for reducing GHG emissions lies in electrifying transport through electrification of public transport, switching (one part) of road freight and passenger transport to rail and increasing the share of electric and/or hybrid as well as plug-in passenger vehicles, and encouraging non-motorised modes of transport. The development of public electrified transport would reduce the share of individual Road transportation and thus improve air quality in many cities (with a reduction in GHG emissions).

By encouraging the procurement of electric and/or hybrid as well as plug-in passenger vehicles, emissions can be reduced, especially having in mind the expected reduction of the emission factor of the electricity network. There is a significant potential in the development of non-motorised modes of transport (cycling and walking) in urban areas, which should be set at a high level of priority in spatial planning. None of the above measures has so far been sufficiently recognised in the sectoral strategic documents. Due to the planned increase in the volume of transport, possible measures may only mitigate the continuing trend of increasing emissions.

In agriculture, there is significant potential for reducing emissions through multiple benefit measures such as biogas production and its use for electricity and heat production. Such plants (biogas plants) eliminate methane emissions and convert it into useful forms of energy. In doing so, they can play a significant role in balancing the grid, and above all provide an additional source of income to farmers and contribute to the sustainability of agricultural production.

Proven tendencies to increase the volume of felling in the last 10 years do not follow with the same intensity the increase of the area under forests, which can be characterised as a negative effect in the direction of reducing greenhouse gas emissions. Nevertheless, today it is possible to identify measures whose application in the field of forestry can contribute to the overall potential of climate change mitigation. This primarily refers to the full certification of the entire forest fund in Bosnia and Herzegovina in order to improve the sustainable management of forest complexes. One of the most important measures is the continuous afforestation of degraded forest cover and afforestation and rehabilitation of forest bare lands in order to maintain and preserve the existing forests and their surface increase in the coming period.

In the field of waste management, the potential for reducing emissions is, above all, in waste prevention (resource efficiency, cleaner production), separate collection, recycling and reuse of waste, production of biogas and compost from organic waste to reduce the amount of waste for disposal to a minimum. In addition to reducing direct methane emissions, these measures also indirectly reduce emissions because they reduce the energy required to produce new materials and replace the use of fossil fuels. There is significant potential in landfills through the installation of landfill gas collection and utilisation systems.

Bosnia and Herzegovina is in the process of opting for significant quantitative reductions in GHG emissions. By signing the Green Agenda for the Western Balkans, Bosnia and Herzegovina has committed itself to contributing to Europe's climate neutrality. The key challenge is to take advantage of the transition to a low-carbon economy to achieve the goals of rapidly improving the economic situation and social cohesion. In this process, there is potential for economic growth and job creation that would be the result of investing in emission reduction projects in the sectors of electricity, district heating, buildings, transport, waste and especially for the sustainability of agriculture and forestry.

Bosnia and Herzegovina should focus on building new capacities in RES, taking into account the security of energy supply with a gradual reduction of coal production and active work on a fair transition of mining areas with the use of international funds for this purpose. In the current economic situation, Bosnia and Herzegovina does not have sufficient resources to restructure the regions dependent on coal mines.

Conducted scenario analyses have shown that the potential to reduce GHG emissions is slightly more than one third by 2030, and almost two thirds by 2050 compared to 1990. Taking into account the size of the GHG sinks in 2014 and emissions under the mitigation scenario in 2050, total net emissions in 2050 would be around 5,330 Gg CO_{2eq} (taking into account emissions from sectors not taken into account here) which is about 80% less than net emissions in 1990.

In order to use these potentials, it is necessary to implement measures that are demanding both in terms of planning and finances. Therefore, intensive international assistance is needed for capacity building, education,

technology transfer, establishment of financial mechanisms to encourage decarbonisation, preparation of the necessary study and project documentation, as well as project financing itself.

OTHER RELEVANT ACTIVITIES

Technology needs assessment for mitigation and adaptation

Nationally Appropriate Mitigation Actions (NAMAs) – are a significant mechanism to support climate change mitigation through international funding, technology transfer and capacity building. In Bosnia and Herzegovina, a mechanism has been established for approving and sending NAMA projects under the UNFCCC registry, the purpose of which is to record the demand for international support for the implementation of NAMAs in order to facilitate obtaining financial resources, technology and capacity building support through these measures.

Based on climate scenarios and climate change mitigation scenarios within the preparation of the Fourth National Communication, the *2020-2030 Climate Change Adaptation and Low-Emission Development Strategy of Bosnia and Herzegovina* was initiated. The Strategy represents a significant and important step forward towards a sustainable "green economy" in Bosnia and Herzegovina and clearly defines measures and activities for reducing GHG emissions and climate change adaptation, as well as the resources necessary for their implementation.

In October 2015, Bosnia and Herzegovina submitted the first Intended Nationally Determined Contribution (INDC), and ratified the Paris Agreement by the Decision on Ratification of the Paris Agreement in accordance with the UNFCCC (Official Gazette of BiH - International Agreements, No. 01/17). Under the provisions of the Paris Agreement, states have an obligation to submit updated and more ambitious documents on climate change mitigation activities every five years. With this in mind, in March 2021 Bosnia and Herzegovina adopted, and in April 2021 submitted to the United Nations Framework Convention on Climate Change (UNFCCC) updated Nationally Determined Contribution (NDC) reaffirming its commitment to fulfilling the Paris Agreement. Bosnia and Herzegovina is one of the first countries in the Western Balkans to adopt an updated NDC with a plan to reduce greenhouse gas emissions.

As part of the process of drafting this report, the Technological Needs Assessment for climate change mitigation and adaptation for the sectors of agriculture and water resources was initiated and its basic findings are given in Chapter 5.1.5.

Overview of plans and programs for systematic observing

One of the important assumptions to successfully combat climate change is the strengthening of capacity; i.e. institutional and staff training and development, and improving of meteorological monitoring. In order to develop a sustainable system for the estimation of GHG emissions and their elimination in the long term, it is recommended to revise relevant environmental and air protection laws in accordance with the general requirements of Regulation (EU) no. 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at the levels of Bosnia and Herzegovina and the Union relevant to climate change and repealing Decision No 280/2004/EC, in order to prescribe the preparation and implementation of subsidiary legislation, which will primarily establish a mandatory data flow system between the competent authorities with clear responsibilities and deadlines.

Education, training and raising awareness

Activities conducted so far in the field of education and raising awareness about climate change have not been well organised and the results are quite modest. Therefore, a better education in the sphere of environmental protection and raising awareness are of particular importance because it can help in the implementation of long-term strategies and policies related to climate change. It is very important to organise a coordinated joint implementation between different stakeholders, especially government institutions and civil society.

In Bosnia and Herzegovina, there is a need to raise the level of knowledge of current staff to a higher level in the environmental sector at all administrative levels, which requires the development of long-term strategies with actions and time intervals formed on the basis of needs assessment.

It is necessary to organise trainings that will meet the goals set by the Strategy in cooperation with organisations/institutions that have the capacity for such trainings. On the other hand, environmental officials should transfer the acquired knowledge to the industry sector in the form of training programmes, focusing on pollution prevention, the Environmental Management System (EMS) and the introduction of standards in order to establish adequate and efficient cooperation in sector of the economy.

By introducing educational programmes, current staff could increase their skills and new staff would be trained.

In the current education system, school curricula still do not include environmental issues to the extent that they should, so it is necessary to develop programmes that will integrate the environment in the curricula of primary, general and vocational secondary schools and universities, and especially in curricula of biotechnical and technical faculties as well as faculties of natural sciences and faculties of economics and of law.

Training needs for the purpose of strengthening capacity and raising public awareness are presented in detail in the Chapter 5.3.

Preparation of operational programmes to inform the public

In order to implement adaptation and mitigation programmes, it is necessary for the information to reach all levels, types and profiles of education, all citizens, business organisations and all government employees. Basic concept for the overall information system remains unchanged when compared to the Second and Third National Communications.

In the period between the two reports, work continued on the functioning of the website www.unfccc.ba and informing the public about the situation regarding climate change in the world and in Bosnia and Herzegovina. As part of the preparation of this report, the Interactive Climate Atlas of Bosnia and Herzegovina was updated and improved.

CONSTRAINTS AND GAPS

This chapter provides an overview of the constraints and obstacles related to institutional, legal, financial and technical capacity, as well as human resource capacity in Bosnia and Herzegovina that affect the implementation of obligations under the United Nations Framework Convention on Climate Change.

1 COUNTRY CONTEXT

1.1 Structure and institutional framework

Bosnia and Herzegovina is a sovereign state with a decentralised political and administrative structure. It comprises two entities: the Federation of Bosnia and Herzegovina (FBiH) and the Republika Srpska (RS), and the Brčko District (BD). The Federation of Bosnia and Herzegovina is divided into 10 cantons.

Figure 1: Administrative organisation of Bosnia and Herzegovina

According to Annex IV of the Dayton Peace Agreement, which is the Constitution of Bosnia and Herzegovina, issues such as foreign policy, foreign trade policy and customs policy are the responsibility of the institutions of Bosnia and Herzegovina. All functions and powers that are not explicitly assigned by the Constitution to the institutions of Bosnia and Herzegovina belong to the entities. Therefore, environmental protection in Bosnia and Herzegovina is the responsibility of the Federation of Bosnia and Herzegovina, the Republika Srpska and the Brčko District, respectively.

Nevertheless, Bosnia and Herzegovina has certain competences in the areas of implementation of international agreements and the environment. The Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina is responsible, inter alia, for performing tasks and duties within the competence of Bosnia and Herzegovina related to defining policy, basic principles, coordinating activities and harmonising plans of entity

authorities and institutions at the international level in the areas of agriculture, energy, environmental protection, development and use of natural resources, and tourism.[1]

Institutions responsible for environmental management are:

- In the Federation of Bosnia and Herzegovina - the Ministry of Environment and Tourism of the Federation of Bosnia and Herzegovina and the relevant cantonal ministries, within their competences,
- In the Republika Srpska - Ministry of Spatial Planning, Civil Engineering and Ecology (which is the focal point for the United Nations Framework Convention on Climate Change)
- In Brčko District - Department for Urbanism and Property-Legal Issues of the Government of Brčko District.

At its 66th session held on 16 May 2002, the Council of Ministers of Bosnia and Herzegovina adopted the proposals and draw a conclusion adopting the proposal on organisational structure and responsible authority for coordination of international agreements (conventions) in Bosnia and Herzegovina. By that conclusion, it had been decided that Ministry for Spatial Planning, Civil Engineering and Ecology of the Republika Srpska should coordinate the activities on implementation of the United Nations Framework Convention on Climate Change (UNFCCC). The Council of Ministers of Bosnia and Herzegovina is a party to a number of international environmental agreements and conventions, and it is fully committed to meeting the requirements stipulated in these agreements.

Bosnia and Herzegovina is a potential candidate for membership in the European Union (EU). The Stabilisation and Association Agreement between the European Communities and their Member States, of the one part, and Bosnia and Herzegovina, of the other part, was signed in Luxembourg on 16 June 2008 and entered into force on 1 June 2015. It replaced the Interim Agreement on Trade and Trade-Related Matters, which had been in force since 1 July 2008. In February 2016, Bosnia and Herzegovina applied for EU membership. With the adoption of the Decision on the system of coordination of the European integration process in Bosnia and Herzegovina (Official Gazette of BiH, No. 72/16 and 35/18), the operational and institutional system and coordination of institutions in Bosnia and Herzegovina on implementation of activities related to the process of integration of Bosnia and Herzegovina into the EU were defined. However, progress towards EU reforms is limited.

Bosnia and Herzegovina ratified the United Nations Framework Convention on Climate Change on 6 December 2000. Following the ratification, Bosnia and Herzegovina has made a number of efforts to establish appropriate political, institutional and legal frameworks so as to meet the commitments of the Convention. The focal point of Bosnia and Herzegovina for the UNFCCC is the Ministry of Spatial Planning, Civil Engineering and Ecology of the Republika Srpska. According to the Convention, Bosnia and Herzegovina has the status of a developing country, which means, among other things, that it has an obligation to report on GHG emissions and to participate in international cooperation mechanisms to reduce emissions and adapt to climate change. Bosnia and Herzegovina acceded to the Kyoto Protocol on 16 April 2007.

Bosnia and Herzegovina has so far produced three national communications and two biennial reports on greenhouse gas emissions. The preparation and submission of these reports is an obligation of Bosnia and Herzegovina, as a signatory to the UNFCCC, in accordance with Decision 17/CP8 and other relevant documents of the Convention.

In 2010, Bosnia and Herzegovina submitted its Initial National Communication under the United Nations Framework Convention on Climate Change to the UNFCCC Secretariat. In October 2013, the Second National

[1] Law on Ministries and Other Bodies of Administration of BiH (Official Gazette of BiH, No. 5/03, 42/03, 26/04, 42/04, 45/06, 88/07, 35/09, 59/09 and 103/09 2009)

Communication under the UNFCCC was adopted and forwarded to the Secretariat of the Convention. The Third National Communication of Bosnia and Herzegovina (TNC) and the Second Biennial Update Report on Greenhouse Gas Emissions (SBUR) of Bosnia and Herzegovina under the UN Framework Convention on Climate Change were adopted by the Council of Ministers of Bosnia and Herzegovina on 23 May 2017 and submitted to the Secretariat of the Convention in Bonn. Within the TNC and SBUR reports, information related to climate change, greenhouse gas inventory, climate change mitigation, vulnerability to climate change and steps taken to adapt to climate change, as well as information on public awareness, education, training, systemic research, and technology transfer were updated and improved. Furthermore, the work on TNC and SBUR strengthened the individual capacity of climate research experts in Bosnia and Herzegovina in government institutions, academia and non-governmental organisations, and further strengthened the organisational capacity of the UNFCCC Central Institution in Bosnia and Herzegovina - the Ministry of Spatial Planning, Civil Engineering and Ecology of the Republika Srpska, as well as the two entity hydro-meteorological institutes.

Bosnia and Herzegovina ratified the Paris Agreement by the Decision on Ratification of the Paris Agreement under the UNFCCC (Official Gazette of BiH - International Agreements, No. 01/17) and thus confirmed its activities on climate change mitigation. In October 2015, Bosnia and Herzegovina submitted the *First Intended Nationally Determined Contribution* (INDC), clearly stating that Bosnia and Herzegovina used market mechanisms to facilitate, accelerate and enhance development and technology transfer, capacity building and access to financial resources that support low carbon and climate change resilience/adaptation. According to the provisions of the Paris Agreement, in the forthcoming period, states are obliged to submit updated and more ambitious documents on climate change mitigation activities every five years. In March 2021, Bosnia and Herzegovina adopted the Nationally Determined Contribution (NDC), which was prepared in accordance with Decision 1/CP.21 of the Paris Agreement and represents a revision of the First Intended Nationally Determined Contribution. (INDC).

1.2 Environmental statistics

The status of the development of the emission inventories in Bosnia and Herzegovina is primarily stipulated by the air protection laws for the Federation of Bosnia and Herzegovina and the Republika Srpska that are currently in effect. The following should be emphasised in these laws:

- The Ministry of Environment and Tourism of the Federation of Bosnia and Herzegovina and the Ministry for Spatial Planning, Civil Engineering and Ecology of the Republika Srpska each release the Report on Air Pollution Emission Inventories in January each year for two preceding years.
- In the Federation of Bosnia and Herzegovina, the cantons release the Report on Air Pollution Emission Inventories in April each year (including dissemination from natural resources) for two preceding years.
- Pursuant to Article 28 of the Law on Environmental Protection (Official Gazette of the Federation of Bosnia and Herzegovina, No. 33/03 and 38/09) and Article 2 of the Rulebook on registers of plants and pollutants (Official Gazette of the Federation of Bosnia and Herzegovina, No. 82/07), the Ministry of Environment and Tourism of the Federation of Bosnia and Herzegovina is responsible for the establishment, development and maintenance of the Register of plants and pollutants in the Federation of Bosnia and Herzegovina. In 2012, an application was installed in the Ministry for entering data into the electronic database of the Register of Register of plants and pollutants - BH PRTR (Bosnia and Herzegovina Pollutant Release and Transfer Register), in accordance with the prescribed European methodology E-PRTR.
- Pursuant to the Law on Environmental Protection (Official Gazette of the Republika Srpska, No. 71/12, 79/15, 70/20) and the Rulebook on the methodology and manner of keeping the register of plants and pollutants (Official Gazette of the Republika Srpska, No. 92/07), the Hydrometeorological Service of the

Republika Srpska maintains the Pollutant Release and Transfer Register (PRTR) which contains information on the discharge of pollutants into the air, water and soil, and on the transfer of waste. Pursuant to Article 49 of the Law on Air Protection (Official Gazette of the Republika Srpska, No. 124/11, 46/17), the Hydrometeorological Service also keeps a register of greenhouse gas emissions, which includes: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). Pursuant to Article 67 of the Law, the information system on air quality is an integral part of the single information system for environmental protection, and it is also managed by the Hydrometeorological Service of the Republika Srpska.

Emission inventory reports must be prepared in accordance with the reporting requirements defined by international agreements. Emission inventories must be prepared for the following substances: SO_2, N_2O, CO_2, CO, NH_3, NOx, CH_4, NMVOCs, C_6H_6 and PM10. The emission register is maintained by fields of activity. Emission assessments are performed in accordance with internationally approved methods and guidelines. Polluters, specialised institutions and authorised bodies are responsible for submitting the data required for dissemination, assessment, and/or monitoring to the ministries.

Statistical institutions in Bosnia and Herzegovina (Agency for Statistics of Bosnia and Herzegovina, Institute of Statistics of the Federation of Bosnia and Herzegovina and Institute of Statistics of the Republika Srpska) collect certain data on the environment as defined by the Statistical Survey Programme. The legal framework for the development, production and dissemination of European statistics is determined by Regulation (European Commission) no. 223/2009 of the European Parliament and of the Council of 11 March 2009 on European statistics. The European Statistical System functions as a network in which Eurostat harmonises statistics in close cooperation with national statistical offices. Eurostat, in close partnership with the European Environment Agency, provides environmental statistics, environmental accounts and environmental indicators that support the development, monitoring and evaluation of EU environmental policies, strategies and initiatives. Through the annual Programme of Statistical Surveys, the Agency for Statistics of Bosnia and Herzegovina implements Eurostat statistical requirements for the following environmental domains:

- Environmental accounts
- Sustainable development
- Climate change strategies
- Statistics for monitoring the circular economy
- Europe 2020 Strategy
- Initiatives for natural resources, water and waste.

1.3 Geographical characteristics

Bosnia and Herzegovina is located in the centre of the Balkan Peninsula, between the Adriatic and Pannonian regions, surrounded by the Republic of Croatia (931 km) in the north, northwest and south, and the Republic of Serbia (375 km) and the Republic of Montenegro (249 km) in the east, while in the south, in Neum, it exits to the Adriatic Sea in the length of 21.2 km. According to its geographical position, Bosnia and Herzegovina belongs to the Adriatic and Black Sea Basins.

Bosnia and Herzegovina has a total surface area of 51,209.2 km², composed of 51,197 km² of land and 12.2 km² of sea. Of the total land area, 42% are mountains, 24% hills, 29% karst area and 5% lowlands. The average altitude is 500 meters, and less than 8% of the surface is situated at an altitude of less than 150 m above sea level.

There are seven river basins in Bosnia and Herzegovina (Una, Vrbas, Bosna, Drina, Sava, Neretva, Trebišnjica and Cetina). Hydrographically, 75.5% of Bosnia and Herzegovina belongs to the Black Sea basin, with the most significant tributaries: the Una, Vrbas, Drina, Bosnia and Sava, and 24.3% to the Adriatic basin with the most significant tributaries: the Neretva and Trebišnjica.

1.4 Population trends

Data from internationally recognised population estimates and projections prepared annually by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (UN DESA) and published in the publication *World Population Prospects*, show that in 2017 there were 3.352 million inhabitants in Bosnia and Herzegovina. According to the same source, it is estimated that in Bosnia and Herzegovina in 2025 there will be 3.212 million inhabitants, and in 2050 2.685 million (Figure 2). If five-year periods are observed, this would mean that in the period 2015−2025 Bosnia and Herzegovina will lose about 217,000 people, and in the period 2015−2050 about 744,000 people.

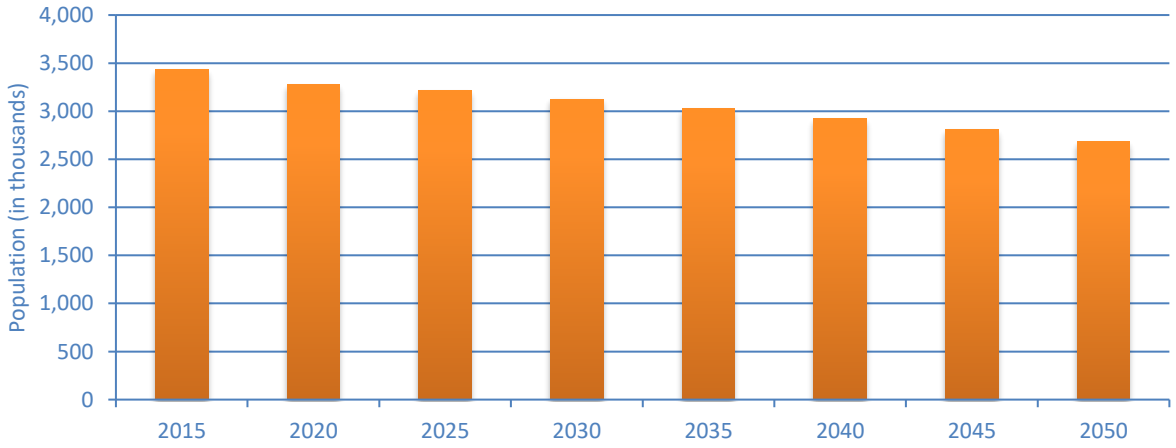


Figure 2: Estimate of population change in Bosnia and Herzegovina for the period 2015-2050
/Data source: *Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat*[2]/

1.5 Climate

In Bosnia and Herzegovina, three dominant climates prevail due to the geographical position, geological substrate, relief, coverage of the terrain with plant communities and the proximity of the Adriatic Sea:

- Continental and temperate continental climate - represented in the area of northern Bosnia and in the valleys of the middle reaches of the Una, Sana, Vrbas, Bosnia and Drina rivers. Mean annual air temperatures are relatively high and range from 9.6°C to 11.4°C, with distinct seasons. The highest average annual precipitation is in the north-western parts (between 1000 and 1500 mm), while the lowest amounts were recorded in the area around Bijeljina, Orašje and Šamac (below 800 mm).
- mountain and sub-mountain climate - includes the hilly-mountainous area of Bosnia and Herzegovina that stretches from the border of the northern area to the southern border, which is a line that stretches from Posušje and the southern slopes of Čabulja, Velež and Bjelašnica to Bileća. This area is affected by the Central European continental climate from the north and the Mediterranean climate from the south. Mean annual air temperatures range from 1.2°C to 11.6°C. The spatial distribution of

[2]Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat: *World Population Prospects 2019,* available at: https://esa.un.org/unpd/wpp/

the annual precipitation is uneven due to the complex relief. The windward sides of high mountains have large annual precipitation ranging between 1500 and 2300 mm, while in sheltered river valleys and basins they are significantly less and amount to 700 to 800 mm.

- Mediterranean and modified Mediterranean climate - represented in the southwest of the country, i.e. in the area of Herzegovina. Due to the close proximity of the Adriatic Sea and its direct impact on the character of climatological elements, this area has the characteristics of a maritime climate. Mean annual air temperatures have relatively high values and range from 12.8°C to 15.2°C. Precipitation in this area is unevenly distributed, both during the year and spatially. Čapljina has the lowest precipitation with 1070 mm, and Vrbanj (Orjen) the highest with 3347 mm.[3]

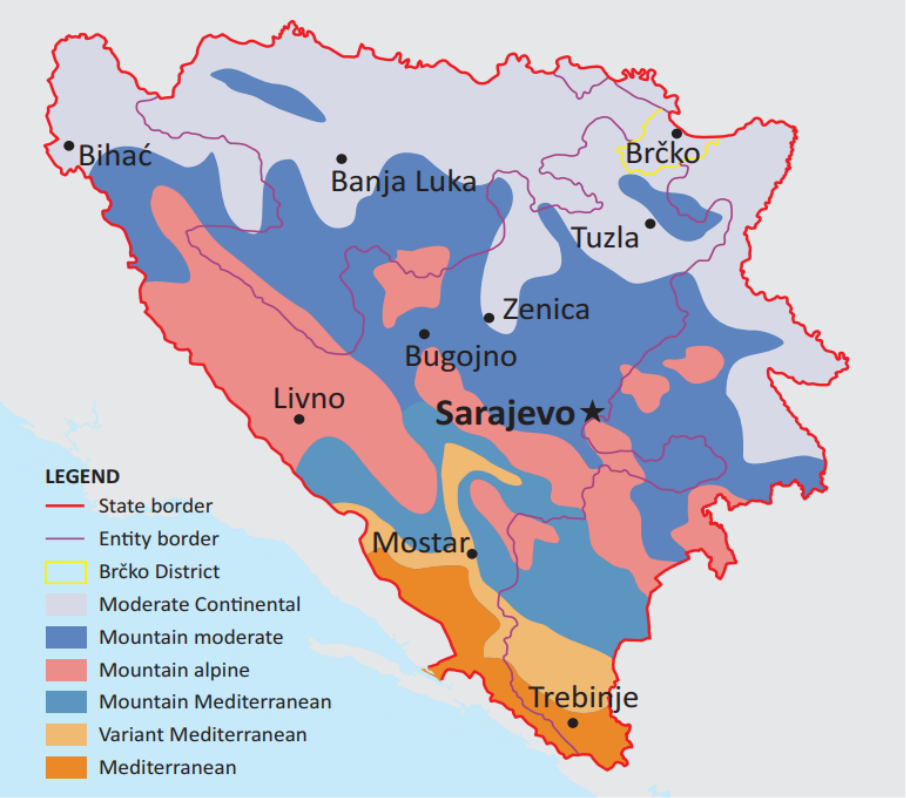


Figure 3: Climate of Bosnia and Herzegovina
/Data source: Hydrometeorological Service of the Federation of Bosnia and Herzegovina/

1.6 Sector analysis

1.6.1 Economy and industry

Based on the results of modelling and scenarios, as well as on previous research and activities related to the impact and adaptation to climate change in Bosnia and Herzegovina, it is shown which sectors are vulnerable to the effects of climate change. Based on the projections and the obtained results, it may be concluded how the changed climate will affect their sector but also what the possible impacts of "a" sector on other sectors are. Industry in Bosnia and Herzegovina is a very important economic sector, and it is extremely important in the world of social development. Effective adaptation measures to climate change are necessary to reduce vulnerability and increase resilience, both of the population and of the most important economic sectors. Also,

[3] Source: Hydrometeorological Service of the Federation of Bosnia and Herzegovina, available at: https://www.fhmzbih.gov.ba/latinica/KLIMA/klimaBIH.php

if the implementation of climate change mitigation measures is related to the development strategy of the industrial sector, then it is possible to influence the creation of new jobs in the production of adequate equipment. Another advantage of the measures is the construction of roads and improved electricity supply in remote villages and near power plants, and the construction of other infrastructure.

The recovery of the economy, and thus of the industry as its component, was significantly better compared to the TNC development period. Data from the Agency for Statistics of Bosnia and Herzegovina for 2015 show that the GDP value amounted to BAM 28,540 million, and compared to 2014, the nominal was higher by 4.52% while the real growth was 3.03%. The average GDP per capita was BAM 7,473.

Observed by economic activities, the highest growth was recorded in: arts, entertainment and recreation (11.49%); professional, scientific and technical activities (11.30%); manufacturing (11.17%) and agriculture, forestry and fishing (9.36%)[4].

GDP for Bosnia and Herzegovina in 2016 nominally amounted to BAM 29,899 million and compared to 2015, the nominal was higher by 4.59% while the real growth was 3.07%. GDP per capita and amounted to BAM 8,516.

Observed by economic activities, significant real growth of gross value added was recorded by: Agriculture, forestry and fishing (7.64%), Other service activities (7.59%), Production and supply of electricity (7.0%); Transport and storage (4,94%).

Table 1: Main economic indicators for Bosnia and Herzegovina in the period 2004-2012[5]

Indicators	2014	2015	2016
Nominal GDP (EUR billion)	14.0	14.6	15.3
GDP per capita (EUR)	3,967	4,155	4,355
Real growth rate of GDP	1.2	3.1	3.1
Average net salary (EUR)	424	424	428
Annual inflation (%)	-0.9	-1.0	-1.1
Annual unemployment rate (%)	27.5	27.7	25.4
Foreign currency reserves (EUR million)	4,001	4,400	4,873

Table 2: Share of Entities in GDP (%)[6]

Indicators	2014	2015	2016
Bosnia and Herzegovina	**100.00**	**100.00**	**100.00**
Federation of Bosnia and Herzegovina	64.97	65.38	65.34
Republika Srpska	32.76	32.20	32.22
Brčko District	2.27	2.42	2.44

[4] Agency for Statistics of BiH: Gross Domestic Product for Bosnia and Herzegovina 2015 - Production approach, first results http://www.bhas.ba/saopstenja/2016/GDP%20Proizvodni2015.pdf

[5] Economic indicators_April 2020.pdf http://www.fipa.gov.ba/informacije/statistike/pokazatelji/Ekonomski%20pokazatelji_april%202020_B.pdf

[6] Agency for Statistics of BiH: Gross Domestic Product for Bosnia and Herzegovina 2015 - Production approach, first results http://www.bhas.ba/saopstenja/2016/GDP%20Proizvodni2015.pdf

In 2016, an increase in the physical volume of industrial production of 4.3% was registered in Bosnia and Herzegovina compared to the previous year (Figure 4). This growth in production volume was accompanied by an increase in the number of employees within the industry of 2.5%.

If we observe the average movement of the consumer price index in Bosnia and Herzegovina in 2014 compared to the average in 2013, it can be concluded that an average deflation of 0.9% was recorded in that period. In any case, the economic growth of Bosnia and Herzegovina was extremely modest in both variants given the very low base.

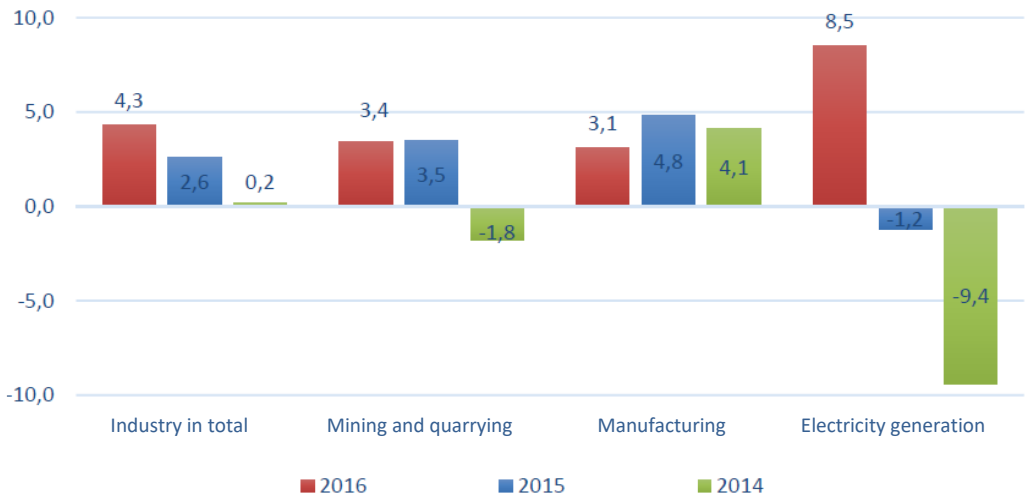


Figure 4: Overview of industrial production trends in Bosnia and Herzegovina by sectors in 2016 (growth rates g/g)
/ Source: Agency for Statistics of Bosnia and Herzegovina, 2017/

The standard of living in Bosnia and Herzegovina, measured by GDP per capita, is only 30% of the European average, which is at the very bottom of the list of countries published by EUROSTAT. In order to converge towards the European average at a reasonable pace (e.g. reaching the average in 30 years), Bosnia and Herzegovina needs an average economic growth that is at least three times higher than the European (1.9% in 2016) given the base that is at the level of one third of the European average. Nevertheless, it can be said that in 2016 some progress was made compared to the previous five years when the average annual economic growth in Bosnia and Herzegovina was only 1.5%.

1.6.2 Energy

Total electricity generation in Bosnia and Herzegovina in 2016 amounted to 17,767 GWh, which is a 14% increase compared to 2015 (15,629 GWh). Electricity generation (gross) in hydropower plants was 5,641 GWh, in thermal power plants it was 11,673 GWh, while in industrial power plants it was 453 GWh. Own consumption in the energy sector amounted to 1,158 GWh (27 GWh in HPPs, 1,065 GWh in TPPs and 66 GWh in industrial power plants). Total electricity consumption in 2016 in households amounted to 42.6% (4,733 GWh), while in industry it was 36.2% (4,014 GWh). Building sector, transport, agriculture and other consumers account for 21.2% of total consumption. The total generation of thermal energy in Bosnia and Herzegovina in 2016 was 5,657 TJ, of which 3,493 TJ (61.7%) was generated in the heating plants, 1,523 TJ or 26.9 5 in thermal power plants, and 641 TJ or 11.3% in industrial power plants. In the final consumption of thermal energy in 2016, households have the largest share with 77.4%, and industry and other consumers 22.6%.

1.6.3 Transport

The total length of the road network in Bosnia and Herzegovina is 22,976 km. Observed according to the categorisation, there are 172 km of motorways, 3,870 km of trunk roads, 4,734 km of regional roads and 14,200 km[7] of other/local roads.

Table 3: Length of road network in Bosnia and Herzegovina [8]

Road category	Road length in km			
	FBiH	RS	BD	BiH Total
Motorway	92	80	-	172
Trunk road	2,068	1,765	37 *	3,870
Regional road	2,546	2,151	37 *	4,734
Local road				14,200[9]
TOTAL	**4,706**	**3,996**	**74**	**22,976**

** Data obtained on the basis of the total length of roads in BiH*

According to available data on registered motor vehicles by type of propulsion energy (data available for the following vehicle categories: passenger vehicles, buses, trucks), 22.61% of vehicles use petrol, 72.3% of vehicles use diesel, while the remaining 5.09% vehicles use some of the alternative energy sources.

The volume of Road transportation in Bosnia and Herzegovina is represented through two indicators: (i) cargo transport and (ii) passenger transport. Comparing the data from previous Climate Change Communications and based on available data for the years 2015, 2016 and 2017, it can be concluded that the volume of transport in Bosnia and Herzegovina has an increasing trend. Table 4 presents a more detailed overview of the volume of transport by year with a percentage decrease or increase in the volume of transport from one year compared to another.

Table 4: Volume of transport in Bosnia and Herzegovina

Transport	Type of transport	Year		Increase/decrease in 2016 compared to 2015	Increase/decrease in 2017 compared to 2016
		2015	2016		
Public Road transportation	**Cargo transport**				
	Vehicles – kilometres travelled	458,147	507,985	+10.88%	+15.4%
	Tons of goods transported	8,288,000	9,377,000	+13.14%	+7.96%
	Ton/km	3,405,231,000	4,015,177,000	+17.91%	+6.60%
	Passenger transport				
	Vehicles – kilometres travelled	87,254,000	85,475,000	-2.04%	+9.95
	Transported passengers	20,471,000	16,505,000	-19.37%	-3.63%
	Passenger - kilometres	1.690.393.000	1.706.372.000	+0,95%	-2,61%

[7] Framework Transport Strategy of Bosnia and Herzegovina http://www.mkt.gov.ba/aktivnosti/default.aspx?id=5029&langTag=bs-BA

[8] Framework Transport Strategy of Bosnia and Herzegovina http://www.mkt.gov.ba/aktivnosti/default.aspx?id=5029&langTag=bs-BA

[9] Framework Transport Strategy of Bosnia and Herzegovina http://www.mkt.gov.ba/aktivnosti/default.aspx?id=5029&langTag=bs-BA

Transport	Type of transport	Year		Increase/decrease in 2016 compared to 2015	Increase/decrease in 2017 compared to 2016
		2015	2016		
Urban and suburban transport	Vehicles – kilometres travelled	60.592.000	62.937.000	+3,87%	+1,01%
	Transported passengers	138.705.000	131.776.000	-5,00%	-0,97%

/Source: Agency for Statistics/

Given the growth in the number of registered passenger vehicles, the growth of passenger - kilometres in this segment is also estimated. Observed through the cargo transport and passenger transport, the volume of railway transport in Bosnia and Herzegovina is shown in Table 5.

Table 5: The volume of railway transport in Bosnia and Herzegovina

Cargo transport	2015	2016	2017
Tons of goods transported	13,819,000	13,156,000	13,254,000
Ton/km	1,286,480,000	1,142,639,000	1,116,731,000
Passenger transport	**2015**	**2016**	**2017**
Transported passengers	518,000	409,000	472,000
Passenger - kilometres	34,305,000	23,701,000	29,518,000

/Source: Agency for Statistics/

There is a noticeable decrease in both the number of passengers and the tons of goods transported in 2016 compared to 2015, and an increase in 2017. A similar decline followed by an increase is noticeable in the number of passenger - kilometres, while the situation is slightly different when it comes to tonne-kilometres. A slight decrease in the number of tonne-kilometres from year to year is noticeable.

Air traffic data show that there are 27 officially registered airports in Bosnia and Herzegovina. However, only 4 airports are registered for international traffic, namely Sarajevo, Banja Luka, Mostar and Tuzla. Data on the volume of air traffic refer to the above 4 airports. The number of airport operations in 2016 was 16,713.

Bosnia and Herzegovina has a very short coastline in Neum and does not have regulated adequate access to international waters and therefore no seaport. The international port that is the most important for the economy of Bosnia and Herzegovina is the Port of Ploče in Croatia, with a capacity of 5 million tonnes per year. In Bosnia and Herzegovina, the Sava River is the main navigable river and it is 333 km long. Water transport along the Sava River is linked with the Danube River, which is designated as Trans-European Transport Corridor VII. The main features of river transport in Bosnia and Herzegovina are as follows: neglected navigable routes, the absence of technologically modern fleet (the use of towing instead of pushing), technical and technological obsolescence, as well as the devastated ports and no shipyards with slipways. On a positive note, it should be noted that river navigation has the same institutional status as other modes of transport.

1.6.4 Agriculture

The share of agriculture, hunting and related service comprised 6.37% or BAM 1.9 billion of GDP in 2016. GDP increased slightly compared to 2015, when it amounted to 6.24%.

Of the total area of Bosnia and Herzegovina, which amounts to 5,113 million hectares, about 47% is suitable for agriculture. In the structure of agricultural land in 2016, arable land and gardens cover 1,025,000 ha. The total sown area in 2016 was 531 thousand ha, fallow land and uncultivated arable land 490 thousand ha, and

nurseries and other on arable land about 4 thousand ha[10]. There are about 0.66 ha of agricultural land per capita, of which 0.31 ha is arable land and gardens[11].

According to the data of the Agency for Statistics of Bosnia and Herzegovina for 2016, in the structure of total sown areas, cereals participate with 58.9%, industrial plants with 2.3%, vegetables with 13.9% and fodder plants with 24.9%. Actual production in 2016 amounted to 1,657,556 t of cereals, 1,029,900 fodder plants, 779,582 t of vegetables and potatoes, and 25,420 t of industrial crops. Harvested area and total production of the most important crops is higher compared to the same period in 2015 (wheat is higher by 43.9%, corn by 50.0%, potatoes by 20.4%, etc.).

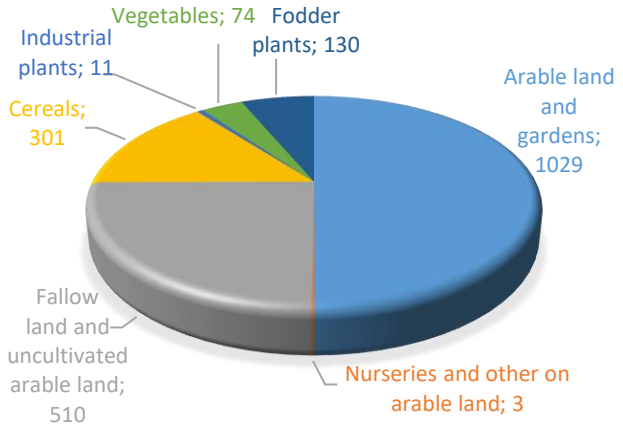


Figure 5: Arable land, by land utilisation in 2015

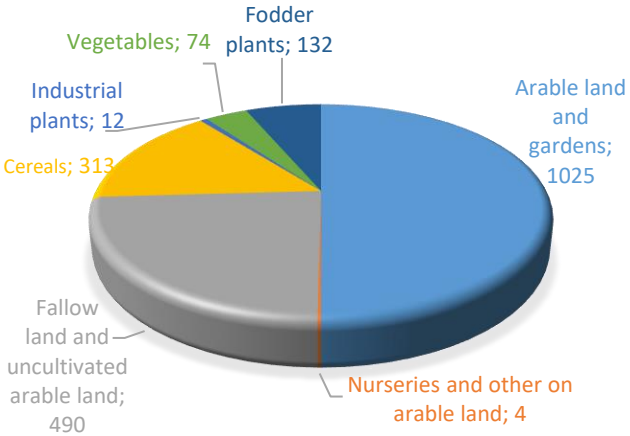


Figure 6: Arable land, by land utilisation in 2016

Forty-five percent of the agricultural land is hilly (300 to 700 meters above sea level), of moderate quality and suitable for semi-intensive cattle breeding. Mountainous regions (over 700 meters above sea level) represent additional 35% of agricultural land. However, high altitude (low temperatures and snow), slopes as well as limited soil fertility reduce the possibility of using this land for cattle grazing only in the spring and summer. Less than 20% of agricultural land (half of the total arable land) is suitable for intensive agriculture, and is mainly found in lowland areas in the north of the country, in the river valleys. Natural water resources are abundant,

[10]Agency for Statistics of Bosnia and Herzegovina (2017): Agriculture, environment and regional statistics, Harvested area, total production and yield of the most important crops, 2016

[11]Budget based on population projections (for 30 June 2016), Agency for Statistics of Bosnia and Herzegovina (2017): Bosnia and Herzegovina in numbers

with many unpolluted rivers and available groundwater. Despite the abundance of water, water supply is a limiting factor for production in many areas. Only about 0.65% of areas suitable for agriculture is irrigated.

According to the 2017 Report[12] of the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, the total trade in agricultural products in 2016 amounted to BAM 3.9 billion and compared to the previous year is higher by 5% and by 14% compared to 2014 exchange. The value of imports of agricultural products in 2016 increased by 2%, while exports increased by 14% compared to 2015. The coverage of imports by exports of agricultural products in 2016 was 32%.

1.6.5 Forestry

The interaction of biological and geological diversity and human influence on them, over a long history, have conditioned an extremely high degree of landscape, species and genetic diversity in Bosnia and Herzegovina. In addition, the influence of specific orography, geological and pedological structure, hydrology and climate also give their significance. Urban areas are mainly located in the valleys of larger rivers, and most of the area can be characterised as a rural area in which forest ecosystems play an important role.

The area of Bosnia and Herzegovina is divided into four ecological vegetation areas - the Pannonian, Inner Dinarides, Transitional Illyrian-Moesian and Mediterranean area[13]. At lower altitudes and hilly areas there are mostly oak forests. They are followed by a belt with beech forests, beech and fir, beech, fir and spruce, and finally at the highest altitudes it ends with a subalpine beech, spruce and mountain pine. There is also a special belt of spruce forests, as well as forests of distinct floristic diversity marked by numerous endemic and relict species. Although small, Bosnia and Herzegovina is a country of high bio-ecological potential at one of the "hotspots" of world biodiversity.[14]

Existing traditional management systems are based on natural forest regeneration, which have been applied in practice for decades and which have contributed to the creation of significant diversity in forests, as well as the application of today's increasingly recognisable practice of "nature-compatible management". That is why today in Bosnia and Herzegovina there are 93% natural and 7% planted forests, i.e. forest crops[15]. Plantation with selected clones (varieties) of fast growth is almost non-existent.

The proof of sustainable forest management in Bosnia and Herzegovina is the certification of forests that has been carried out in the last 10 years. According to the *Forest Stewardship Council* (FSC) from July 2020, there are 336 companies in Bosnia and Herzegovina with a valid FSC standard, of which the largest number are those engaged in wood processing and trade. The public companies that manage forests with FSC standards are: Public Forestry Enterprise "Šume Republike Srpske" /Forests of the Republika Srpska/, a. d. Sokolac; Forest Business Company "Unsko-sanske šume" /Una-Sana Forests/, d.o.o., Bosanska Krupa; Forest Company "Hercegbosanske šume" /Herzeg-Bosnia Forests/, d.o.o., Kupres; Public Enterprise "Šume Tuzlanskog kantona" /Forests of Tuzla Canton/, d. d., Kladanj; Cantonal Public Enterprise for State Forest Management "Sarajevo-šume" /Sarajevo Forests/ d.o.o.; Forestry Company "Srednjobosanske šume" /Central Bosnia Forests/, Donji Vakuf and Public Enterprise "Bosansko-podrinjske šume" /Bosnian Podrinje Forests/, d.o.o., Goražde. The implementation of this

[12]Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina (2017): Report on Agriculture, Food and Rural Development for Bosnia and Herzegovina

[13] Stefanović, V., Beus, V., Burlica, Č., Dizdarević, H., Vukorep, I. 1983. Ecological and vegetational dellineation of Bosnia and Herzegovina. Special edition No 18. Faculty of Forestry Sarajevo: 1-49.

[14] Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G. & Kent, J. (1999). Biodiversity hotspots for conservation priorities. Nature 403, 853-858.

[15] Mataruga, M., Ballian, D., Terzić, R., Daničić, V., Cvjetković, B. (2019) State of Forests in Bosnia and Herzegovina: Ecological and Vegetation Distribution, Management and Genetic Variability, edited by Šijačić-Nikolić, M., Milovanović, J., Nonić, M. in "Forests of Southeast Europe Under a Changing Climate - Conservation of Genetic Resources". Springer, p: 3-19.

system significantly contributes to better management and administration of state forests, and a greater contribution to the protection and improvement of all forest functions, from economic sustainability, social responsibility to environmental development.

According to official data, there are not enough protected areas (which mainly include forest ecosystems) but a positive trend of increasing these areas must be pointed out. The national parks (Kozara - 3,907.54 ha; Sutjeska - 17,350 ha; Una - 19,800 ha; Drina - 27,972.35 ha) and numerous protected areas in other IUCN categories should certainly be highlighted.

In Bosnia and Herzegovina, there is no harmonised data on the area under forests. Inaccurate definition of the condition of forests (primarily surface area), entails the question of accuracy in assessing adaptation and/or mitigation as well as the development of all further strategic goals. At the same time, forestry is considered one of the important sectors in terms of mitigation, as well as vulnerable sectors in terms of adaptation. Although the still unpublished results of the Second Forest Inventory in Bosnia and Herzegovina (2006-2009)[16] show that the total surface area of forests and forest land in Bosnia and Herzegovina is 3,231,500 ha or 63.08%, while the area covered by forests is 2,904,600 ha or 56.7% of the total surface area of Bosnia and Herzegovina. Compared to the data of the First Inventory (1960-1970), a significant increase in forest areas can be noted in all categories (more than 15% - the total surface area of forests and forest land at that time was 2.73 million hectares).

According to the Statistical Yearbooks of the Institute of Statistics of the Republika Srpska and the Institute of Statistics of the Federation of Bosnia and Herzegovina,[17] forests in Bosnia and Herzegovina in 2017 cover 2.60 million hectares, which is 50.77% of the total surface area of Bosnia and Herzegovina (51,209.2 km^2 of which 51,197 km^2 of land and 12.2 km^2 of sea). Of the total land area, 5% are lowlands, 24% hills, 42% mountains and 29% karst areas. The following are the trends in the condition of the surface area, the volume of felling and afforestation in the Federation of Bosnia and Herzegovina and the Republika Srpska.

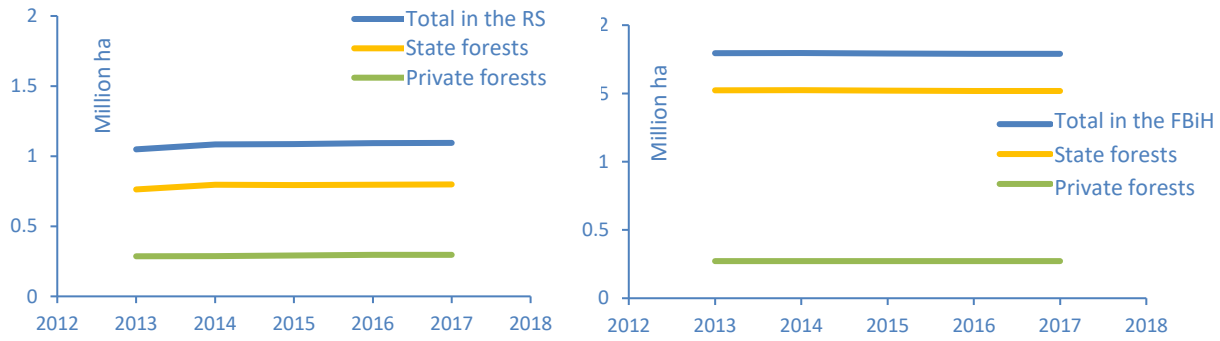


Figure 7: Area under forests in the Republika Srpska and the Federation of Bosnia and Herzegovina in the period from 2013 to 2017

[16] UNDP (2014). Possibilities of using biomass from forestry and wood industry in Bosnia and Hercegovina, 1-21.
FAO (2015). The Forest Sector in Bosnia and Herzegovina Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina, 1-146.

[17] The natural resources management, which results in any activity related to forest management, is the responsibility of the entity authorities in Bosnia and Herzegovina (Republika Srpska, the Federation of Bosnia and Herzegovina) and the Brčko District of Bosnia and Herzegovina. Part of the responsibility is performed at the state level and relates to the implementation of international agreements and the responsibility of Bosnia and Herzegovina, which is mainly the responsibility of the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, and to a lesser extent of the Ministry of Civil Affairs of Bosnia and Herzegovina. Respecting the constitutional competences and responsibility for the condition of forests, most of the data are presented for the Federation of Bosnia and Herzegovina and the Republika Srpska, respectively, and collectively for Bosnia and Herzegovina.

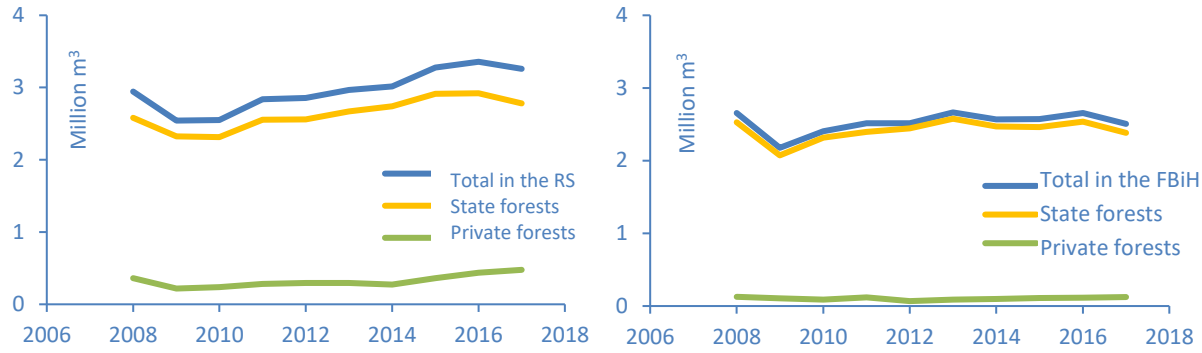


Figure 8: Volume of felling in the Republika Srpska and the Federation of Bosnia and Herzegovina in the period from 2008 to 2017

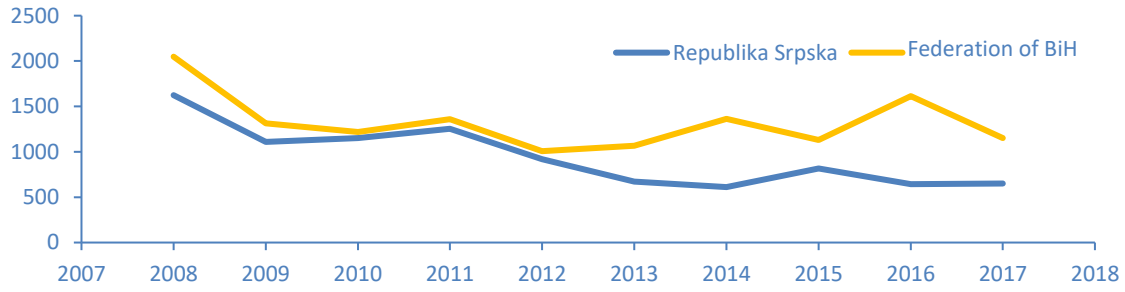


Figure 9: Volume of afforestation in the Republika Srpska and the Federation of Bosnia and Herzegovina in the period from 2008 to 2017

Along with the trend of increasing the surface area under forests and the volume of felling, there is a trend of decreasing the volume of afforestation (Figure 9). Volume of afforestation in the Republika Srpska for the period 2006-2018 is almost twice as small. To this unfavourable trend in the volume of afforestation in the Republika Srpska, as well as in the Federation of Bosnia and Herzegovina, we should add the issue of success in the recorded afforested areas.

The current trend in the number of forest fires shows that there were significantly more forest fires in dry years in the Mediterranean area, and projections show that the risk of forest fires in the future will be higher throughout Bosnia and Herzegovina. Also, the forest fire season will be longer. In general, the number and area of forest fires are strongly correlated with climatic characteristics during the summer months (primarily the amount of precipitation). The problem of forest fires has already been identified as a cross-border problem, and a number of cross-border cooperation projects dealing with this problem have been implemented in Bosnia and Herzegovina and the surrounding countries. A significant problem in forest management in Bosnia and Herzegovina is still the large area of forests and forest land under mines. In 2017, the area under mines in Bosnia and Herzegovina amounted to 1,091 km^2 or 2.2% of the total surface area of Bosnia and Herzegovina.

A significant number of authors have stated that the forest area ratio in the context of ownership is 70:30 in favour of state forests. According to the data of the Institute of Statistics of the Federation of Bosnia and Herzegovina the share of state forest land in the Federation of Bosnia and Herzegovina in 2017 was 82%, and the share of private forests was 18%. In the Republika Srpska, according to the data of the Institute of Statistics of the Republika Srpska, the share of state forests in 2017 was 73%, and the share of private forests was 27%. Private forests are primarily characterised by a large number of forest owners. This refers to small plots,

fragmented property, many owners, unresolved property and legal relations, so some owners do not know where their forest is or do not actively manage it at all.

1.6.6 Waste management

The estimated quantity of municipal waste generated in Bosnia and Herzegovina in 2015 was 1,248,718 tonnes, or 355 kg per capita per year or 0.97 kg per capita per day. The estimated quantity of municipal waste generated in 2016 was 1,243,889 tonnes, or 354 kg per capita per year, or 0.97 kg per capita per day. In 2016, 920,478 tonnes of municipal waste was collected by public waste collection services, which is 0.1% less than in the previous year.

The total quantity of collected waste is comprised of 91.7% of municipal mixed waste, 3.6%, of collected municipal waste separated at the source, 2.8% of waste from gardens and parks and 1.9% of packaging waste.

In 2016, 952,975 tonnes of waste were disposed of in landfills, which is 1.0% less than in the previous year.

Table 6: Quantity of generated municipal waste in BiH

Year	2015	2016
Generated municipal waste	1,248,718	1,243,889
Annual quantity of waste per capita	355*	354
Daily quantity of waste per capita	0.97*	0.97

**Data corrected in accordance with the data of the 2013 Census and the estimates of the Agency for Statistics of BiH*

The percentage of residents involved in municipal waste collection is on average 68%.

For Bosnia and Herzegovina, the percentage of the population covered by the public waste collection system is about 74%[18]. The rest of the population, not covered by such municipal service, is located in rural areas and the outskirts of cities. The rest of the population, not using such municipal service, inhabits mostly rural areas.

In the total quantity of collected waste, the quantity of waste collected by public waste collection services in 2015 amounted to 924,051 tons, while in 2016 it amounted to 920,478 tons, i.e. the share decreased by 0.39%. The largest share of waste is collected from households 715,204 tonnes (2015) and 706,450 tonnes (2016).

In 2016, 952,975 tonnes of waste were disposed of in landfills, which is 0.13% less than in 2015 (954,163 tons). Data on waste streams delivered to landfills confirm the complete reliance on the permanent disposal of municipal waste in landfills.

The mid-term development strategy envisages the introduction of 16 sites for sanitary disposal of solid waste: 10 in the Federation of Bosnia and Herzegovina and 6 in the Republika Srpska. According to the data provided by the system operators (Ekopak d.o.o. Sarajevo and Eko-život d.o.o. Tuzla) in their annual reports for packaging waste, the waste used for processing for other purposes amounted to a total of 19,595.04 t (2015), 33,842.32 t (2016).

It is especially important to emphasise that in Bosnia and Herzegovina there are still no facilities for the treatment of medical and other hazardous waste, while the results of recycling of industrial and municipal waste are still limited.

[18] Source: Agency for Statistics of BiH, http://www.bhas.ba/saopstenja/2017/ENV_01_2016_Y1_0_BS.pdf

The quantity of hazardous waste generated in Bosnia and Herzegovina in 2016 was 13,190 tonnes. The largest quantities of hazardous waste originate from the manufacturing industry and amount to 10,638 tonnes, and they participate in the structure of the total generated hazardous waste with 80.6%. The largest part of hazardous waste from the manufacturing industry comes from the production of base metals and finished metal products, with a share of 83%. The quantities of hazardous waste generated in the production of base metals and finished metal products are 110% higher than in 2014. For other industries, the quantity of hazardous waste decreased, except in the production of pulp, paper and paper products but the impact of this industry is negligible given that it participates in the total generated hazardous waste with 1.4%.[19]

1.6.7 Water resource management

Water resource management in Bosnia and Herzegovina is based on the laws on water of the Federation of Bosnia and Herzegovina[20] and the Republika Srpska[21], respectively, which are already largely in line with the EU Water Framework Directive and the EU Directive on the Assessment and Management of Flood Risks. Laws on water in Bosnia and Herzegovina with their secondary legislation are implemented through three basic branches of water management: water use, water protection and protection against harmful effects of water.

In institutional terms, the Ministry of Agriculture, Forestry and Water Management of the Republika Srpska and the Public Institution "Vode Srpske", as well as the Ministry of Agriculture, Water Management and Forestry of the Federation of Bosnia and Herzegovina, with the Sava River Watershed Agency and the Agency for Watershed of the Adriatic Sea are responsible for water management. In the Brčko District of Bosnia and Herzegovina, the Department of Agriculture, Forestry and Water Management of the Government of the Brčko District is responsible for water. The Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina has an organisational unit for water, with responsibility for overall coordination at the national and international levels.

At the entity level, the strategic documents 2010-2022 Water Management Strategy of the Federation of Bosnia and Herzegovina[22], and the 2015-2024 Strategy of Integrated Water Management of the Republika Srpska[23] were prepared, and at the state level after the catastrophic floods in 2014, the "2014-2021 Action Plan for Flood Protection and River Management in Bosnia and Herzegovina"[24] was prepared and adopted.

The Sava River Basin Management Plan of the Republika Srpska[25], the Trebišnjica River Basin Management Plan of the Republika Srpska [26], the Water Management Plan for the Sava River Basin in the Federation of Bosnia and Herzegovina[27], the Water Management Plan for the Adriatic Sea Basin in the Federation of Bosnia and Herzegovina[28] and the Sava River Basin Management Plan for the Brčko District have been adopted. These plans refer to the period 2016-2021. The update of the first plans, i.e. the public hearing procedure for the mentioned plans for the period 2022-2027, is in progress.

[19] Source: Agency for Statistics of BiH, http://bhas.gov.ba/data/Publikacije/Metodologije/ENV_00_2020_MD_0_HR.pdf
[20] Law on Water (Official Gazette of FiH, No. 70/06)
[21] Law on Water (Official Gazette of RS, No. 50/06 and 92/09)
[22] er Management Strategy of the Federation of Bosnia and Herzegovina 2010-2022
[23] Strategija integralnog upravljanja vodama Republike Srpske 2015-2024
[24] The 2014-2021 Action Plan for Flood Protection and River Management in Bosnia and Herzegovina
[25] The 2017-2021 Sava River Basin Management Plan of the Republika Srpska
[26] The 2017-2021 Trebišnjica River Basin Management Plan of the Republika Srpska
[27] The 2016-2021 Water Management Plan for the Sava River Basin in the Federation of Bosnia and Herzegovina (Official Gazette of FBiH, No. 44/18)
[28] The Water Management Plan for the Adriatic Sea Basin in the Federation of Bosnia and Herzegovina (Official Gazette of FBiH, No. 44/18)

Water resources in Bosnia and Herzegovina are already directly affected by climate change and further negative changes can be expected. Although Bosnia and Herzegovina is not one of the countries for which greater water scarcity has been an obstacle to development in the past, it can be expected that climate change will lead to significant changes in water availability in the future, along with frequent extreme events. Water management has an increasingly important role to play in adapting society to climate change.

For the preparation of this communication for water resources in Bosnia and Herzegovina, in addition to the above documents, the Climate Change Adaptation and Low Emission Development Strategy for Bosnia and Herzegovina[29] and the Initial, Second and Third National Communication of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change[30] were used. As a source of data, various reports of domestic institutions and foreign organisations were used, as well as works and analyses of domestic and foreign experts of various professions.

1.6.8 Tourism

Bosnia and Herzegovina is a country with a rich natural and social attraction, in which tourism is recognised as one of the most important drivers of economic development. Its importance and role are emphasised in the 2008-2018 Tourism Development Strategy in the Federation of Bosnia and Herzegovina and the 2011-2020 Tourism Development Strategy of the Republika Srpska.

Due to the dominant hilly and mountainous relief, some of the most popular and most visited tourist destinations are mountain centres such as Jahorina or Bjelašnica. Also, the tourist offer highlights the urban units of Sarajevo, Mostar, Banja Luka, Travnik, etc., which tourists visit mostly because of the cultural and historical heritage and gastronomic offer, and Neum as a destination for coastal bathing tourism. An important segment are religious and spa tourism, and congress tourism. Recently, protected natural areas have been established for the development of ecotourism, while tourist activities related to rivers and lakes are becoming increasingly popular.

Analysing the period 2008-2018, it may be concluded that the number of tourists at the level of Bosnia and Herzegovina grew at an annual rate of 8.7%, and the number of overnight stays at an annual rate of 7.8%. In the Federation of Bosnia and Herzegovina, in the same period, the number of tourist arrivals and overnight stays doubled, while in the Republika Srpska there was an increase in the annual rate of almost 70%, and overnight stays by 58%. In the Brčko District, the number of tourist arrivals and overnight stays decreased in the period from 2008 to 2014, after which it is constantly increasing. The World Tourism Organization (UNWTO) has forecast a total increase of 10.5% for the tourism market of Bosnia and Herzegovina by 2020. Based on official tourism statistics, the average increase since 2010 is close to 14% per year, and there is still enough room for more efficient use of tourism potential. Although the number of tourists is increasing from year to year, the tourism industry in Bosnia and Herzegovina still records a low level of revenues, primarily due to the lack of institutional and legislative support, which favours the development of the so-called grey economy.

[29] Climate Change Adaptation and Low Emission Development Strategy for Bosnia and Herzegovina, 2013, https://www.ba.undp.org/content/bosnia_and_herzegovina/bs/home/library/energija-i-okolis/climate-change-adaptation-and-low-emission-development-strategy-.html

[30] Second National Communication of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change, 2013, https://www.ba.undp.org/content/bosnia_and_herzegovina/bs/home/library/energija-i-okolis/sncbih-2013.html; Third National Communication (TNC) and Second Biennial Update Report on Greenhouse Gas Emissions (SBUR) of Bosnia and Herzegovina, 2016 https://www.ba.undp.org/content/bosnia_and_herzegovina/bs/home/library/energija-i-okolis/tre_i-nacionalni-izvjetaj-bih.html

1.6.9 Health care

The leading causes of mortality in the population of Bosnia and Herzegovina include diseases of the circulatory system with a share of 51.6% in the Federation of Bosnia and Herzegovina[31] and 49% in the Republika Srpska[32], as well as malignant diseases causing 22.3% of deaths in the Federation of Bosnia and Herzegovina[33] and 20.6% in the Republika Srpska[34]. Therefore, diseases of the circulatory system and malignant diseases account for almost three quarters of all causes of death in Bosnia and Herzegovina. Among the five leading causes of death are diseases of the respiratory system.

The organisation, financing and provision of health care in Bosnia and Herzegovina are the responsibility of the Federation of Bosnia and Herzegovina, Republika Srpska and Brčko District of Bosnia and Herzegovina, and are regulated by the Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska Government and Department of Health and Other Services of Brčko District. At the state level, the Ministry of Civil Affairs of Bosnia and Herzegovina, as the responsible ministry in the Council of Ministers of Bosnia and Herzegovina, is responsible for "carrying out tasks and discharging duties which are within the competence of Bosnia and Herzegovina and relate to defining basic principles, coordinating activities and harmonising plans of the Entity authorities and defining a strategy at the international level in the field of health and social welfare [35].

Although society cares about the general health of the population, a system for monitoring the movement of diseases that can be linked to climate change has not yet been established in Bosnia and Herzegovina. Legislation in Bosnia and Herzegovina and other relevant documents related to the health care sector do not contain sufficient comprehensive information on the impact and adaptation of the sector to climate change. There are no data from health-related statistics on the impact of climate change on the health of the population, nor are there results based on scientific research. Therefore, it is not possible to more precisely determine the connection between weather conditions, i.e. biometeorological phases and the incidence of chronic non-communicable diseases, primarily diseases of the circulatory and respiratory systems, as well as individual infectious diseases. However, although there are no data based on scientific research, climate change certainly affects the health of the population in Bosnia and Herzegovina.

The Law on Health Care (Official Gazette of the Federation of Bosnia and Herzegovina, No. 46/10 and 75/13) and the Law on Protection of the Population from Infectious Diseases in the Federation of Bosnia and Herzegovina (Official Gazette of the Federation of Bosnia and Herzegovina, No. 29/05) and the Law on Health Care of the Republika Srpska (Official Gazette of the Republika Srpska, No. 106/09 and 44/15) and the Law on Protection of the Population from Infectious Diseases in the Republika Srpska (Official Gazette of the Republika Srpska, No. 90/17, 42/20 and 98/20) oblige public health institutions to implement preventive measures that improve the general health condition, i.e. reduce morbidity and mortality. These preventive measures relate, inter alia, to the protection of public health from risk factors arising from the environment (contaminated water, food, air, soil, vectors of infectious diseases, etc.), including meteorological and climatological factors (extreme heat, cold, changes in barometric pressure, etc.). The Law on Health Care in the Brčko District of Bosnia and Herzegovina from 2011 is in force in the Brčko District, and the Guidelines for drafting the Law on Protection of the Population from Infectious Diseases were adopted in 2017.

[31] Public Health Institute of the Federation of BiH, 2017
[32] Public Health Institute of the Republika Srpska, 2017
[33] Public Health Institute of the Federation of BiH, 2017
[34] Public Health Institute of the Republika Srpska, 2017
[35] Report "Strengthening BiH health care systems for EU integration", EuropeAid/120971/C/SV/

1.6.10 Education

The education system in Bosnia and Herzegovina includes: pre-school education, nine-year primary education which is compulsory and free for all children from six to fifteen years of age, secondary education which is optional and higher education. In Bosnia and Herzegovina at the beginning of the school year 2015/2016 there were 291,342 pupils enrolled in 1,850 primary schools, which is 5,477 pupils or 1.8% less than in the previous school year, while 133,228 students were enrolled in 311 secondary schools, which is less than in the previous school year by 10,653 students, or 7.4%. In the school year 2015/2016 there were 105,299 students enrolled in the winter semester of the first cycle of higher education studies, including integrated studies, of which 94,090 students were enrolled in all years of study, and 11,209 were graduates. In 2015, 15,974 students graduated/completed their academic or vocational studies, which is 5.6% less than in the 2014 school year. The number of students who enrolled in the school year 2015/16 was 23,310, which is 10% less than in the previous academic year.[36]

There are 8 public higher education institutions and 29 private higher education institutions (including independent colleges and universities) in Bosnia and Herzegovina, which offer a total of about 500 study programmes. 14 ministries are responsible for the field of education (1 state-level, 2 entity-level, 10 cantonal and the relevant department in the Government of the Brčko District), of which 12 directly with full authority in higher education.

Each entity, canton, and Brčko District as a separate organisational unit in Bosnia and Herzegovina, has its own law, covering each of the four levels of education. Therefore, there are more than thirty laws at different levels that regulate this area.

In the Republika Srpska, higher education and the science sector are regulated at the entity level: the Ministry of Education and Culture of the Republika Srpska and the Ministry of Science and Technology of the Republika Srpska. In the Federation of Bosnia and Herzegovina, public universities are established by cantons, while the Ministry of Education and Science of the Federation of Bosnia and Herzegovina performs administrative, professional and other tasks at the entity level, including copyright and intellectual property rights, as well as coordination of scientific and research activities. The cantonal ministries in the Federation of Bosnia and Herzegovina regulate education and science policy for their cantons. The Brčko District, as a separate administrative unit, also has the authority for education and science policy.

1.6.11 Programme for sustainable development by 2030 – sustainable development goals

On the Summit on Sustainable Development, which took place on 25 September 2015, the Member States of the United Nations adopted a Programme for sustainable development by 2030, which contains 17 sustainable development goals aimed at eradicating poverty, combating inequality and injustice and addressing climate change by 2030.

The sustainable development goals, also called Global goals, build on the Millennium Development Goals (MDGs) – eight goals of fighting against poverty that the world has committed to achieve by 2015. Millennium Development Goals, adopted in 2000, include a number of issues, including the fight against poverty, hunger, disease, gender inequality and the provision of water and sanitary living conditions. In achieving the Millennium Development Goals a huge success was accomplished, which indicates the importance of having a unifying programme that is based on goals and outputs. Despite the success, poverty is not completely eradicated.

[36] Source: Institute of Statistics of FBiH; Institute of Statistics of the Republika Srpska, Brčko Branch Office of the Agency for Statistics of BiH, Agency for Statistics of BiH

Global goals and broader sustainability programme go far beyond the Millennium Development Goals and address the underlying causes of poverty and the universal need of development to the benefit of all people.

Climate change mitigation (goal 13) is one of the 17 global goals of the Programme for Sustainable Development by 2030. In order to achieve the progress on several goals in parallel, this requires an integrated approach. As part of this goal, the idea is that by 2020, 100 billion USD is mobilised annually to address the needs of developing countries and mitigate disasters caused by climate change. Implementation of this goal, in the context of an integrated approach, will require significant changes in the sphere of policy and investment of the resources within the climate change segment of Bosnia and Herzegovina.

2 GREENHOUSE GAS EMISSION INVENTORY

2.1 Methodology

Sources of emissions and sinks of greenhouse gases are divided into five main sectors: energy; industrial processes and product use; agriculture and land use, land use change; forestry and waste.

The GHG emission inventory in the Fourth National Communication (FNC) has been prepared for 2015 and 2016. For the preparation of the inventory in this Fourth National Communication, the methodology of the Intergovernmental Panel on Climate Change (IPCC) prescribed by the Convention based on the reference manual of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was used. The inventory for 2015 and 2016 was prepared in software version 2.54.6396.19217 (6 July 2017). The software does not calculate NOx, CO, SO_2, NMVOC emissions.

The 2006 guidelines are divided into five parts:

- Part 1: General Guidance and Reporting
- Part 2: Energy
- Part 3: Industrial Processes and Product Use
- Part 4: Agriculture, Forestry and Other Land Use (AFOLU)
- Part 5: Waste

The software, version 2.54.6396.19217, consists of five parts:

- Part 1: Energy
- Part 2: Industrial Processes and Product Use
- Part 3: Agriculture, Forestry and Other Land Use (AFOLU)
- Part 4: Waste
- Part 5: Other

The 2006 IPCC guidelines are useful for compiling greenhouse gas inventories and mainly use the emission factors recommended by the IPCC.

The very approach of the IPCC methodology enables accuracy, consistency, transparency and comparability of calculations. A certain estimate of budget uncertainty and verification of input data is required, in order to improve the accuracy and security of the obtained results. As another improvement of accuracy, IPCC enables another verification of results in two ways, the first more detailed way is the so-called Sectoral Approach, and another simpler way is the Reference Approach.

The assessment of the quality of the inventory as well as the accuracy of the results has not been verified by independent experts.

For the purposes of preparing the GHG emission trend in the Fourth National Communication, the data presented in the Third National Communication including the corrections for the year 2014 of 21 December 2017 were used.

Table 7 gives an overview of the global warming potentials used.

Table 7: Global warming potentials for individual gases (period 100 years)

Greenhouse gas	Global warming potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
CF_4	6,500
C_2F_6	9,200
SF_6	23,900

2.2 Data collection and processing system

For the preparation of the Fourth National Communication, a consortium of companies ENOVA d.o.o. Sarajevo, CETEOR d.o.o. Sarajevo and the Jožef Stefan Institute Ljubljana was selected through a public tender.

Data from large energy and industrial plants were collected based on the answers to the prepared questionnaires through the Hydrometeorological Service of the Federation of Bosnia and Herzegovina and the Hydrometeorological Service of the Republika Srpska, while other data were taken from the press releases published on the website of the Agency for Statistics of Bosnia and Herzegovina, Institute of Statistics of the Republika Srpska, Institute of Statistics of the Federation of Bosnia and Herzegovina. Data for the purpose of F-gas calculation were taken from the Indirect Taxation Authority of Bosnia and Herzegovina.

2.3 Overview of emission estimates for 2015 and 2016 by sectors

2.3.1 Energy

The energy sector is the leader when it comes to CO_2 emissions, as much as 70% of total emissions. This sector covers all activities involving the consumption of fossil fuels as well as fugitive emissions from fuels. Fugitive emissions occur during the production, transmission, processing, storage and distribution of fossil fuels. The energy sector is a major source of anthropogenic greenhouse gas emissions. The emission calculation is based on data on fossil fuel consumption, obtained from the operators of thermal power plants, heating plants and through appropriate official energy studies, which enabled the calculation in accordance with the prescribed IPCC methodology, for the sectoral approach. In the calculation for the reference approach, which takes into account only the total fuel balance, without sub-sectoral analysis, it was difficult to be precise given the different categorisations of coal types used for the sectoral and reference approach. The calculation for the sectoral approach was made in accordance with the IPCC Guidelines.

The two most energy-intensive sub-sectors are energy conversion (thermal power plants, heating plants, transport) and fuel combustion in industry. Most of the CO_2 emissions from energy conversion come from the combustion of fuels in thermal power plants, and the changing pattern in coal consumption affects changes in total emissions. The change in fuel in industrial plants contributes to the stated variable emission values.

2.3.1.1 Methodology

According to the 2006 IPCC Guidelines for the Development of National Emission Inventories, the Energy Sector is divided into subsectors. The subsectors are as follows:

1 - Energy
1.A - Fuel Combustion Activities
1.A.1 - Energy Industries
1.A.2 - Manufacturing Industries and Construction
1.A.3 - Transport
1.A.4 - Other Sectors
1.A.5 - Non-Specified
1.B - Fugitive Emissions from Fuels
1.B.1 - Solid Fuels
1.B.2 - Oil and Natural Gas
1.B.3 - Other Emissions from Energy Production
1.C - - Carbon Dioxide Transport and Storage
1.C.1 – Transport of CO_2
1.C.2 - Injections and Storage
1.C.3 - Other

The quantities of coal used for the GHG emission inventory are based on data on energy consumption collected from thermal power plants and heating plants. Elektroprivreda Bosne i Hercegovine /Electric power company/ in the Federation of Bosnia and Herzegovina and Elektroprivreda /Electric power company/ of the Republika Srpska in the Republika Srpska have data on fuel consumption in thermal power plants and coal characteristics obtained on the basis of chemical analysis of coal performed by accredited laboratories, and these data can be considered reliable. The heating plants also have data on fuel consumption, which were also submitted to the hydrometeorological services.

Data on coal production were collected through databases from the Institute of Statistics of the Federation of Bosnia and Herzegovina, Institute of Statistics of the Republika Srpska and the Agency for Statistics of Bosnia and Herzegovina. The consumption of brown coal is divided into lignite and sub-bituminous coal based on their lower heating value, in accordance with the IPCC methodology. Accordingly, only coal from the Banovići coalmine that met this condition is categorised as sub-bituminous coal, while the remaining coal is classified as lignite. Fuel consumption data were collected at the entity level and then summed up together, following the net weight principle.

The calculation of fuel consumption using the reference approach for the energy sector was performed in accordance with the requirements of the methodology (imports, exports, stock changes) for 2015 and 2016, and differences in the reference and sectoral approach were recorded due to statistical data on coal types. Namely, statistics distinguish lignite and brown coal, regardless of their lower heating value, while the IPCC methodology categorises lignite as coal with a lower heating value below 17,435 TJ/kt (4,165 kcal/kg), and sub-bituminous coal as coal with a lower heating value above 17,435 TJ/kt. However, the data collected from the operators were classified according to the IPCC methodology. Furthermore, operators of large energy and industrial plants provided data in accordance with questionnaires compiled separately for each sector and activity, which contain data on fuel consumption, product quantity and required technological parameters, and these data can be considered reliable.

2.3.1.2 Carbon dioxide (CO_2) emissions from energy industries

CO_2 emissions from fuel combustion depend on the amount of fuel consumed (energy balance and data from thermal power plants, heating plants and industrial power plants), thermal power (chemical analysis of energy sources), CO_2 emission factors (value from IPCC Guidelines 2006), energy balance is based on data from of all available sources. Data from the Institute of Statistics of the Federation of Bosnia and Herzegovina, Institute of Statistics of the Republika Srpska and the Agency for Statistics of Bosnia and Herzegovina - Brčko Branch) on fuel production and consumption were used. In addition, data on annual consumption of coal, natural gas and other energy sources were used. Energy balances of Bosnia and Herzegovina (balance of coal and gas, balance of petroleum products) were used to compile the inventory for 2015 and 2016. However, emissions according to the reference and sectoral approach differ by 2.17% in 2015 and 0.20% in 2016, probably due to the difference in anthracite consumption and its consumption from the estimate using the reference approach. Furthermore, the Stanari Thermal Power Plant was put into operation in 2016, but not at full capacity.

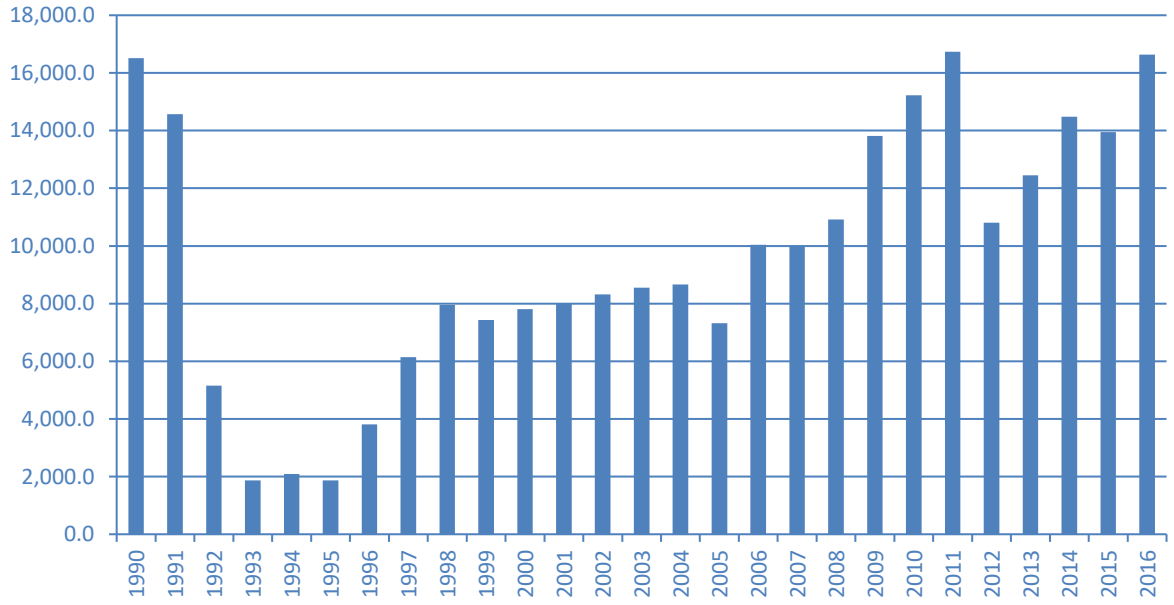


Figure 10: CO_2 emissions (Gg) for the period 1990 - 2016 - energy sector

Data collected from operators are classified according to the IPCC methodology. Furthermore, operators of large energy and industrial plants provided data in accordance with questionnaires compiled separately for each sector and activity. Data on fuel consumption, product quantity and required technological parameters were requested, and such obtained data can be considered reliable.

In 2015, CO_2 emissions amounted to 13,948.28 Gg CO_2, while in 2016 CO_2 emissions amounted to 16,635.06 Gg CO_2. These data indicate a decrease of -3.68% in 2015, and an increase of 14.87% in 2016 compared to 2014.

2.3.1.3 Manufacturing industries and construction

For 2015 and 2016, the calculation of greenhouse gas emissions related to the category of manufacturing industries and construction was performed on the basis of the official publication of the Agency for Statistics of Bosnia and Herzegovina and the annual reports of the Federation of Bosnia and Herzegovina and the Republika Srpska.

In 2015, CO_2 emissions amounted to 1,507.60 Gg CO_2, while in 2016 CO_2 emissions amounted to 1,117.53 Gg CO_2. From year to year, an increase in CO_2 emissions has been recorded in this sector, as can be seen from the attached calculation results. These data indicate an increase of 75.91% in 2015, or 30.39% in 2016 compared to 2014.

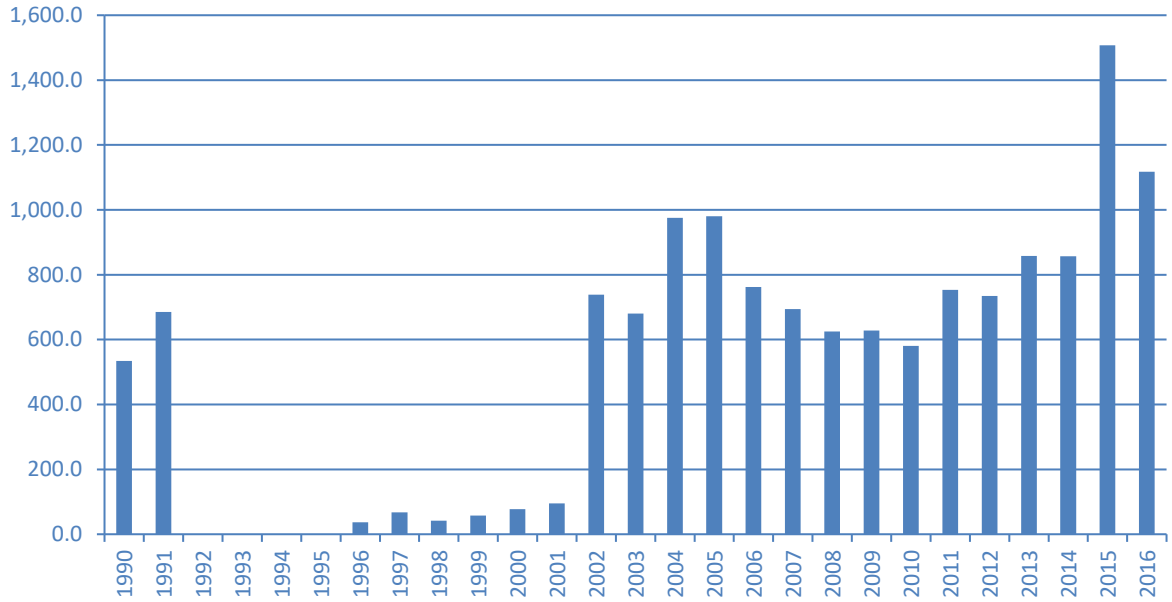


Figure 11: CO_2 emissions (Gg) for the period 1990 - 2016 - manufacturing industries and construction sector

2.3.1.4 Carbon dioxide (CO_2) emissions from transport

For 2015 and 2016, the calculation of greenhouse gas emissions related to the transport category was performed on the basis of the official publication of the Agency for Statistics of Bosnia and Herzegovina - Balance of Petroleum Products. No official fuel consumption data for a particular vehicle category are available.

The volume of Road transportation in Bosnia and Herzegovina is shown through two indicators: (i) transport of goods and (ii) transport of passengers. Comparing the data from previous Climate Change Communications and based on available data for the years 2015 and 2016, it can be concluded that the volume of transport in Bosnia and Herzegovina has an increasing trend.

Tonne-kilometres for 2015 amounted to 3,405,231,000 km, and for 2016 they amounted to 4,015,177,000 km. Mileage of vehicles in public road transportation in 2015 amounted to 458,147 km, and in 2016 they amounted to 507,985 km, an increase of 10.87% compared to 2015. Mileage in urban and suburban transport in 2015 amounted to 60,592 km, in 2016 it was 62,937 km, which is an increase of 3.87% compared to 2015.

Data on fuel consumption for 2015 and 2016 were taken from the official publication of the Agency for Statistics of Bosnia and Herzegovina - Balance of Petroleum Products. The share of fuel in the transport sector is taken from the total balance of petroleum products for Bosnia and Herzegovina. Consumption for 2015 of diesel fuel is 761,451 t, petrol 192,762 t and LPG 36,957 t. Consumption for 2016 of diesel fuel is 909,954, petrol 198,247 t and LPG 45,974 t.

The data on the development of air transport is confirmed by the fact that 4 airports are licensed to perform international air transport. Consumption for kerosene for 2015 was 6,239 t, and for 2016 it was 10,222 t.

In 2015, CO_2 emissions amounted to 3,198.60 Gg CO_2, while in 2016 CO_2 emissions amounted to 3,726.56 Gg CO_2. From year to year, an increase in CO_2 emissions has been recorded in this sector, as can be seen from the attached calculation results. These data indicate an increase of 4.76% in 2015 and 22.05% in 2016 compared to 2014.

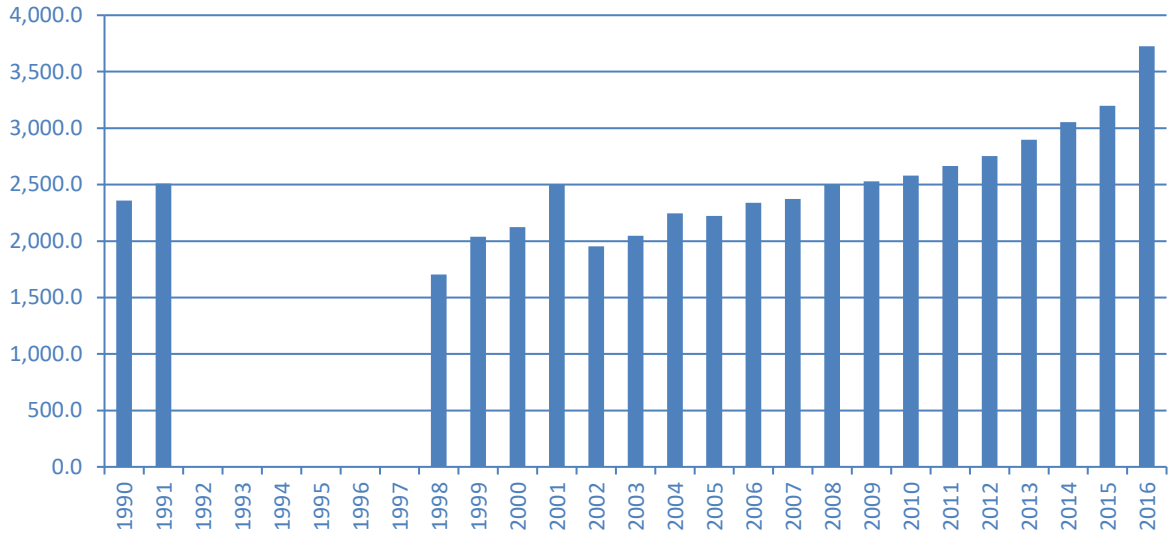


Figure 12: CO_2 emissions (Gg) for the period 1990 - 2016 – transport sector

2.3.1.5 Fugitive emissions from fuels

For 2015 and 2016, the calculation of greenhouse gas emissions related to the category of fugitive emissions was performed on the basis of the official publication of the Agency for Statistics of Bosnia and Herzegovina - Oil Balance.

In 2015, CO_2 emissions amounted to 458.44 Gg CO_2, while in 2016 CO_2 emissions amounted to 513.73 Gg CO_2. These data indicate a decrease of -25.79% in 2015, or -16.84% in 2016 compared to 2014.

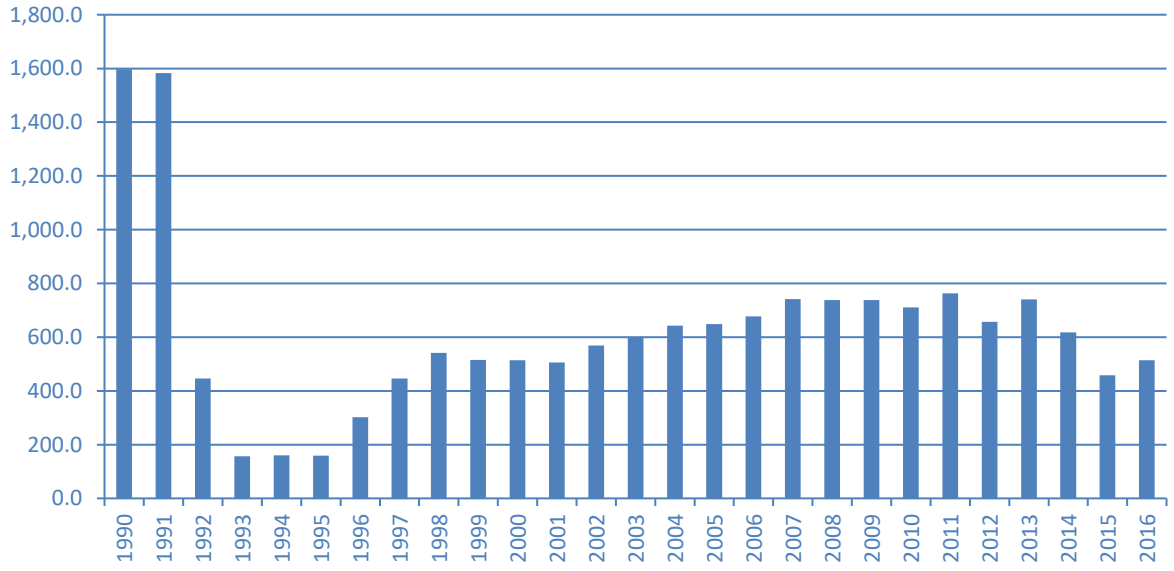


Figure 13: CO_2 emissions (Gg) for the period 1990 - 2016 – fugitive emissions

2.3.1.6 Total emissions from energy sector

In 2015, CO_2 emissions amounted to 20,411.01 Gg CO_2, while in 2016 CO_2 emissions amounted to 23,429.38 Gg CO_2. These data indicate an increase of 0.80% in 2015, or 15.70% in 2016 compared to 2014. Compared to 1990, CO_2 emissions decreased by -17.99% in 2015, and by -5.86% in 2016.

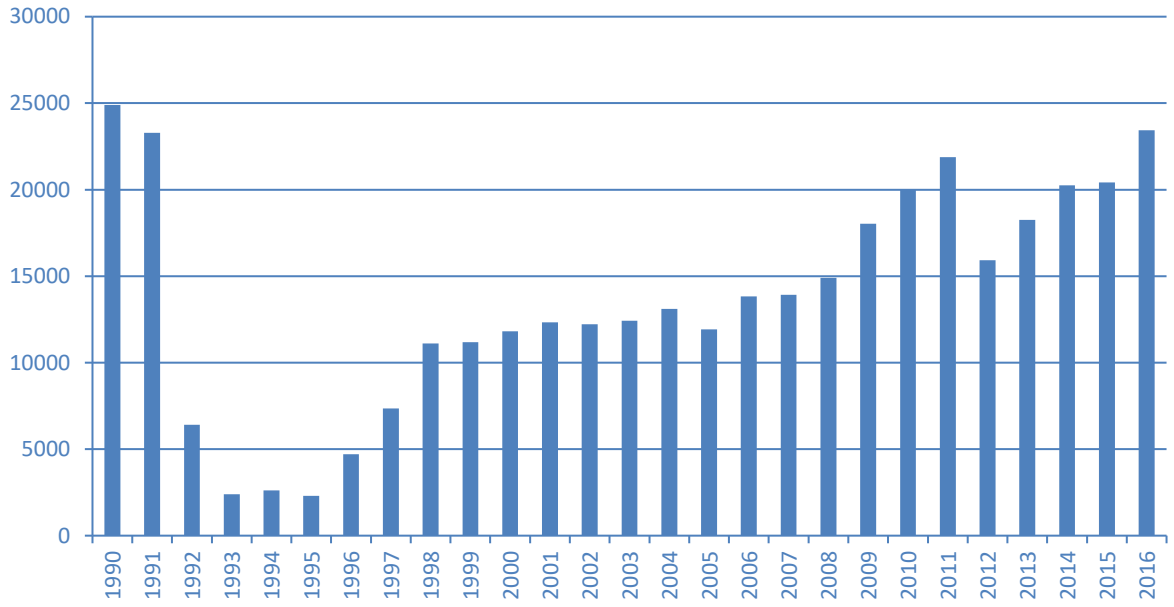


Figure 14: CO_2 emissions (Gg) for the period 1990 - 2016 - energy

2.3.2 Industrial processes

2.3.2.1 Methodology

During various non-energy industrial processes, greenhouse gas emissions occur during the conversion of input substance(s) into the final product(s). The greenhouse gases produced in these processes are by-products, most commonly carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4).

Significant emissions of carbon dioxide occur in the production of cement, limestone, ammonia and in the use of limestone and dehydrated soda in industrial plants. N_2O emissions occur in the production of nitric acid, while methane emissions occur in the production of chemical compounds such as ethylene. Emissions also occur through the consumption of fluorocarbons (HFCs) and perfluorocarbons (PFCs) used as replacement gases, gases present in refrigeration and air conditioning systems, foam suppression, fire extinguishers and aerosol compounds, and negatively affected the ozone layer. Sulphur hexafluoride (SF6) emissions may occur during testing and handling of high voltage circuit breakers and installations in which it is used as an insulating gas. Carbon monoxide (CO), nitrogen oxides (NOx), sulphur dioxide (SO_2) and NMVOCs can be formed in some industrial petrochemical processes.

The "Industrial Processes" sector is divided into subsectors according to the 2006 IPCC Guidelines for the preparation of National Emission Inventories 2006. The subsectors are:

2 - Industrial processes and product use
2.A - Mineral Industry
2.B - Chemical Industry
2.C - Metal Industry
2.D - Non-Energy Products from Fuels and Solvent Use
2.E - Electronics Industry
2.F - Product Uses as Substitutes for Ozone Depleting Substances
2.G - Other Product Manufacture and Use
2.H - Other

Data from industrial processes calculated for the needs of the greenhouse gas inventory in the Fourth National Communication of Bosnia and Herzegovina were obtained from the following industries:

- Iron and steel industry;
- Paper and paper products industry;
- Cement production (two cement plants: Kakanj and Lukavac);
- Production of heavy soda, light soda and baking soda (Sisecam Soda Lukavac);
- Production of coke, nitrogen and maleic anhydride (AMK);
- Production of crude oil and petroleum products (Brod).

For all significant activities within the sector, emission factors are prescribed under the IPCC 2006 Guidelines for National Greenhouse Inventories and Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories.

The EF used to calculate CO_2 emissions from the iron or steel industries is 1.46 t CO_2/t of iron or steel produced, given the integrated technology using a basic oxygen furnace (BOF), for steel production coefficients of 1.35 were used, for coke ovens 0.56 and for sintering 0.2.

For aluminium production the EF is 1.7 for the Solderberg process. For cement production from 0.4 for LUMAL to 0.9392 clinker fractions in cement, and EF is 0.816.

Bearing in mind that CO_2 emissions from F-gases are not included in the Inventory for the period up to 2014, this Fourth National Communication presents F-gas emissions separately (Table 8).

Table 8: F-gas emission in Bosnia and Herzegovina

	F-gas emission (Gg CO_2eq)				
	R134a	**R404A**	**R407C**	**R410A**	**Total**
2012	72.242	153.762	32.971	52.118	311.09
2013	81.064	163.573	36.572	67.173	348.38
2014	90.053	171.347	39.657	85.353	386.41
2015	99.070	179.553	41.914	106.554	427.09
2016	108.744	188.993	43.244	131.229	472.21
2017	118.942	197.784	43.379	158.986	519.10
2018	130.005	208.475	42.390	189.790	570.66

/Source: HFC Outlook model for Bosnia and Herzegovina, based on data from the Indirect Taxation Authority of Bosnia and Herzegovina and the Ozone Unit of Bosnia and Herzegovina/

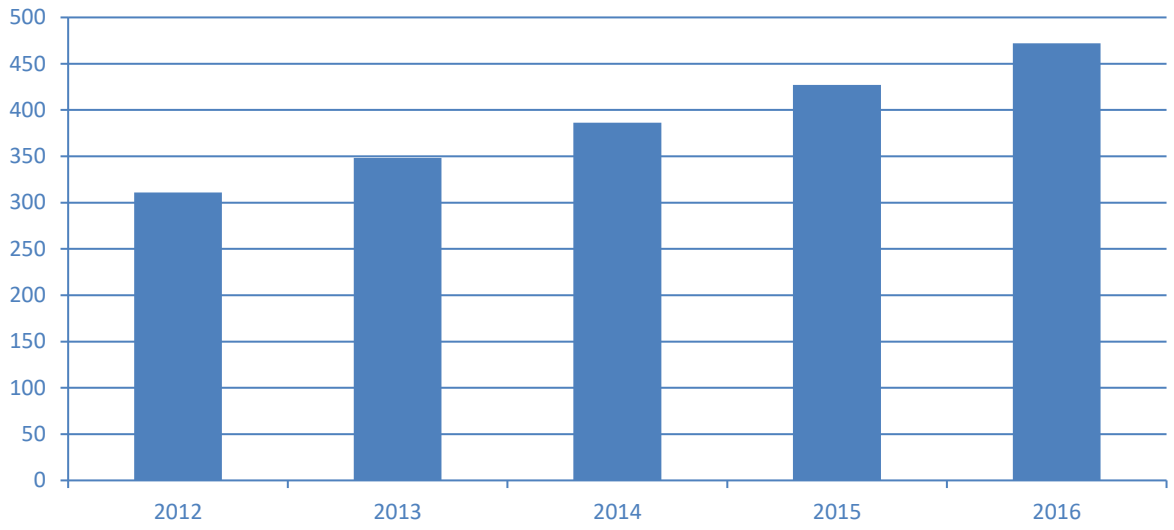


Figure 15: CO_2 emissions (Gg) for the period 2012 - 2016 - F-gas sector

2.3.2.2 Total emissions from the industrial processes sector

The calculation of greenhouse gas emissions for 2015 and 2016 related to the category of Industrial Processes emission was performed on the basis of the official publication of the Agency for Statistics of Bosnia and Herzegovina, the Institute of Statistics of the Republika Srpska and the Institute of Statistics of the Federation of Bosna and Herzegovina.

In 2015, CO_2 emissions amounted to 2,906.94 Gg CO_2, while in 2016 CO_2 emissions amounted to 2,660.39 Gg CO_2. These data indicate an increase of 29.35% in 2015, or 18.38% in 2016 compared to 2014. Compared to 1990, there is a decrease in emissions by -18.21% in 2015, and by -25.15% in 2016.

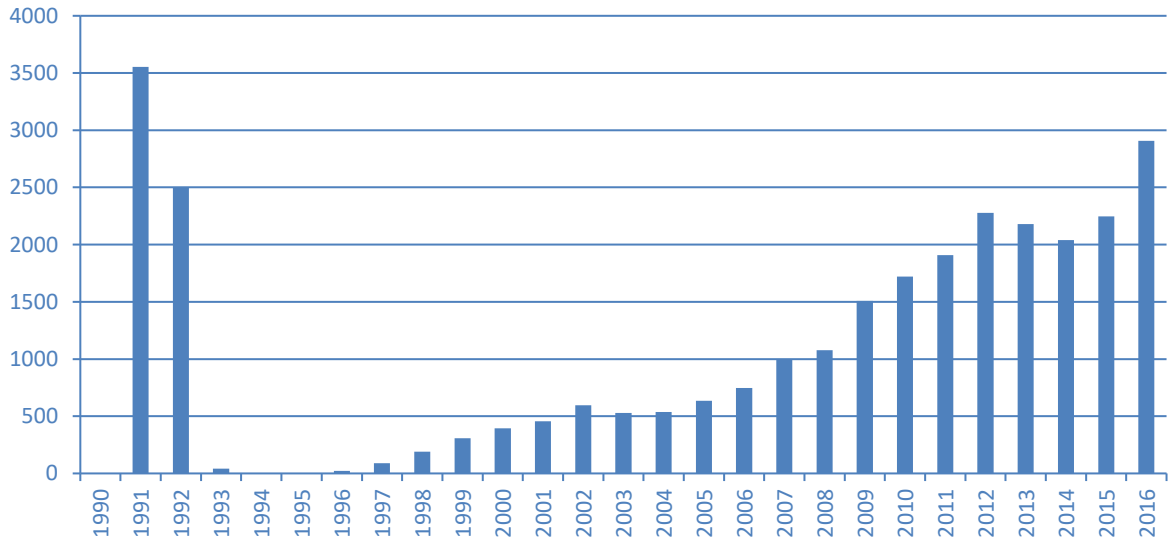


Figure 16: CO_2 emissions (Gg) for the period 1990 - 2016 – industrial processes sector

2.3.3 Agriculture

2.3.3.1 Methodology

In the Fourth National Communication of Bosnia and Herzegovina on Climate Change, the inventory of greenhouse gas emissions and sinks refers to the period 1990-2016. The methodology described in the following guidelines is used to calculate greenhouse gas emissions: 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines) and IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC Good Practice Guidance) prepared by the Intergovernmental Panel on Climate Change (IPCC).

The 2006 IPCC Guidelines methodology provides default emission factor values for all relevant activities of the agricultural sector. Due to the lack of data for the calculation of emission factors of Bosnia and Herzegovina, the recommended emission factors were used (Tier 1).

2.3.3.2 Data collection and processing system

The inventory preparation process involves several steps that include data collection and processing, emission estimation and recalculation in accordance with the IPCC methodology, and the compilation of the inventory with the preparation of reports and a table overview of emissions.

In the last, Third National Communication (TNC), an GHG emission inventory was made for the period 2002-2009, and for the preparation of the Fourth National Communication of Bosnia and Herzegovina on Climate Change under the UNFCCC, data were collected for the period until 2016. The two main sources of data on plant and animal production are the Agency for Statistics of Bosnia and Herzegovina and the FAO database. Official statistics are given priority when compiling the inventory. FAO data were an adequate substitute for the animal population not covered by national statistics. Since the methodology of division into subcategories of animals in statistical yearbooks has changed over the years, and is not the same at the entity level (more detailed at the level of the Federation of Bosnia and Herzegovina), cattle categories have been reclassified into adequate IPPC categories.

It is important to note that the statistics used from the statistical yearbooks of Bosnia and Herzegovina are not in line with the IPCC methodology in terms of data availability and data formats. This applies to all sectors but it is particularly emphasised in the sector of agriculture and land use, land-use change and forestry - LULUCF. Also, the lack of legislation in the type and scope of data that need to be collected is a major problem.

Due to the lack of appropriate categorisation, the Tier 1 method was used for all animals as well as the default emission factors (EF) specific to the animal type, climate zone, geographical area (Eastern Europe), as well as the level of development of the region. There is no methodology for calculating methane (CH_4) emissions for poultry in the 2006 IPCC.

2.3.3.3 Methane emissions (CH_4)

Methane is formed as a direct product of animal metabolism. The largest producers of methane are ruminants (cows, other cattle and sheep). There are two significant sources of methane emissions: intestinal fermentation caused by the process of ruminant digestion (dairy cows are the largest source) and various procedures related to the storage and application of organic fertilisers (fertiliser management). Total methane emissions from domestic animals are obtained as the sum of emissions from intestinal fermentation and emissions related to fertiliser management.

According to the IPCC methodology, methane emissions are determined for each type of animal (dairy cows, other cows and bulls, sheep, goats, horses, pigs and poultry). The default IPCC emission factors were used for the calculation.

A recalculation was performed for all years in a row related to the category of animals. According to the previously used methodology, dairy cows and heifers were included in the calculation of dairy cattle, and now, due to the change in methodology, only dairy cows are included.

Methane emissions decreased between 1992 and 1996 due to the war which significantly affected the animal population (significant decrease compared to 1990), crop production, consumption of mineral fertilisers and agricultural practice in general, but since 2006 methane emissions have not changed significantly, and in 2015 it amounted to 1,037.80 Gg CO_2eq, and in 2016 to 1,031.30 Gg CO_2eq.

2.3.3.4 Nitrous oxide emission (N_2O)

Nitrous oxide (N_2O) is produced in the soil by nitrification and denitrification processes. The IPCC methodology estimates N_2O emissions using the addition of nitrogen to the soil (artificial or organic fertilisers - manure, crop residues, sewage sludge or mineralisation of N in soil organic matter). Within the agricultural sector, three sources of N_2O emissions have been identified: direct N_2O emissions from agricultural soils, direct N_2O emissions from livestock breeding and indirect N_2O emissions caused by agricultural activities.

The largest emission is the result of direct emissions from agricultural soils. According to the IPCC methodology, this includes: mineral nitrogen, nitrogen from organic fertilisers, the amount of nitrogen bound by N - fixing crops, the amount of N formed by decomposition of plant residues and the amount formed by soil mineralisation caused by histosol cultivation. A significant amount of N_2O is formed during the storage of manure and is attributed to livestock breeding. This includes emissions from anaerobic lagoons, liquid systems, solid manure storage systems, etc. N_2O emissions from pastures are included under Agricultural soils.

N_2O emissions from agriculture vary slightly over the years, ranging from 3 to 4 Gg. Total N_2O emissions amounted to 2.80 Gg in 2015 and 3.10 Gg in 2016, 868.00 Gg CO_2eq in 2015 and 961.00 Gg CO_2eq in 2016.

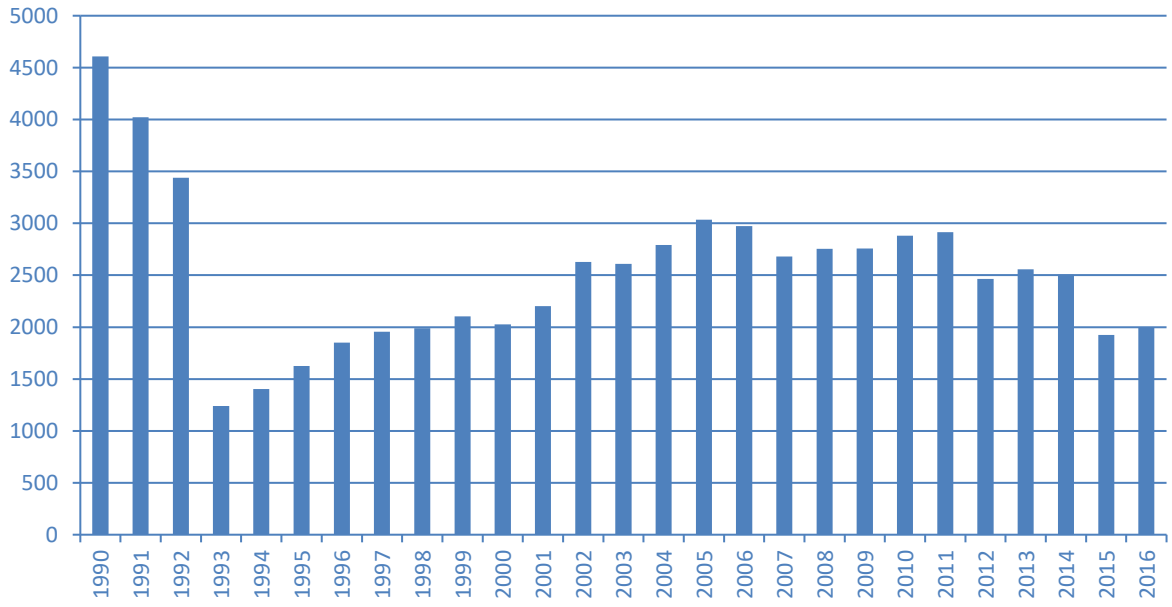


Figure 17: CO_2 emissions (Gg) for the period 1990 - 2016 – agricultural sector

After 1992, N_2O emissions from agriculture decreased due to war circumstances and limited agricultural practices at the time. Increased N_2O emissions are mostly the result of increased consumption of mineral fertilisers (2006) and due to the increase in crop production (2002).

2.3.3.5 Uncertainty of calculation

Uncertainty of CH_4 and N_2O emission calculations is related to the reliability of data and emission factors and amounts to 30% for the agricultural sector.

2.3.3.6 Recommendations for future improvement for the agricultural sector-Inventory

Several areas for improvement have been identified, primarily research aimed at collecting more detailed data on the number of animals by species and categories. Detailed categorisation of livestock for Bosnia and Herzegovina is very important in order to be able to calculate the estimate of emissions by the Tier 2 method. There are also specific data such as data on live animal weight and milk fat content to replace the default IPCC values in the Tier 2 calculation.

2.3.4 Forestry

According to the Initial National Communication of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change (Vukmir et al., 2009), the storage potential of greenhouse gases by forest ecosystems was -7,423.5 Gg CO_2 in the base year 1990. The Second Biennial Update Report of Bosnia and Herzegovina to the UNFCCC (Radusin et al., 2016) provides data for 2014, where the potential of forest and wood biomass as a sink is estimated at -6,397.67 Gg CO_2.

For the GHG inventory from the forestry sector for 2015 and 2016, slightly lower values of storage potential were obtained than in previous years, noting that the latest version of the official IPCC calculation software was used for this inventory. In addition, a much more detailed division of forests and forest land into different categories has been made, and sinks related to wood products (HWP), as well as emissions from biomass combustion in forest ecosystems, have been included in the calculation.

2.3.4.1 Methodology

To conduct an inventory of greenhouse gases in the forestry sector, which includes forests and forest lands, the official methodology of the Intergovernmental Panel on Climate Change (IPCC) was used, namely:

- *The 2003 Good Practice Guidance for Land Use, Land-Use Change and Forestry*
- *The 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Volume 4: Agriculture, Forestry and Other Land Use, Chapter 4: Forest land and Chapter 12: Harvested Wood Products.*

The official IPPC software was used in the calculations: Inventory Software Version 2.54.6396.19217. Calculations were performed for the years 2015 and 2016, for chapters:

- 3. Agriculture, Forestry and Other Land use – 3.B Land – 3.B.1 Forest land – 3.B.1.a – Forest land Remaining Forest land.
- 3.C.1.a - Biomass burning in forest lands
- 3.D.1- Harvested Wood Products.

2.3.4.2 Data collection and processing system

In addition to the use of reference scientific literature in the subject area, data were collected exclusively using the desk research method, in other words, existing data at the level of Bosnia and Herzegovina were used for the production of GHG inventory, without additional field measurements. In accordance with the available official statistical data for the Federation of Bosnia and Herzegovina, Republika Srpska and Brčko District, the following 16 categories have been defined and entered in the working forms for 3.B.1.a - Forest Land Remaining Forest Land: 1. Coppice deciduous forests of the Federation of Bosnia and Herzegovina, 2. Coppice deciduous forests of the Republika Srpska, 3. Private coniferous forests of the Federation of Bosnia and Herzegovina, 4. Private coniferous forests of the Republika Srpska, 5. Private deciduous forests of the Republika Srpska, 6. Private deciduous forests of the Federation of Bosnia and Herzegovina, 7. Forest plantations of conifers of the Republika Srpska, 8. Forest plantations of deciduous trees of the Republika Srpska, 9. High degraded deciduous trees of the Republika Srpska, 10. High degraded conifers of the Republika Srpska, 11. High forests of conifers of the Republika Srpska, 12. High forests of deciduous trees of the Republika Srpska, 13. High forests of conifers of the Federation of Bosnia and Herzegovina, 14. High forests of deciduous trees of the Federation of Bosnia and Herzegovina, 15. High forests of Brčko, 16 Coppice forests of Brčko. These categories are defined in accordance with the available data from the official statistical bulletins, so that 9 categories are defined for the Republika Srpska, 5 categories for the Federation of Bosnia and Herzegovina and 2 categories for Brčko. This fact can be changed by harmonising the data collected by official statistics, not only for this, but for all other areas. By defining these categories, a much more detailed analysis was made than was the case so far during the GHG inventory from this sector for Bosnia and Herzegovina, not focusing exclusively on the Tier 1 approach, with an effort to define as much available data for the conditions of Bosnia and Herzegovina, which means combination with Tier 2 approach. This type of calculation contributes to much greater accuracy and obtaining more relevant data.

Specific statistical data for defined categories of forests and forest land are taken from official statistical data (publications), namely: Institute of Statistics of the Republika Srpska (2016), Forestry. Statistical Bulletin No. 16; Institute of Statistics of the Republika Srpska (2017), Forestry. Statistical Bulletin No. 17; JPS "Šume Republike Srpske" (2016), Cadastre of Forests and Forest Land in the Republika Srpska, situation as of 31 December 2015; JPS "Šume Republike Srpske" (2017), Cadastre of Forests and Forest Land in the Republika Srpska, situation as of 31 December 2016; Institute of Statistics of the Federation of Bosnia and Herzegovina (2016), Forestry in the Federation of Bosnia and Herzegovina for 2015, Statistical Bulletin No. 226; Institute of Statistics of the Federation of Bosnia and Herzegovina (2017), Forestry in the Federation of Bosnia and Herzegovina for 2016, Statistical Bulletin No. 259; Ministry of Agriculture, Forestry and Water Management of the Federation of Bosnia and Herzegovina (2018), State Forest and Forest Land Records for 2017, Forest Administration of the Federation of Bosnia and Herzegovina. Data for wood products were taken from the Food and Agriculture Organisation of the United Nations (FAOStat) statistical database. Individual parameters (climate region, soil type, ecosystem type, species, etc.) are determined by experts from of Bosnia and Herzegovina.

2.3.4.3 Results of emission/sink estimates for 2015 and 2016 for the forestry sector

2.3.5 Carbon dioxide emissions (CO_2)

Data on emissions caused by fires in forest areas amounted to 0.01254 Gg CH_4 in 2015, and 0.03113 Gg CH_4 in 2016.

2.3.6 Sinks – LULUCF (Land use, land-use change and forestry)

Data on CO_2 sinks for forest areas (Forest land remaining forest land) and wood products (HWP):

for 2015 -5,378.47 Gg CH_4 and for 2016 -5,076.98 Gg CH_4.

The total balance of sinks and greenhouse gas emissions for 2015 for forest areas, wood products and fires for 2015 is -6,095.70 Gg CH_4 and for 2016 it is -5,836.68 Gg CH_4.

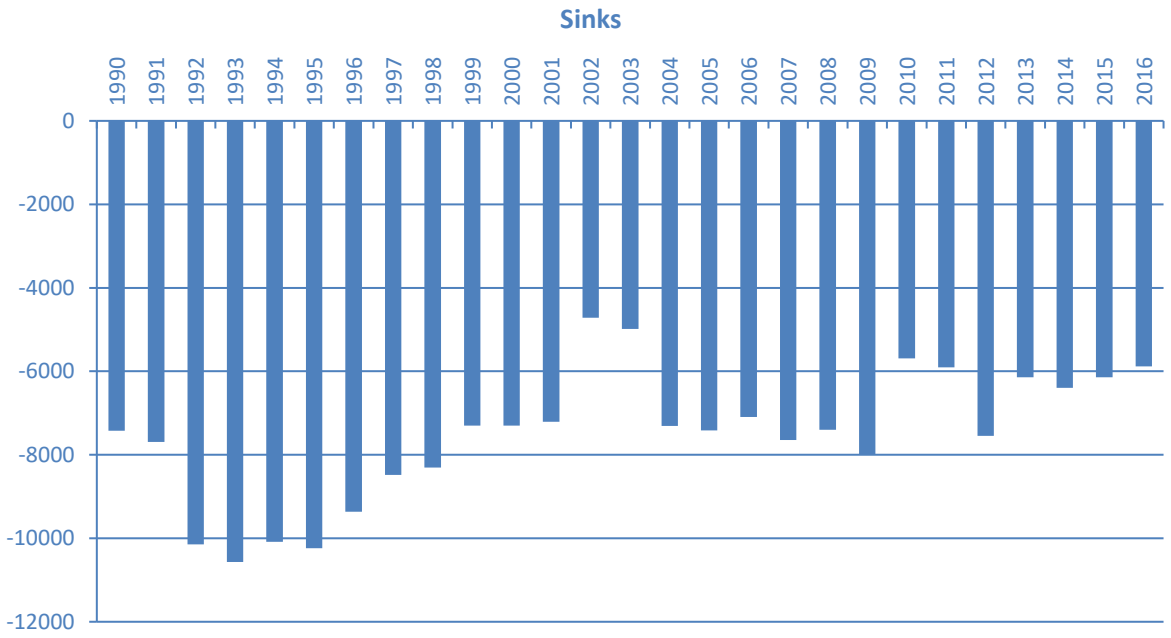


Figure 18: CO_2 sinks (Gg) for the period 1990 - 2016 - forestry sector

2.3.6.1 Uncertainty of calculation

Uneven data structure and incompleteness for different administrative units (Federation of Bosnia and Herzegovina, Republika Srpska and Brčko District of Bosnia and Herzegovina) may affect calculation uncertainty. Also, due to the lack of certain data, they had to be determined on the basis of expert assessment, which may affect the uncertainty of the calculation.

Determining the percentage share for certain categories of forests in the Federation of Bosnia and Herzegovina were taken from the State Forest Records of the Forest Administration of the Federation of Bosnia and Herzegovina (2017). The data for the Herzegovina-Neretva Canton and West Herzegovina Canton are also listed in this Record only collectively, without a more detailed division, and therefore there was no possibility for their inclusion in the calculation.

The categories in Chapter 3.B.1.b relating to other types of land that have been converted to forest land have not been processed due to lack of data. It should be emphasised that the 2006 IPPC Guidelines and the 2003 GPG for LULUCF, contained the recommendation to use the "20-year rule", i.e. that land should be in the same type of use for 20 years in order to be considered a specified category of land (for example, land can be considered a forest only 20 years after afforestation - Under default assumptions therefore land will be transferred from a conversion category to a remaining category after it has been in a given land use for 20 years). Among other things, abandoned agricultural lands that are currently under forest cover can be included here but due to the lack of official data, this category could not be analysed within this calculation.

The limitation is the smaller volume of data (primarily in terms of data types) for private in relation to state forests, so in certain cases the data for private forests are defined on the basis of analogy with state forests. The

same methodology was used due to the lack of data by individual Entities and/or District. Data for the Loss of carbon disturbances and Annual carbon loss from drained organic soils cards were not available, so no calculations were made for this type of carbon loss.

2.3.6.2 Recommendations for further improvement

One of the basic problems in Bosnia and Herzegovina stems from the complex state system and division into several administrative units. This is further reflected in the different format, and often the methodology of data collection related to forestry, but also other areas. A special problem is if individual data are only summarised (as the previously mentioned example for two cantons in Federation of Bosnia and Herzegovina). The recommendation for future improvement is to define the necessary data for the preparation of the GHG inventory (in the field of forestry, but also in other areas) and to initiate a procedure for harmonising the form of presentation of statistical data between the Federation of Bosnia and Herzegovina, Republika Srpska and the Brčko District of Bosnia and Herzegovina. Also, it is recommended that all necessary data be consolidated and published by the Agency for Statistics of Bosnia and Herzegovina. It should be borne in mind that the collection and publication of data related to private forests is much smaller than in the case of state forests. It is necessary to emphasise the lack of official data from the conducted Forest Inventory on large areas for Bosnia and Herzegovina, as well as the real situation of a larger area under forests that was formed on abandoned agricultural land. It is also recommended that by organising trainings by reference international experts, additional strengthening of human resources for the preparation of GHG inventories be performed.

2.3.7 Waste

According to the IPCC 2006 guidelines, the "waste" sector includes the following categories: solid waste disposal, biological treatment of solid waste, waste incineration and wastewater management. This Inventory does not take into account waste incineration or biological treatment of solid waste. The IPCC methodology used to estimate greenhouse gas emissions follows the IPCC guidelines which represent the procedures for estimating greenhouse gas emissions given by the international experts of the Intergovernmental Panel on Climate Change (IPCC). Greenhouse gases (GHG) from the waste management sector include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Greenhouse gas emissions are expressed in terms of CO_2 equivalent, where the global warming potential of methane (the main component of landfill gas) and nitrous oxide is 21 for methane and 310 for nitrous oxide in relation to CO_2.

The "Waste" sector is divided into sub-sectors according to the 2006 IPCC Guidelines for the Preparation of National Emission Inventories. The subsectors are the following:

4.Waste
4.A - Solid Waste Disposal
4.B - Biological Treatment of Solid Waste
4.C - Incineration and Open Burning of Waste
4.D - Wastewater Treatment and Discharge
4.E - Other

The IPCC 2006 guidelines prescribe a mandatory methodology for calculating emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) generated from waste management activities. The activities that result in the highest emissions are the disposal and treatment of municipal solid waste, as well as wastewater management. Emissions that are treated by the methodology include CH_4 emissions that occur during the disposal and treatment of municipal waste, landfilling of household wastewater and indirect emissions of N_2O from human secretions.

Given the fact that almost all landfills (for the observed period) in Bosnia and Herzegovina are landfills of municipal waste that are not adequately managed and deeper than 5 m, the default correction factor of methane according to IPCC 2006 of 0.8[37] was used. Data on the total disposed municipal waste were obtained from official documents of the Federation of Bosnia and Herzegovina, Republika Srpska, the Agency for Statistics of Bosnia and Herzegovina, the institute of Statistics of the Federation of Bosnia and Herzegovina and the institute of Statistics of the Republika Srpska. These data served as input for Activity data 4.A.

For the structure of municipal waste, the factors applied in Eastern Europe are taken over, as follows:

- food waste - 30.1%,
- paper - 21.8%,
- wood - 7.5%,
- textiles - 4.7% and
- plastic - 35.9%.

The predominant method of waste disposal in Bosnia and Herzegovina is the disposal of waste in landfills. This way of waste disposal and inadequate wastewater management cause a generally negative impact on the environment and thus leads to an increase in greenhouse gas emissions.

In 2016, several large wastewater treatment plants in Bosnia and Herzegovina started operating and thus the share of sources of greenhouse gas emissions in Bosnia and Herzegovina was shown to change.

The estimated quantity of municipal waste produced in Bosnia and Herzegovina in 2015 is 1,248,718 tonnes, while 941,551 tonnes of municipal waste was collected by public transport. The estimated quantity of municipal waste generated in 2016 is 1,243,889 tonnes, 946,775 tonnes of municipal waste was collected by public transport.

According to the IPCC Guidelines 2006, waste inventory has been recommended since 1950. In this case, the inventory for the waste sector included available data from 1950. For the purposes of calculating the emission from municipal waste, data for the number of inhabitants from the official documents on the census of 1951, 1961, 1971, 1981, 1991, 2013 were used. The quantity of waste per capita for the period from 1950 to 2009 that was taken into account is 380 kg/capita/year. For the purposes of calculating emissions from industrial waste, GDP data in the period from 1950 to 1994 in the amount of $ 100 million were used. Data for GDP from 1994 to 2016 were taken from www.worldbank.org Waste generation rate 5 Gg/Sm GDP/year was used from 1950 to 2016. In that case, the emission generated by the disposal of solid waste amounts to 53.46 Gg CH_4 for 2015, or 53.01 Gg CH_4 for 2016. Data from the Agency for Statistics of Bosnia and Herzegovina were used to calculate emissions from wastewater treatment from households [38].

For the calculation of emissions from industrial water processing from the food industry, data from annual statistics were collected for: beer and malt/syrup, dairy products, meat, paper and pulp, vegetables, fruits and juices and wines. In that case, emissions from wastewater treatment and discharges amount to 19.76 Gg CH_4 and 0.273 Gg N_2O for 2015, and 17.08 Gg CH_4 and 0.28 Gg N_2O for 2016, respectively. In summary, if the available data from 1950 are included in the emission calculation, 73.27 Gg CH_4 and 0.273 Gg N_2O for 2015 were emitted, and 17.08 Gg CH_4 and 0.28 Gg N_2O for 2016. The total eq CO_2 emission in 2015 would be 1,537.85 Gg and for 2016 it is 1,472.12 Gg.

[37] Table 3.1. Guideline Waste

[38] http://bhas.gov.ba/data/Publikacije/Saopstenja/2018/ENV_02_2017_Y1_0_BS.pdf

Applying the method of calculating emissions used in previous reports, the starting year was 2002, in which case the emissions from solid waste disposal would amount to 23.20 Gg CH_4 for 2015, and 23.96 Gg CH_4 for 2016. Emissions from wastewater treatment and discharges, using the method where the starting year is 2002, would be 19.76 Gg CH_4 and 0.27 Gg N_2O for 2015, and 17.08 Gg CH_4 and 0.28 Gg N_2O for 2016, respectively. The total emission is 42.96 Gg CH_4 and 0.273 N_2O for 2015, and 41.04 Gg CH_4 and 0.28 Gg N_2O for 2016.

Based on the above, including available data from 1950, the total CO_2 emissions from waste are 1,622.54 for 2015 and 1,558.95 for 2016.

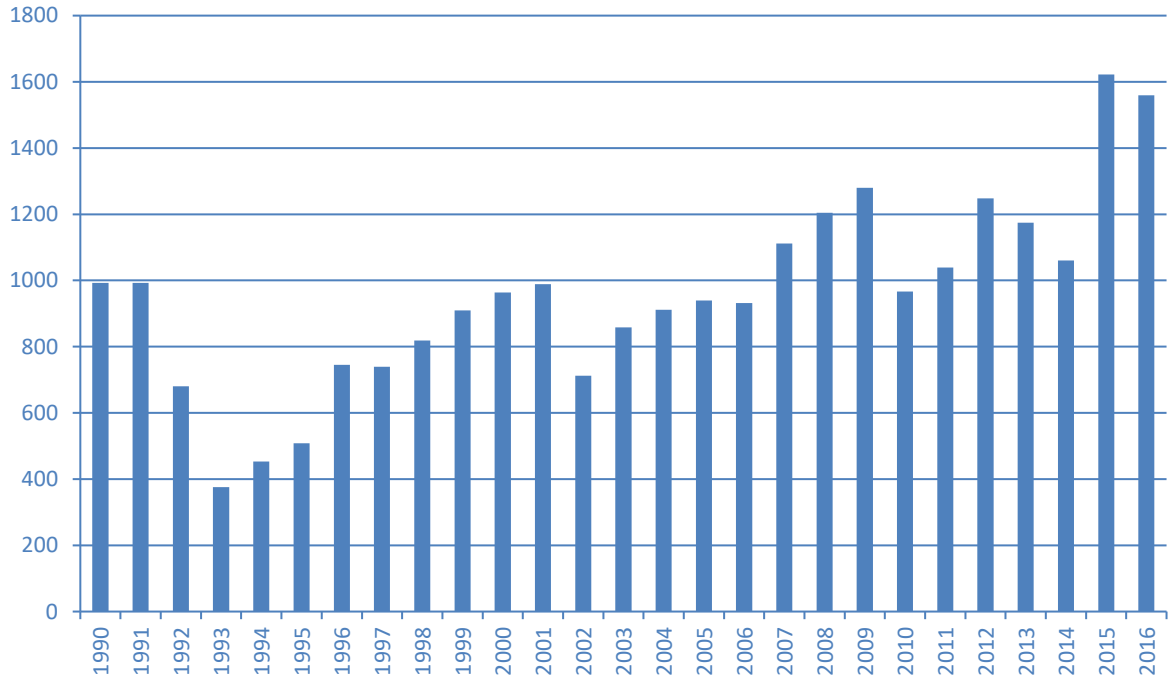


Figure 19: CO_2 emissions (Gg) for the period 1990 - 2016 - waste sector

According to the above, there is an evident decrease in greenhouse gas emissions from waste by 53.04% in 2015 and 47.05% in 2016 compared to 2014. Also, there is an evident decrease in greenhouse gas emissions from waste by 63.49% in 2015 and 57.08% in 2016 compared to 1990.

2.4 Emission estimation results for 2015 and 2016

This section presents the results of the calculation of greenhouse gas emissions for Bosnia and Herzegovina. The results are presented first as total (aggregate) emissions of all greenhouse gases by sectors, and then as emissions of individual greenhouse gases, also by sectors. In order to enable mutual aggregation and overall display of emissions, it is necessary to multiply the emission of each gas by its greenhouse potential (GWP - Global Warming Potential) because greenhouse gases have different radiation properties, contribute differently to the greenhouse effect.

Greenhouse potential is a measure of the impact of a gas on the greenhouse effect in relation to the impact of CO_2 and then the emission of greenhouse gases is expressed in units of Gg CO_2eq (mass of CO_2 equivalent). Carbon dioxide is one of the most significant greenhouse gases, especially when considering the consequences of human activities. It is estimated to be responsible for 50% of global warming. The most important anthropogenic sources of CO_2 are the burning of fossil fuels (for electricity production, industry, transport,

heating, etc.), industrial activities (production of steel, cement, etc.), changes in land use and forestry (in Bosnia and Herzegovina due to the increment volume of wood in this sector there is a negative emission - sink).

Appropriate markings are used in the reporting tables to fill in the blanks depending on whether the emissions are not occurring (NO - not occurring) or the emissions have not been estimated. (NE - not estimated).

2.4.1 Carbon dioxide (CO_2) emission by sector

2.4.1.1 Carbon dioxide (CO2) emissions by sectors for 2015

The energy sector makes the largest contribution to CO_2 emissions, with a share of 76%, followed by the industrial sector of 11%, the agricultural sector of 7% and the waste sector of 6%.

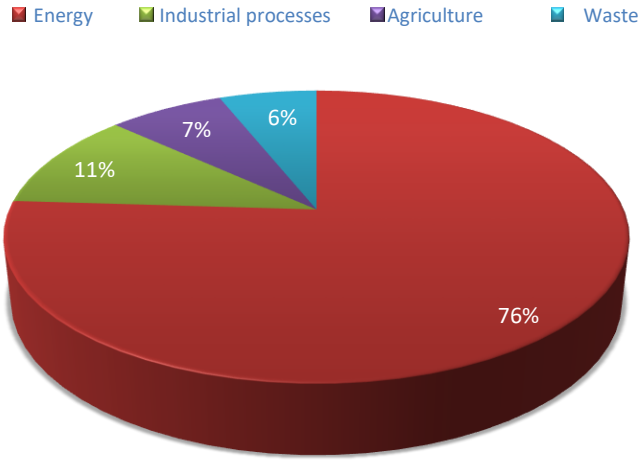


Figure 20: Share of GHG emissions by sectors in 2015

2.4.1.2 Carbon dioxide (CO2) emissions by sectors for 2016

The energy sector makes the largest contribution to CO_2 emissions, with a share of 79%, followed by the industrial sector of 9%, the agricultural sector of 7% and the waste sector of 5%.

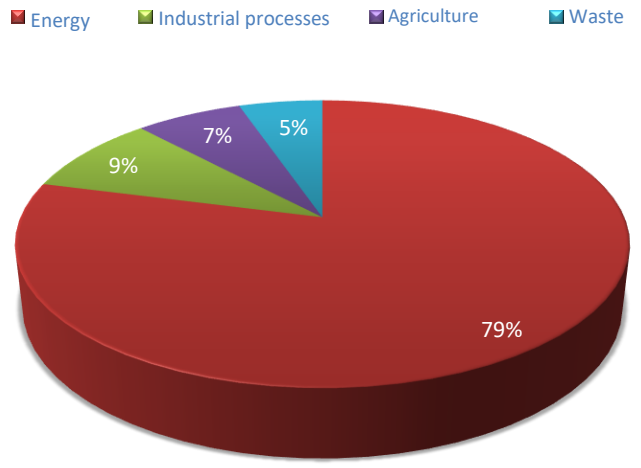


Figure 21: Share of GHG emissions by sectors in 2016

2.4.2 Total emissions

The Inventory of emissions for 2015 is shown in Table 9, and the Inventory of emissions for 2016 is shown in Table 10.

Table 9: Inventory of emissions for 2015

Category	Emission (Gg)			Emission CO_2 equivalent (Gg)				Emission (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF6	Other halogenated gases with conversion factors eq. CO_2 (3)	Other halogenated gases without conversion factors eq. CO_2 (4)	NOx	CO	NM VOC	SO_2
Total BiH emissions and sinks	17008.03	124.36	3.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 - Energy	20241.65	1.70	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A - Fuel Combustion Activities	19785.00	1.61	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B - Fugitive Emissions from Fuels	456.64	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.C - Carbon Transport and Storage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 - Industrial Processes and Product Use	2906.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A - Mineral Industry	804.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.B - Chemical Industry	47.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.C - Metal Industry	2054.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.D - Non-Energy Products from Fuels and Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E - Electronics Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.G - Other Product Manufacture and Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.H - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 - Agriculture, Forestry and Other Land Use	-6140.56	49.43	2.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.A - Livestock	0.00	49.42	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B - Land	-5378.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C - Aggregate Sources and Non-CO_2 Emissions Sources on Land	0.00	0.01	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D - Other	-762.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 - Waste	0.00	73.23	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Category	Emission (Gg)			Emission CO_2 equivalent (Gg)				Emission (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF6	Other halogenated gases with conversion factors eq. CO_2 (3)	Other halogenated gases without conversion factors eq. CO_2 (4)	NOx	CO	NM VOC	SO_2
4.A - Solid Waste Disposal	0.00	53.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.B - Biological Treatment of Solid Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.C - Incineration and Open Burning of Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.D - Wastewater Treatment and Discharge	0.00	19.76	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.A - Indirect N_2O Emissions from the Atmospheric Deposition of Nitrogen in NOx and NH_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Memo items (5)												
International Bunkers	19.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a.i - International Aviation (International Bunkers) (1)	19.67	0.00	0.00						0.00	0.00	0.00	0.00
1.A.3.d.i - International water-borne Navigation (International Bunkers) (1)	0.00	0.00	0.00						0.00	0.00	0.00	0.00
1.A.5.c - Multi-lateral Operations (1)(2)	0	0	0	0	0	0	0	0	0	0	0	0

Table 10: Inventory of emissions for 2016

Category	Emission (Gg)			Emission CO_2 equivalent (Gg)				Emission (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with conversion factors eq. CO_2 (3)	Other halogenated gases without conversion factors eq. CO_2 (4)	NOx	CO	NM VOCs	SO_2
Total BiH emissions and sinks	20009.34	121.34	3.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 - Energy	23230.52	2.10	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A - Fuel Combustion Activities	22718.66	2.01	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.B - Fugitive Emissions from Fuels	511.86	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.C - Carbon Transport and Storage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 - Industrial Processes and Product Use	2660.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.A - Mineral Industry	851.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.B - Chemical Industry	53.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.C - Metal Industry	1754.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.D - Non-Energy Products from Fuels and Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.E - Electronics Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.F - Product Uses as Substitutes for Ozone Depleting Substances	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.G - Other Product Manufacture and Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.H - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3 - Agriculture, Forestry and Other Land Use	-5881.56	49.14	3.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.A - Livestock	0.00	49.11	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B - Land	-5076.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.C - Aggregate Sources and Non-CO2 Emissions Sources on Land	0.00	0.03	2.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.D – Other	-804.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4 - Waste	0.00	70.10	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.A - Solid Waste Disposal	0.00	53.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Category	Emission (Gg)			Emission CO_2 equivalent (Gg)				Emission (Gg)				
	Net CO_2 (1)(2)	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with conversion factors eq. CO_2 (3)	Other halogenated gases without conversion factors eq. CO_2 (4)	NOx	CO	NM VOCs	SO_2
4.B - Biological Treatment of Solid Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.C - Incineration and Open Burning of Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.D - Wastewater Treatment and Discharge	0.00	17.08	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5 - Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.A - Indirect N2O Emissions from the Atmospheric Deposition of Nitrogen in NOx and NH3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.B - Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Memo items (5)												
International Bunkers	32.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.A.3.a.i - International Aviation (International Bunkers) (1)	32.23	0.00	0.00						0.00	0.00	0.00	0.00
1.A.3.d.i - International water-borne Navigation (International Bunkers) (1)	0.00	0.00	0.00						0.00	0.00	0.00	0.00
1.A.5.c - Multi-lateral Operations (1)(2)	0	0	0	0	0	0	0	0	0	0	0	0

Table 9shows the greenhouse gas emissions for 1990, 2012, 2013, 2014, 2015 and 2016

Table 11: CO_2 emission per years (Gg)

Greenhouse gas source category/year	1990	2012	2013	2014	2015	2016
Total emissions (Gg CO_2 - eq) without sinks	34043.49	21816.43	24027.84	26062.19	26884.61	29677.06
Total emissions (Gg CO_2 - eq) with sinks	26461.1	14270.09	17886.84	19664.52	20744.05	23795.50
1.Energy	**24888.95**	**15923.96**	**18258.28**	**20249.68**	**20411.01**	**23429.38**
A. Fuel Combustion (sectoral approach)		15266.62	17517.75	19631.89	19952.58	22915.65
1.Energy industries	16,510.1	10805.02	12449.53	14480.94	13948.28	16635.06
2. Manufacturing industries and construction	534.7	735.05	858.26	857.03	1507.60	1117.53
3. Transport	2,357.7	2753.18	2896.33	3053.2	3198.60	3726.56
4. Other sectors	3,889.4	973.37	1313.63	1240.72	1298.08	1436.50
5. Other (specify)		NE	NE	NE		
B. Fugitive emissions from fuels	1,597.1	657.34	740.53	617.79	458.44	513.73
2. Industrial Processes	**3554.07**	**2178.76**	**2039.72**	**2247.36**	**2906.94**	**2660.39**
A. Mineral products	736.8	599.42	605.58	728.1	804.67	851.72
B. Chemical industry	213.9	217.42	42.38	59.76	47.45	53.71
C. Metal production	2,603.4	1361.92	1391.76	1459.5	2054.82	1754.50
D. Other production		NE	NE	NE	NE	NE
E. Production of halocarbons and SH		NE	NE	NE	NE	NE
F. Consumption of halocarbons and SH		0	0	0	0	0
3. Solvent and other product use		**NE**	**NE**	**NE**	**NE**	**NE**
4. Agriculture	**4608.01**	**2465.83**	**2555.4**	**2504.96**	**1924.27**	**1995.82**
A. Enteric fermentation	1,548.3	807.51	813.88	799.64	900.00	895.72
B. Manure management	682.0	323.07	330.77	323.93	267.04	262.533
C. Rice cultivations		NE	NE	NE	NE	NE
D. Agricultural soils	2,377.7	1335.25	1410.75	1381.39	757.2242	837.58

Greenhouse gas source category/year	1990	2012	2013	2014	2015	2016
5. Land-use change and forestry	**-7423.53**	**-7546.34**	**-6141**	**-6397.67**	**-6140.56**	**-5881.56**
A. Forests and wood biomass	-7,423.5	-7546.34	-6141	-6397.67	-6140.56	
B. Forest and grassland conversion		NE	NE	NE	NE	NE
C. Abandonment of managed lands		NE	NE	NE	NE	NE
D. CO_2 emissions and removals from soil		NE	NE	NE	NE	NE
6. Waste	**992.46**	**1247.89**	**1174.45**	**1060.19**	**1622.54**	**1558.96**
A. Solid waste disposal on land	992.5	918.81	847.66	741.89	1122.74	1113.28
B. Wastewater handling		329.08	326.79	318.3	499.80	445.67
C. Waste incineration		NE	NE	NE	NE	NE
Memo items					**19.85**	**32.52**
International bunkers		NE	NE	NE	19.85	32.52
Aviation		NE	NE	NE	19.85	32.52
Marine		NE	NE	NE	NE	NE
CO_2 emission from biomass		NE	NE	NE	NE	NE

2.5 Estimate of calculation uncertainty

Uncertainty estimate in trend 2015-2016 is 5,440. The base year for estimating uncertainty is 2015. The total inventory uncertainty is 8,377.

2.5.1 Key sources of emission

Analyses of key emission sources were conducted for the 2015 and 2016 inventories. Detailed analyses for each year are shown in Cumulative Tables 7A in the software, and Table 12: Trend assessment of key sources of emissions shows a trend assessment.

Table 12: Trend assessment of key sources of emissions

A	B	C	D	E	F	G	H
IPCC Category Code	IPCC Category	Greenhouse gas	2015 assessment Ex0 (Gg CO_2 Eq)	2016 assessment Ext (Gg CO_2 Eq)	Trend assessment (Txt)	% share in trend	Cumulative total of column G
1.A.1	Energy industries - solid fuels	CO_2	13238.38	16044.00	0.03	0.24	0.24
1.A.2	Manufacturing industries and construction - solid fuels	CO_2	846.42	398.36	0.02	0.16	0.39
2.C.1	Iron and steel production	CO_2	1798.03	1503.43	0.02	0.15	0.54
3.B.1.a	Forest land remaining forest land	CO_2	-5378.45	-5076.98	0.01	0.13	0.68
1.A.1	Energy industries – liquid fuels	CO_2	557.68	408.89	0.01	0.06	0.74
4.A	Solid waste disposal	CH_4	1122.74	1113.28	0.01	0.05	0.79
3.D.1	Harvested wood products	CO_2	-762.12	-804.58	0.00	0.04	0.83
3.A.1	Enteric fermentation	CH_4	900.01	895.72	0.00	0.04	0.86
4.D	Wastewater treatment and discharge	CH_4	415.03	358.75	0.00	0.03	0.90
1.A.3.b	Road transportation	CO_2	3128.29	3645.22	0.00	0.02	0.91
2.A.1	Cement production	CO_2	479.46	499.07	0.00	0.01	0.93
1.A.4	Other sectors - solid fuels	CO_2	769.17	851.28	0.00	0.01	0.93
2.C.3	Aluminium production	CO_2	167.52	164.08	0.00	0.01	0.94
1.A.2	Manufacturing industries and construction – liquid fuels	CO_2	482.98	530.47	0.00	0.01	0.95
3.A.2	Manure management	CH_4	137.80	135.58	0.00	0.01	0.95
3.A.2	Manure management	N_2O	129.24	126.95	0.00	0.01	0.96
2.A.2	Lime production	CO_2	325.21	352.66	0.00	0.01	0.97
1.A.4	Other sectors – gaseous fuels	CO_2	137.98	139.34	0.00	0.01	0.97

A	B	C	D	E	F	G	H
IPCC Category Code	IPCC Category	Greenhouse gas	2015 assessment Ex0 (Gg CO_2 Eq)	2016 assessment Ext (Gg CO_2 Eq)	Trend assessment (Txt)	% share in trend	Cumulative total of column G
2.C.2	Ferroalloys production	CO_2	89.28	87.44	0.00	0.00	0.98
1.A.2	Manufacturing industries and construction - gaseous fuels	CO_2	169.07	181.32	0.00	0.00	0.98
3.C.6	Indirect N_2O emission from manure management	N_2O	77.85	76.83	0.00	0.00	0.98
1.B.1	Solid fuels	CO_2	456.64	511.86	0.00	0.00	0.99
3.C.4	Direct N_2O emission from managed soils	N_2O	516.25	580.65	0.00	0.00	0.99
4.D	Wastewater treatment and discharge	N_2O	84.77	86.92	0.00	0.00	0.99
3.C.5	Indirect N_2O emission from managed soils	N_2O	162.86	179.44	0.00	0.00	0.99
1.A.4	Other sectors - liquid fuels	CO_2	368.28	417.12	0.00	0.00	0.99
1.A.1	Energy industries - solid fuels	N_2O	60.60	73.71	0.00	0.00	1.00
1.A.1	Energy Industries - gaseous fuels	CO_2	86.75	102.66	0.00	0.00	1.00
1.A.4	Other sectors - solid fuels	CH_4	16.92	22.41	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - solid fuels	N_2O	3.95	1.83	0.00	0.00	1.00
1.A.3.b	Road transportation	CH_4	9.44	12.12	0.00	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CH_4	1.78	0.83	0.00	0.00	1.00
2.B.7	Soda ash production	CO_2	47.45	53.71	0.00	0.00	1.00
1.A.3.b	Road transportation	N_2O	60.87	69.22	0.00	0.00	1.00
1.A.1	Energy industries - liquid fuels	N_2O	1.23	0.87	0.00	0.00	1.00
1.A.1	Energy industries - biomass	N_2O	0.27	0.80	0.00	0.00	1.00
3.C.1	Emissions from biomass burning	CH_4	0.26	0.65	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - biomass	N_2O	1.45	1.98	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - liquid fuels	N_2O	0.76	1.15	0.00	0.00	1.00
1.A.1	Energy industries - biomass	CH_4	0.13	0.41	0.00	0.00	1.00
1.A.1	Energy industries - solid fuels	CH_4	2.74	3.33	0.00	0.00	1.00
1.B.2.b	Natural gas	CH_4	1.79	1.87	0.00	0.00	1.00
1.A.1	Energy industries - liquid fuels	CH_4	0.43	0.31	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - biomass	CH_4	0.74	1.01	0.00	0.00	1.00
1.A.4	Other sectors - solid fuels	N_2O	3.54	3.92	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - liquid fuels	CH_4	0.29	0.40	0.00	0.00	1.00
1.A.4	Other sectors - gaseous fuels	CH_4	0.26	0.26	0.00	0.00	1.00

A	B	C	D	E	F	G	H
IPCC Category Code	IPCC Category	Greenhouse gas	2015 assessment Ex0 (Gg CO_2 Eq)	2016 assessment Ext (Gg CO_2 Eq)	Trend assessment (Txt)	% share in trend	Cumulative total of column G
1.A.4	Other sectors - liquid fuels	N_2O	0.86	0.96	0.00	0.00	1.00
1.A.4	Other sectors - liquid fuels	CH_4	1.00	1.13	0.00	0.00	1.00
1.A.4	Other sectors - gaseous fuels	N_2O	0.08	0.08	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - gaseous fuels	N_2O	0.09	0.10	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - gaseous fuels	CH_4	0.06	0.07	0.00	0.00	1.00
1.A.1	Energy industries - gaseous fuels	N_2O	0.05	0.05	0.00	0.00	1.00
1.A.1	Energy industries - gaseous fuels	CH_4	0.03	0.04	0.00	0.00	1.00
1.B.2.b	Natural gas	CO_2	0.00	0.00	0.00	0.00	1.00
1.B.2.a	Oil	CH_4	0.00	0.00	0.00	0.00	1.00
1.B.2.a	Oil	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.1	Energy industries - other fossil fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.1	Energy industries - other fossil fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.1	Energy industries - other fossil fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.1	Energy industries - peat	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.1	Energy industries - peat	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.1	Energy industries - peat	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.1	Energy industries - biomass	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - other fossil fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - other fossil fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - other fossil fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - peat	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - peat	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - peat	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.2	Manufacturing industries and construction - biomass	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.a	Civil Aviation	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.a	Civil Aviation	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.a	Civil Aviation	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.c	Railways	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.c	Railways	CH_4	0.00	0.00	0.00	0.00	1.00

A	B	C	D	E	F	G	H
IPCC Category Code	IPCC Category	Greenhouse gas	2015 assessment Ex0 (Gg CO_2 Eq)	2016 assessment Ext (Gg CO_2 Eq)	Trend assessment (Txt)	% share in trend	Cumulative total of column G
1.A.3.c	Railways	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - liquid fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - liquid fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - liquid fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - solid fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - solid fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - solid fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - gaseous fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - gaseous fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - gaseous fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - other fossil fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - other fossil fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - other fossil fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - peat	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - peat	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - peat	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - biomass	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - biomass	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.d	Water-borne navigation - biomass	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.3.e	Other transportation	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.3.e	Other transportation	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.3.e	Other transportation	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - other fossil fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - other fossil fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - other fossil fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - peat	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - peat	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - peat	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - biomass	CO_2	0.00	0.00	0.00	0.00	1.00

A	B	C	D	E	F	G	H
IPCC Category Code	IPCC Category	Greenhouse gas	2015 assessment Ex0 (Gg CO_2 Eq)	2016 assessment Ext (Gg CO_2 Eq)	Trend assessment (Txt)	% share in trend	Cumulative total of column G
1.A.4	Other sectors - biomass	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.4	Other sectors - biomass	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - liquid fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - liquid fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - liquid fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - solid fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - solid fuels	CH4	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - solid fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - gaseous fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - gaseous fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - gaseous fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - other fossil fuels	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - other fossil fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - other fossil fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - peat	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - peat	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - peat	N_2O	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - biomass	CO_2	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - biomass	CH_4	0.00	0.00	0.00	0.00	1.00
1.A.5	Non-specified - biomass	N_2O	0.00	0.00	0.00	0.00	1.00
1.B.1	Solid Fuels	CH_4	0.00	0.00	0.00	0.00	1.00
1.B.1	Solid Fuels	N_2O	0.00	0.00	0.00	0.00	1.00
1.B.2.a	Oil	N_2O	0.00	0.00	0.00	0.00	1.00
1.B.2.b	Natural gas	N_2O	0.00	0.00	0.00	0.00	1.00
1.C	Carbon dioxide transport and storage	CO_2	0.00	0.00	0.00	0.00	1.00
2.A.3	Glass production	CO_2	0.00	0.00	0.00	0.00	1.00
2.A.4	Other process uses of carbonates	CO_2	0.00	0.00	0.00	0.00	1.00
2.B.1	Ammonia Production	CO_2	0.00	0.00	0.00	0.00	1.00
2.B.2	Nitric acid production	N_2O	0.00	0.00	0.00	0.00	1.00

A	B	C	D	E	F	G	H
IPCC Category Code	IPCC Category	Greenhouse gas	2015 assessment Ex0 (Gg CO_2 Eq)	2016 assessment Ext (Gg CO_2 Eq)	Trend assessment (Txt)	% share in trend	Cumulative total of column G
2.B.3	Adipic acid production	N_2O	0.00	0.00	0.00	0.00	1.00
2.B.4	Caprolactam, glyoxal and glyoxylic acid production	N_2O	0.00	0.00	0.00	0.00	1.00
2.B.5	Carbide production	CO_2	0.00	0.00	0.00	0.00	1.00
2.B.5	Carbide production	CH_4	0.00	0.00	0.00	0.00	1.00
2.B.6	Titanium dioxide production	CO_2	0.00	0.00	0.00	0.00	1.00
2.B.8	Petrochemical and carbon black production	CO_2	0.00	0.00	0.00	0.00	1.00
2.B.8	Petrochemical and carbon black production	CH_4	0.00	0.00	0.00	0.00	1.00
2.B.9	Fluorochemical production	SF6, PFCs, HFCs and other halogenated gases	0.00	0.00	0.00	0.00	1.00
2.C.1	Iron and steel production	CH_4	0.00	0.00	0.00	0.00	1.00
2.C.2	Ferroalloys production	CH_4	0.00	0.00	0.00	0.00	1.00
2.C.3	Aluminium production	PFCs (PFCs)	0.00	0.00	0.00	0.00	1.00
2.C.4	Magnesium production	CO_2	0.00	0.00	0.00	0.00	1.00
2.C.4	Magnesium production	SF6	0.00	0.00	0.00	0.00	1.00
2.C.5	Lead production	CO_2	0.00	0.00	0.00	0.00	1.00
2.C.6	Zinc production	CO_2	0.00	0.00	0.00	0.00	1.00
2.D	Non-energy products from fuels and solvent use	CO_2	0.00	0.00	0.00	0.00	1.00
2.E	Electronics industry	SF6, PFCs, HFCs and other halogenated gases	0.00	0.00	0.00	0.00	1.00
2.F.1	Refrigeration and air conditioning	HFCs, PFCs	0.00	0.00	0.00	0.00	1.00
2.F.2	Foam blowing agents	HFCs (HFCs)	0.00	0.00	0.00	0.00	1.00
2.F.3	Fire protection	HFCs, PFCs	0.00	0.00	0.00	0.00	1.00
2.F.4	Aerosols	HFCs, PFCs	0.00	0.00	0.00	0.00	1.00
2.F.5	Solvents	HFCs, PFCs	0.00	0.00	0.00	0.00	1.00

A	B	C	D	E	F	G	H
IPCC Category Code	IPCC Category	Greenhouse gas	2015 assessment Ex0 (Gg CO_2 Eq)	2016 assessment Ext (Gg CO_2 Eq)	Trend assessment (Txt)	% share in trend	Cumulative total of column G
2.F.6	Other applications (specify)	HFCs, PFCs	0.00	0.00	0.00	0.00	1.00
2.G	Other product manufacture and use	SF6, PFCs	0.00	0.00	0.00	0.00	1.00
2.G	Other product manufacture and use	N_2O	0.00	0.00	0.00	0.00	1.00
3.B.1.b	Land converted to forest land	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.2.a	Cropland remaining cropland	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.2.b	Land converted to cropland	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.3.a	Grassland remaining grassland	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.3.b	Land converted to grassland	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.4.a.i	Peatlands remaining peatlands	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.4.a.i	Peatlands remaining peatlands	N_2O	0.00	0.00	0.00	0.00	1.00
3.B.4.b	Land converted to wetlands	N_2O	0.00	0.00	0.00	0.00	1.00
3.B.4.b	Land converted to wetlands	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.5.a	Settlements remaining settlements	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.5.b	Land converted to settlements	CO_2	0.00	0.00	0.00	0.00	1.00
3.B.6.b	Land converted to other land	CO_2	0.00	0.00	0.00	0.00	1.00
3.C.1	Emissions from biomass burning	N_2O	0.00	0.00	0.00	0.00	1.00
3.C.2	Liming	CO_2	0.00	0.00	0.00	0.00	1.00
3.C.3	Urea application	CO_2	0.00	0.00	0.00	0.00	1.00
3.C.7	Rice cultivations	CH_4	0.00	0.00	0.00	0.00	1.00
4.B	Biological treatment of solid waste	CH_4	0.00	0.00	0.00	0.00	1.00
4.B	Biological treatment of solid waste	N_2O	0.00	0.00	0.00	0.00	1.00
4.C	Incineration and open burning of waste	CO_2	0.00	0.00	0.00	0.00	1.00
4.C	Incineration and open burning of waste	CH_4	0.00	0.00	0.00	0.00	1.00
4.C	Incineration and open burning of waste	N_2O	0.00	0.00	0.00	0.00	1.00

2.6 Verification of calculations

During the development of the greenhouse gas inventories for 2015 and 2016, no recalculation of previous calculations was performed. The data used in the inventory development phase have not been verified by a third party (independent expert or institution).

2.7 Recommendations for future improvement

Key shortcomings in the development of the greenhouse gas inventories:

- lack of data
- inconsistency between existing data and data required by the IPCC methodology
- lack of legislation on the type and scope of data collected
- data quality is not guaranteed
- lack of staff in the authorised institution and authorisations (legal basis) for institutions for inventory development
- according to the current practice, some experts are hired to make inventories only for the calculation of inventories for certain years and certain sectors, which is not sustainable in the long run
- trainings available for inventory development, as well as software and other accompanying activities should be attended by representatives of institutions that should perform and work on data collection, data processing and inventory development, and not only individual experts who create inventory for certain years and certain sectors as has been the practice so far
- lack of permanent sources of funding
- insufficient cooperation between institutions
- assessment of inventory quality as well as accuracy of results is not checked by independent experts, and all additional activities are not contracted with associates who engage in inventory calculation for certain years and certain sectors
- lack of awareness of the importance of the census.

Recommendations for improving the greenhouse gas inventory:

- implementation of institutional responsibility for the systematic development of the GHG inventory
- capacity building of the institution authorised to compile the greenhouse gas inventory
- providing permanent sources of funding for the development of greenhouse gas inventories and research projects in individual sectors and for the development of domestic emission factors
- inclusion of other institutions in the inventory system (scientific and professional institutions, ministries, agencies, etc.) in the scientific and professional contribution
- providing up-to-date reports on greenhouse gas emissions
- issuing authorisations for the creation of individual databases on emissions in the appropriate institutions
- raising public awareness on climate protection issues and the potential consequences of climate change
- the assessment of the quality of the inventory as well as the accuracy of the results should be checked by independent experts.

3 VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

3.1 Observed climate change

The Initial National Communication (INC), the Second National Communication (SNC) and the Third National Communication (TNC) on climate change recognise the fact that climate change is affecting Bosnia and Herzegovina, as well as the fact that these changes will occur rapidly by the end of the 21st century. According to the analysis of meteorological data for the period 1961–2016 the mean annual temperature maintains a continuous rise on the entire territory. A positive linear trend in the mean annual temperature has been observed, which has been particularly pronounced in the last 30 years. The trends of annual temperatures at all analysed stations are statistically significant, while the changes are more pronounced in the continental part. The increase in annual air temperature ranges from 0.4 to 1.0°C, while the increase in temperature during the growing season (April - September) even reaches 1.2°C. However, increases in air temperature over the last fourteen years have been even more pronounced. In the analysed period, all indices of warm temperature extremes have positive trends, while the indices of cold temperature extremes have negative trends. The most significant change in this period is observed in the number of cold days (FD) and the number of warm days (SU). At all meteorological stations, the number of cold days (FD) has a negative trend. In the central mountain areas, the number of cold days has decreased by 4 days per 10 years, while in the south of the country the decrease is slightly less amounting to 2 days per 10 years. The number of warm days (SU) has a positive trend, and it is statistically significant.

3.1.1 Temperature changes

The analysis of the change in air temperature was performed for the period 1961-2016. At all meteorological stations in Bosnia and Herzegovina, the coldest month is January, with a mean temperature of -3.8°C in Sokolac to 5.3°C in Mostar.

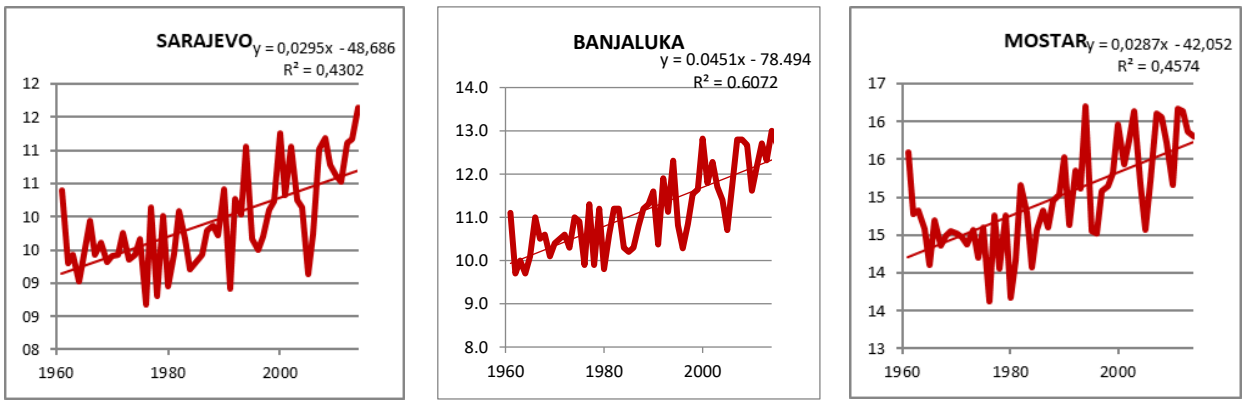


Figure 22: Trends in air temperature changes, 1961–2016 (Sarajevo, Banja Luka, Mostar)

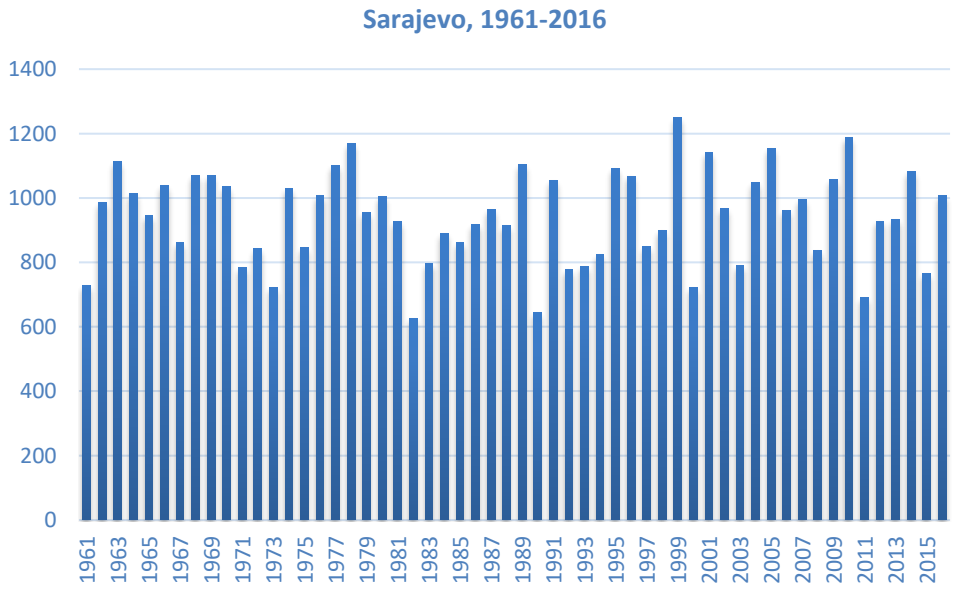
The mean temperature in January in the northern part ranges from -0.2°C to 0.2°C. The warmest month is July, with the highest mean air temperature in the eastern and southern part of the territory (Bijeljina 21.8°C, Bileća 22.1°C and Mostar 25.4°C). The mean temperature in July in Banja Luka is 21.4°C. Mean annual air amplitude

temperature in the period 1961–2016 in the north ranges from 20.2°C in Tuzla to 21.7°C in Bijeljina. The highest annual temperature amplitude in the entire territory of Bosnia and Herzegovina is in Semberija, which is the most continental part of the study area. Temperature amplitudes are somewhat lower in high Herzegovina (for example, Bileća 18.8°C) and in Sarajevo (19.9°C).

Of the ten warmest years in the observed period of 1961–2016 nine years have been recorded since 2000 (only 1994 was among the ten warmest). Some of the warmest years in the analysed period were: 2000, 2007, 2008 and 2014. The year of 2014 was the warmest year in most of Bosnia and Herzegovina. In Semberija, only 2008 and 2016 were warmer than 2014. In Herzegovina, 2014 was not among the first few warmest years. Mostar was the warmest in 2015, then in 1994, 2011 and 2012 (interestingly, there are very small differences in the mean annual temperature in Mostar during the ten warmest years). Since 1990, when the warming trend is more pronounced, only a few years have been colder than the average climatic period (1961–1990), namely 1996 (at all stations except Sokolac), 2005 (in Sanski Most, Prijedor, Doboj, Tuzla, Sarajevo and Bileća), 1995 in Tuzla and Bileća, 1997 in Tuzla and 1991 and 2006 in Bileća. Since 1990, Sokolac has been warmer than the average standard climate period. Among the coldest years in the period 1961–2015 are 1962, 1964, 1976, 1978 and 1980 (all from the period before 1990). In the northwest, the coldest years were recorded at the beginning of the analysed period. The coldest years in Banja Luka and Prijedor were 1962 and 1964. The coldest area in the area from Doboj to Bijeljina was in 1980, and in the area of Sarajevo and Sokolac, as well as in Herzegovina, in 1976.

3.1.2 Changes in precipitation

In the period 1961–2015 most of the territory of Bosnia and Herzegovina was characterised by a slight increase in annual precipitation. Linear trends for the multi-year period 1961–2016 indicate stagnation or a slight increase in precipitation throughout Bosnia and Herzegovina. Changes in precipitation are more pronounced by seasons than on an annual basis. Although no significant changes in precipitation were recorded, the pluviometric regime, i.e. the annual distribution, was greatly disturbed. This is shown in Figure 23 for the years: 2003, 2010, 2011, 2014. This distribution of precipitation has caused severe to extreme droughts and floods.



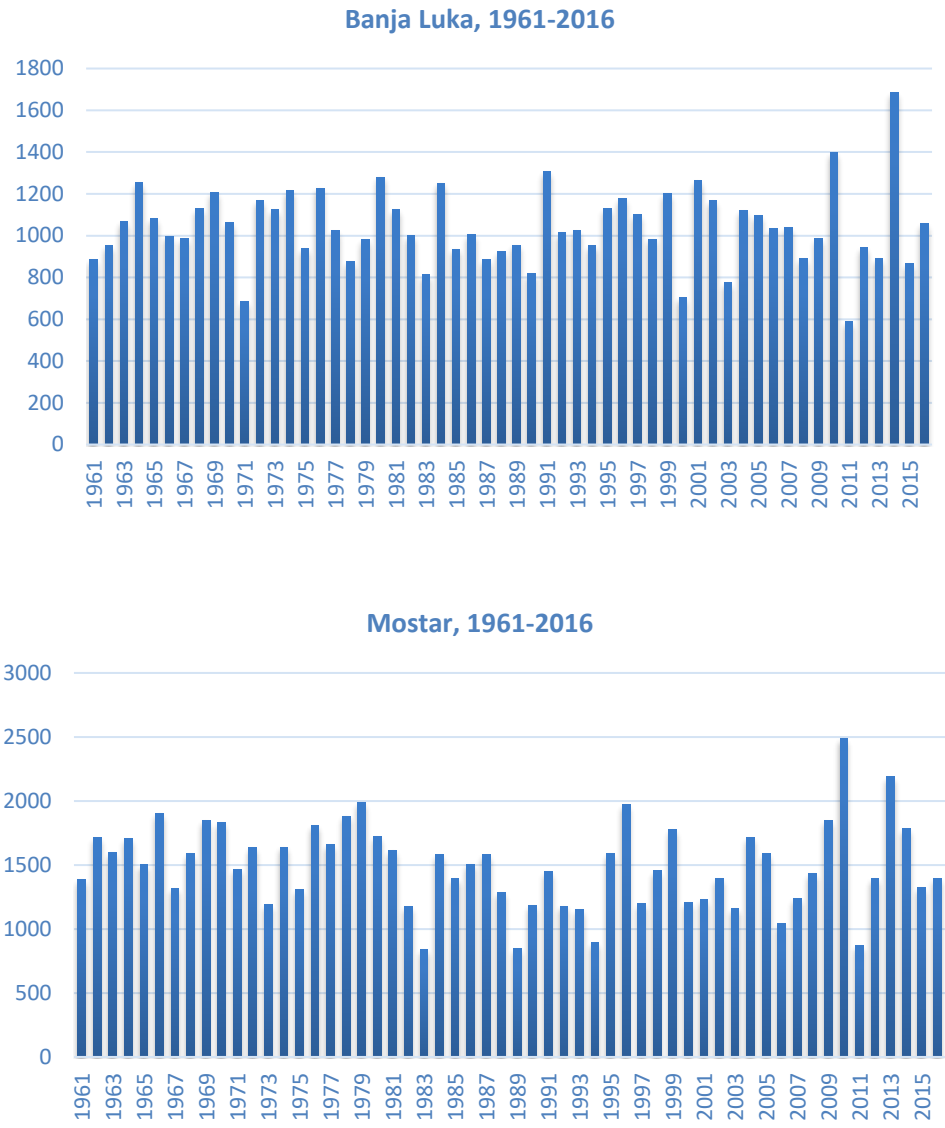


Figure 23: Annual trends in precipitation, 1961-2016 (Sarajevo, Banja Luka, Mostar)
/Source: Hydrometeorological Service of the Federation of Bosnia and Herzegovina, Hydrometeorological Service of the Republika Srpska/

Due to the increased intensity of precipitation and its greater variability, as well as due to the increased share of heavy rains in the total precipitation, the risk of floods increased, especially in the north-eastern part of Bosnia and Herzegovina, where catastrophic floods were recorded in May 2014.

3.1.3 Climate variability and extreme events

Frost days

In the observed period of 1961–2015 in the entire territory of Bosnia and Herzegovina there is a negative trend in the annual number of frost days which is statistically significant in almost all areas. Negative trend values

range from 2.1 to 6.4 days per decade[39]. The change in trend is most pronounced in the north-western part of the territory. After 1990, the year with the lowest number of winter days was recorded. There have been extremely few icy days in the last decade, when global warming was most pronounced. In the northern part of Bosnia and Herzegovina, the annual number of frosty days ranges from 83 to 94 days (average annual frequency is 23-26%). They occur in the period from September to May, with the highest frequency in the winter months - January (23-24 days), December (19-21 days) and February (18-19 days). The maximum frequency of occurrence was recorded in January (73-78%). The average annual number of frosty days is growing from the north to the central, mountainous part of Bosnia and Herzegovina. Most frosty days occur at the two highest meteorological stations - on Bjelašnica 189 days and Sokolac 151 days (frequency of occurrence is 52% and 41%). In higher mountainous regions, frosty days most often occur in the period from September to May (on Bjelašnica throughout the year) but they are most common in the winter season - in January (frequency of 93-98%) and December (frequency of 86-93%). In the higher parts of Herzegovina, on average, 110-112 frost days occur annually, while in the lower parts of this region there are only 20 frost days (in the period from November to March)[40].

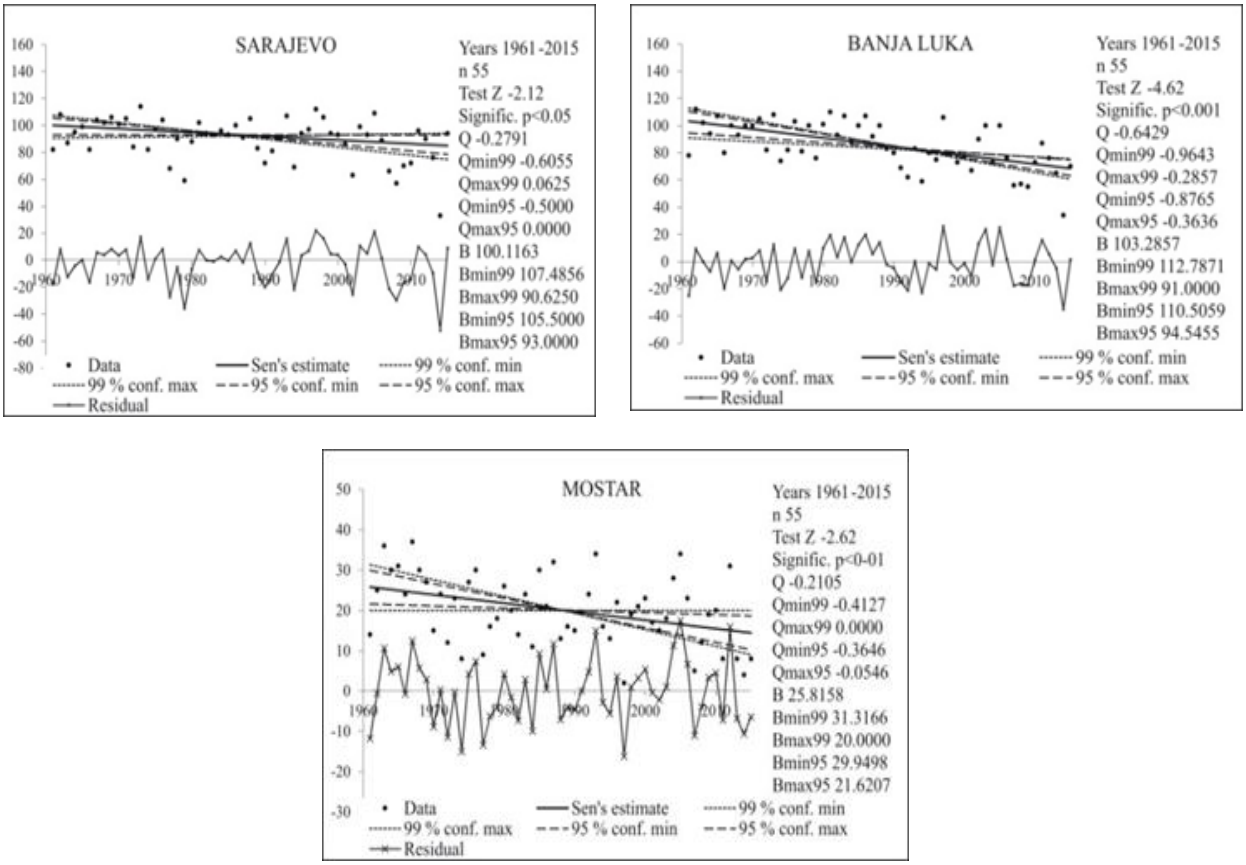
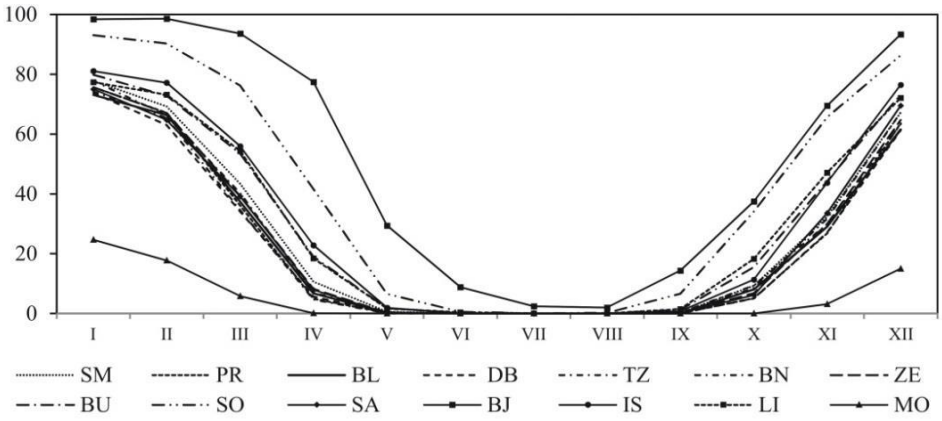


Figure 24: Changing the trend in frost days in Bosnia and Herzegovina (Sarajevo, Banja Luka, Mostar), 1961-2015
/Source: Hydrometeorological Service of the Federation of Bosnia and Herzegovina, Hydrometeorological Service of the Republika Srpska/

[39] Popov, T., Gnjato, S., & Trbić, G. (2017):Trendovi indeksa ekstremnih temperatura u Bosni i Hercegovini – primjer Mostara. Herald, 21, 107–132. doi:10.7251/HER2117107P

[40] Popov, T., Gnjato, S., & Trbić, G. (2017): Trends in frost days in Bosnia and Herzegovina, Glasnik Srpskog geografskog društva 2017 Volume 97, Issue 1, Pages: 35-55. https://doi.org/10.2298/GSGD1701035P



(Key: SM-Sanski Most, PR-Prijedor, BL-Banja Luka, DB-Doboj, TZ-Tuzla, BN-Bijeljina, ZE-Zenica, BU-Bugojno, SO-Sokolac, SA-Sarajevo, IS-Istočno Sarajevo, BJ-Bjelašnica, LI-Livno, MO-Mostar)

Figure 25: Monthly frequency of frost days in Bosnia and Herzegovina (%), period 1961-2015
/Source: Popov et al. 2017/

In the observed period 1961-2015 the total area of Bosnia and Herzegovina is characterised by a pronounced negative trend of the annual number of frost days, which is statistically significant ($p<0.01$ or $p<0.05$, only in Sokolac and Doboj $p<0.1$) in almost all areas. The statistical significance of the negative trend has not been established only for the far north-eastern part of the territory (Bijeljina).

The trend of decreasing annual number of frost days is most pronounced in the north-western part of the territory (especially in Banja Luka - 6.4 days per decade), in Bugojno (5.0 days per decade), Zenica (4.3 days per decade) and at the highest station, Bjelašnica (4.1 days per decade). In other regions, the reduction in the number of frost days ranged from 2.1 to 3.0 days per decade.

The observed negative trends are, primarily, a consequence of the pronounced negative trends in the coldest winter months, January and February. The decrease in the number of frost days during these two months is most pronounced in the north-western part of the territory of Bosnia and Herzegovina (e.g. in Banja Luka the annual number of frost days in January decreased by 2.0 days per decade, and in December by 1.5 days per decade) and in Zenica frost days in January decreased by 1.0 days per decade, and in December by 1.2 days per decade). The identified trends in January show statistical significance in almost the entire area of Bosnia and Herzegovina, while in December the trends are statistically significant in half of the stations. Negative trends were also recorded in other months with the onset of frost but they were not statistically significant and were of much lower intensity.

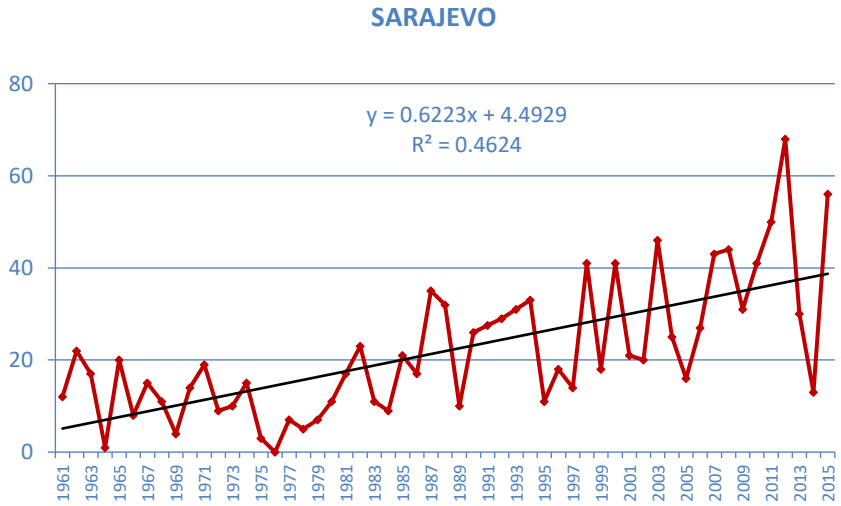
Tropical days

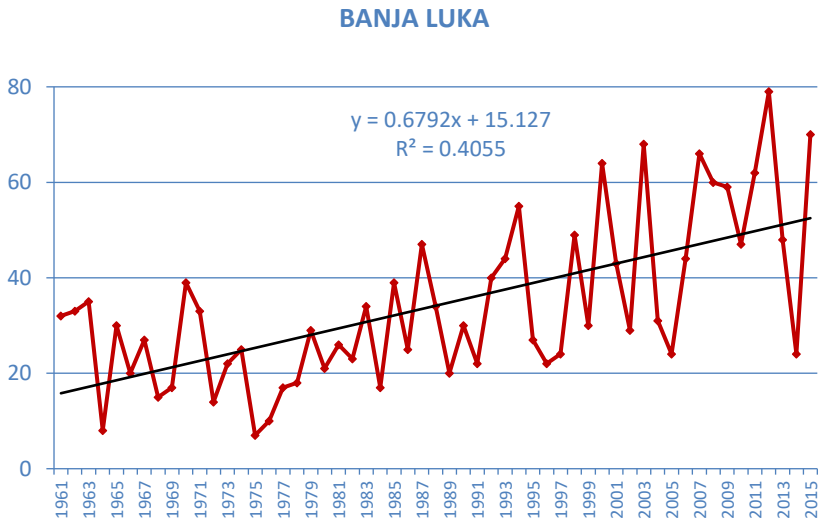
Changes in the frequency of temperature index extremes are based on fixed thresholds (recommended by ETCCDI[41]) in Bosnia and Herzegovina during 1961–2016. The analysis of the trend showed that there was a significant increase in the frequency of hot extremes, while cold extremes showed a tendency to decrease. However, both trends point to global warming in Bosnia and Herzegovina. Trend values estimated for summer days[42] - SU25 (5.3 days in a decade), tropical days[43] - TR30 (4.8 days in a decade) and tropical nights[44] - TR20 (in

[41] Expert Team on Climate Change Detection and Indices
[42] Summer days (SU25: Tmax > 25°C)
[43] Tropical days (TR30: Tmax > 30°C)
[44] Tropical nights (TR20: Tmin > 20°C)

Mostar 6.3 days in a decade) higher than for cold indices (frost days[45] - FD0 (-3.6 days per decade), and especially icing days[46] - ID0 (- 1.7 days per decade)) indicate that the warming of the climate system is more a consequence of the high and rapid rise of warm extremes. The most prominent changes in both hot and cold indices were recorded in Banja Luka, Bugojno and Zenica (Popov, T et al., 2017)[47].

The results of the research by Popov, Trbić and Gnjato (2017) showed stronger trends in the last decade of the 20th century, and especially since the beginning of the 21st century. Future research on frost days should focus on projections of future changes in extreme temperatures. It is expected that changes in the extreme temperature index based on fixed thresholds will have a different impact on key sectors in Bosnia and Herzegovina: agriculture, forestry, hydropower, tourism, public health, but also on risk assessment and environmental protection.[48].





[45] Frost days (FD0: Tmin < 0°C)

[46] Icing days (ID0: Tmax < 0°C)

[47] http://www.doiserbia.nb.rs/Article.aspx?id=0350-35931701035P#.YIuqkbUzZPY

[48] Popov, T., Gnjato, S., & Trbić, G. (2018). CHANGES IN TEMPERATURE EXTREMES IN BOSNIA AND HERZEGOVINA: A FIXED THRESHOLDS-BASED INDEX ANALYSIS. *Journal of the Geographical Institute "Jovan Cvijić" SASA*, *68*(1), 17–33. https://doi.org/10.2298/IJGI1801017P

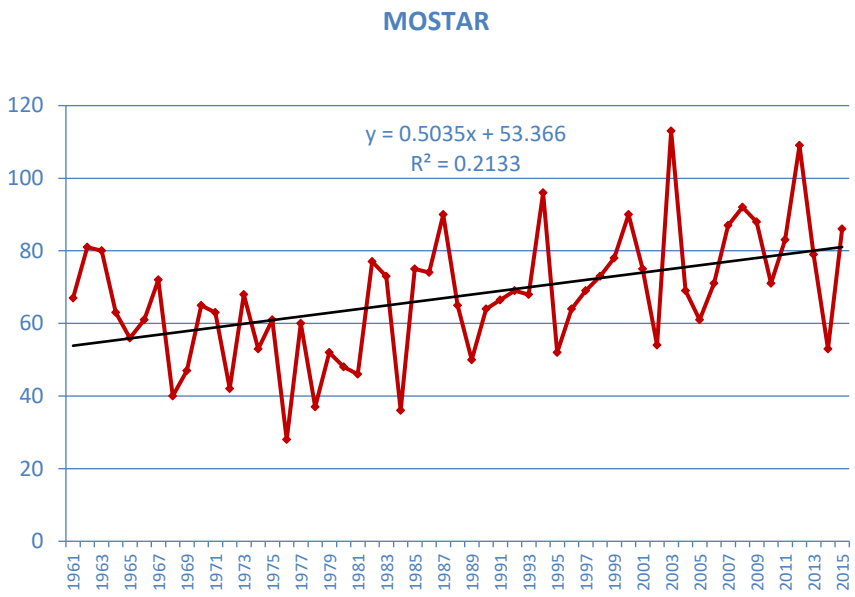


Figure 26: Changing the trend in tropical days in Bosnia and Herzegovina (Sarajevo, Mostar and Banja Luka), 1961-2016
/Source: Hydrometeorological Service of the FBiH, Hydrometeorological Service of the Republika Srpska/

Trends in extreme daily precipitation

The latest trends in extreme daily precipitation indices in Bosnia and Herzegovina were calculated for the period 1961–2016 using RClimDek software (1.0). The examined indices showed mostly weak, insignificant and mixed trends. The analysis of probability density functions also confirmed that for most indices there were no significant changes in the extreme precipitation indices in the period 1991–2016 compared to the period 1961−1990. However, the obtained results suggest a general increase in heavy precipitation in the study area. Growing trends in events with heavy precipitation such as RKS1dan, RKS5dai, SDII, R10mm, R20mm, R95p and R99p indicate changes towards heavy precipitation. The increase in intense heavy precipitation has become more pronounced since the beginning of the 21st century. In addition, an increase in the interannual variability of precipitation was observed in this period.

The research by Popov et al. (2018) found that precipitation changes were not coherent at the regional level - in contrast to coherent and significant temperature trends (i.e. warming trends). These results are in line with the results of similar studies in other parts of the region (Lukovic et al. (Serbia), Buric et al. (Montenegro), Pandzic et al. (Croatia)).

Understanding the patterns of extreme precipitation changes is of great importance in many applied studies: flood risk management, agricultural planning, water resources management, environmental protection, etc. The third major issue is the development and implementation of efficient adaptation and mitigation strategies in different sectors. As such, there is a growing need for more detailed knowledge of extreme patterns in precipitation change[49].

[49] Popov, T, Gnjato, S, Trbić, G. (2018) CHANGES IN TEMPERATURE EXTREMES IN BOSNIA AND HERZEGOVINA:A FIXED THRESHOLDS-BASED INDEX ANALYSIS. *Journal of the Geographical Institute "Jovan Cvijić" SASA*, *68*(1), 17–33. https://doi.org/10.2298/IJGI1801017P.

Wind gusts

Stormy winds are among the most damaging natural hazards in Europe, with around EUR 5 billion in estimated annual losses in the EU. The number of recorded storms has increased significantly in recent decades. The future impacts of extreme winds could be reduced by a series of measures, such as the development and implementation of improved standards in the field of building regulations. The current generation of climate models still cannot reliably show possible wind changes in the future due to its high dynamics.

Over the last two decades, there has been a trend of increasing intensity and frequency of maximum wind gusts in Bosnia and Herzegovina. The largest wind gusts were recorded in the mountainous region (Bjelašnica) where the maximum gust was as high as 60m/s (216 km/h). This wind was recorded in December from the south-southwest direction. Maximum wind gusts over 30m/s were also recorded in the region of Herzegovina (Mostar and Trebinje), and in the northern parts of Bosnia and Herzegovina (Banja Luka and Bihać). The maximum wind gusts in Sarajevo were 26.2 m/s (95 km/h)[50].

Such maximum wind gusts indicate a change in building regulations and more frequent sanitary inspection and removal and replacement of dry and damaged trees in urban areas.

3.2 Climate models and expected climate change

Significant climate change can be expected in the territory of Bosnia and Herzegovina in the future, especially in the case of climate scenarios that do not foresee implementation of appropriate mitigation measures.

This report presents the results of future climate projections for Bosnia and Herzegovina, based on different scenarios of future greenhouse gas concentrations. The future concentration scenarios considered are scenarios RCP2.6, RCP4.5, RCP6.0 and RCP8.6, which are defined in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[51]. The basis for the analysis of possible future climate change are estimates of changes in basic climate variables: mean daily temperatures, minimum daily temperatures, maximum daily temperatures and daily accumulated precipitation on an annual and seasonal basis, for four seasons - December-January-February (DJF), March- April-May (MAM), June-July-August (JJA) and September-October-November (SON). In addition to these results, changes in selected climate indices are presented as indicators of possible changes in the intensity and frequency of extreme weather and climate events, which can cause negative consequences in the functioning of natural ecosystems and various socio-economic sectors such as agriculture, forestry, water resources, human health, biodiversity, ecosystem services, etc. All future changes are presented for the period from 2016 to 2100 in relation to the reference climate period 1986-2005, which was used as a reference in the last, Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Special focus was placed on the three future twenty-year periods, the period of the *near future* 2016-2035, *mid-twenty-first century* 2046-2065. and *late twenty-first century* 2081-2100, which were also selected to present the results in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. In this sense, the analyses presented in this report will be easily comparable with the results presented in reference international publications.

3.2.1 Scenarios of greenhouse gas concentrations

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change defines four possible scenarios for future global concentrations of greenhouse gases, the so-called Representative Concentration Pathway

[50] Source: Data of Hydrometeorological Service of the FBiH, Hydrometeorological Service of the Republika Srpska
[51] https://www.ipcc.ch/assessment-report/ar5/

(RCP). These scenarios represent possible changes in the concentrations of greenhouse gases in the atmosphere in the period 2006-2100, which would be primarily a consequence of future global anthropogenic emissions of the same gases. As the change in the concentration of greenhouse gases in the atmosphere leads to the creation of an energy imbalance in the Earth's climate system, a numerical scenario designation was introduced, which indicates the magnitude of this imbalance expressed in W/m^2. Thus, according to the RCP8.5 scenario, the energy imbalance at the end of this century would be 8.5 W/m^2, according to the RCP6.0 scenario the imbalance would be 6.0 W/m^2, according to the RCP4.5 scenario 4.5 W/m^2 and according to the RCP2.6 scenario 2.6 W/m^2. Scenarios RCP2.6 and RCP4.5 assume that in the future, conditionally speaking, greenhouse gas concentrations will stabilise, while according to scenarios RCP8.5 and RCP6.0, their concentration will continue to grow, i.e. follow the trends observed in the past (Figure 27). Scenario RCP2.6 even assumes that in the second half of this century the concentration of greenhouse gases could even decrease, which would require that anthropogenic emissions at some point become equal to zero, so that potential sinks of gases could lead to reductions in their concentration. In this sense, scenario RCP2.6 can be considered "optimistic", while on the other hand scenario RCP8.5, according to which concentrations rise to approximately 1250 ppm (CO_2 equivalent), can be considered "pessimistic", or as this scenario is colloquially called "Business as usual" scenario, given that according to this scenario, the energy policies of individual countries, primarily in terms of the use of fossil fuels, would remain unchanged in the future. The remaining two scenarios can be considered options that lie somewhere between these two extremes.

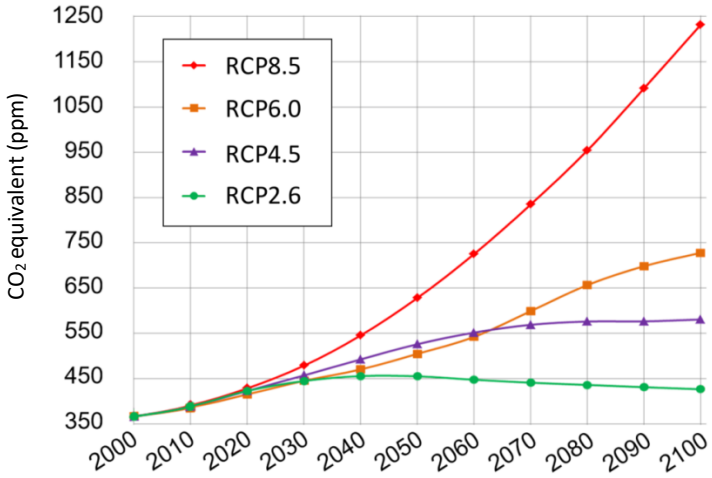


Figure 27: Future concentrations of greenhouse gases for four different scenarios

3.2.2 Climate models

For different scenarios of future concentrations of greenhouse gases, using climate models, which use these concentrations as input variables, appropriate climate projections can be obtained. Global and regional climate models were used in this report, based on the results of which possible future changes in appropriate climate variables and changes in selected climate indices were presented. Global climate models enable obtaining results of climate projections at the global level, however, since their horizontal decomposition is on average about 200 km, for smaller domains whose size is comparable to the area of Bosnia and Herzegovina, based on their results it is not possible to estimate the spatial change of appropriate variables over such domains because only a few points of the climate model cover the entire selected domain (e.g. 2-4 points). Thus, in this report, the results of global climate models are presented only as mean changes of appropriate variables for the entire territory of Bosnia and Herzegovina. On the other hand, regional climate models have significantly better horizontal decomposition, whose size is usually 10 km, so that based on their results it is possible to estimate spatial changes of appropriate variables in smaller areas, and therefore the results of regional climate models

were used to show spatial changes of appropriate variables in the future.

The results of the global climate models were taken from the CMIP5 (Coupled Model Intercomparison Project - phase 5) database[52], which was also used to prepare the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. A total of 42 different models were taken from the CMIP5 database of climate projections, so that the display of future projections of climate variables includes a display of possible ranges of changes in these variables, which was estimated based on the results of the selected model ensemble. The range estimate allows that, for future changes under different scenarios, the corresponding uncertainties in the projections are also estimated. Based on the available data, the changes for all four scenarios described in the previous chapter were analysed.

The results of the regional climate models are taken from the EURO-CORDEX database[53], which is the reference base for climate projections for Europe, and which in recent years has been the basis for many studies on climate change in Europe. Also, this database is the basis for the Copernicus Climate Change Service programme of the European Union, which is just dedicated to climate change, risk assessment and adaptation to climate change[54]. The horizontal resolution of the downloaded data is 11 km, which allows the spatial changes (maps) of the corresponding climate variables to be displayed. Also, the so-called bias-adjusted data, i.e. data from which systematic deviations that are present in the model results have been removed. Data from which the systematic deviation has been removed enable the assessment in future projections of selected climate indices to be more reliable in relation to the situation when data from which the systematic deviation has not been removed are used. Seven representative models for the three scenarios RCP2.6, RCP4.5, and RCP8.5 were taken from this database, as there were no results of the regional climate model for scenario RCP6.0, so in the analysis of spatial changes this scenario will not be analysed.

3.2.3 Future climate projections - global climate model

According to global climate models, for the RCP8.5 climate scenario, which is the most extreme climate scenario, the expected change in mean daily temperature is 4.8°C, with a range of 4°C to 6°C compared to the 1986–2005 reference period. For the middle of this century, the mean change according to this scenario is slightly higher than 2.5°C, while for the near future (2016–2035) the expected change is around 1°C compared to the value from the reference period 1986–2005.

In contrast to temperature changes, precipitation changes show a somewhat more complex structure, with possible both positive and negative changes relative to the reference period, especially for periods in the near future, when all four scenarios show that possible changes range from -5 to + 5% in relation to the values from the reference period. The differences between the scenarios are noticeable only for the periods at the end of the twenty-first century, with the scenario RCP8.5 standing out, according to which at the end of the century the expected value of change is about -10% with a range from -4 to -15%. According to the presented results, only in the case of this scenario future changes can be more significant in the second half of the twenty-first century, when according to this scenario we should expect a decrease in total precipitation, and climate change in terms of potential annual precipitation loss.

[52] https://cmip.llnl.gov/cmip5/
[53] https://www.euro-cordex.net/
[54] https://climate.copernicus.eu/

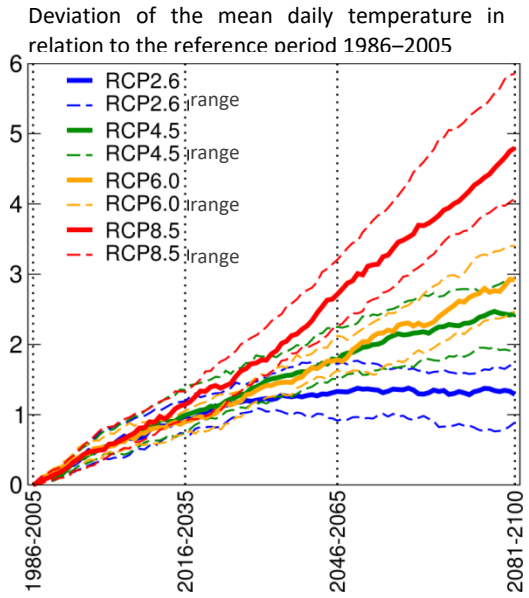


Figure 28: Change in the average annual value (in °C) of the mean daily temperature, shown as the deviation of the 20-year moving average value in relation to the reference period 1986–2005

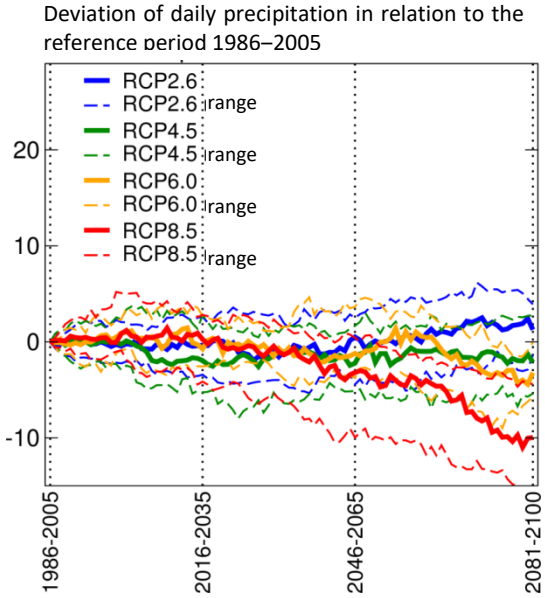


Figure 29: Change in the average annual value (in %) of daily accumulated precipitation, shown as the deviation of the 20-year moving average value in relation to the reference period 1986–2005

3.2.4 Future climate projections - regional climate model

3.2.4.1 Expected temperature changes

According to regional climate models, for the RCP8.5 scenario, the change in mean daily temperature for the first period, the near future (2016–2035), ranges from 0.5 to 1.5°C. For the second analysed period, the middle of the century (2046–2065), the changes range from 1.5 to 3°C. Finally, for the last period (2081–2100), the temperature increase ranges from 2.5 to 5°C, with special emphasis on the increase of maximum daily temperatures for the season June-July-August (JJA), when the temperature increase in most parts of the country is higher by 5°C. Temperature changes are higher in mountainous regions, which is clearly noticeable in the case of changes for the last analysed period, 2081–2100. The season with the smallest deviation is the March-April-May season (MAM).

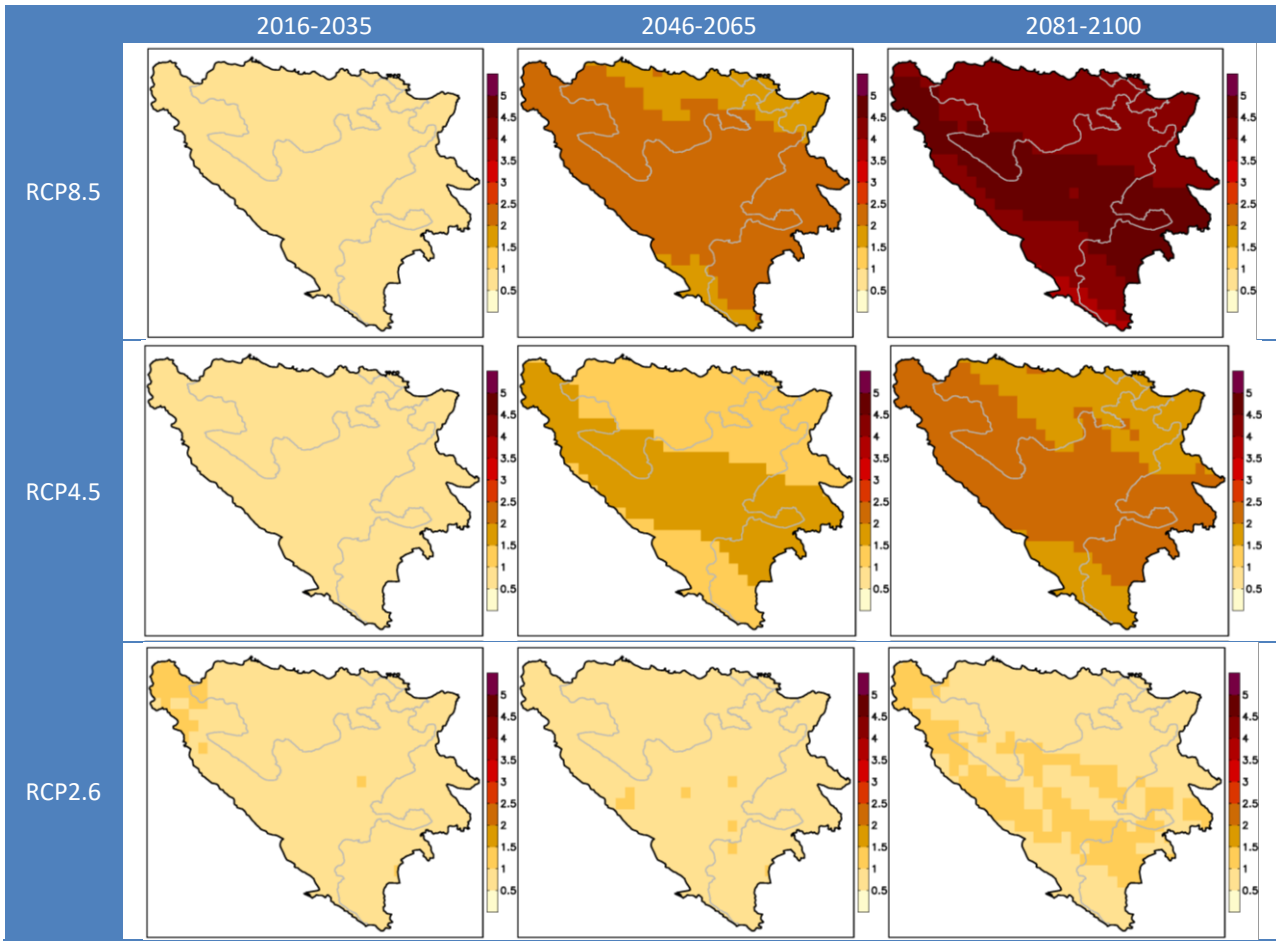


Figure 30: Change in mean daily temperature (in °C) relative to the reference period 1986-2005, for scenarios RCP8.5, RCP4.5 and RCP2.6, on an annual basis, for the three selected future periods 2016-2035, 2046-2065 and 2081-2100

For the RCP4.5 scenario, the change in mean daily temperature for the first period, the near future, ranges from 0.5 to 1.0°C (as well as the change in minimum and maximum daily temperature). For the second analysed period, the middle of the century, 2046-2065, the changes range from 1 to 2°C, while for the last period, 2081-2100, the temperature rise ranges from 1.5 to 2.5°C.

For the RCP2.6 scenario, the change in mean daily temperature ranges from 0.5 to 1.5°C (as well as the change in minimum and maximum daily temperature). At the annual level for the last period, 2081-2100, the end of the twenty-first century, the change in minimum and mean daily temperature in most parts of the territory is up to 1°C, while in the case of maximum temperature this change, in most parts of the territory, is up to 1.5°C.

3.2.4.2 Expected precipitation change

For the scenario RCP2.6, the change of daily accumulated precipitation at the annual level for the first two periods ranges from -5 to 5%, while for the last period, the end of the century, in most parts of the territory the change is positive, and in the south-eastern parts even greater than 5%.

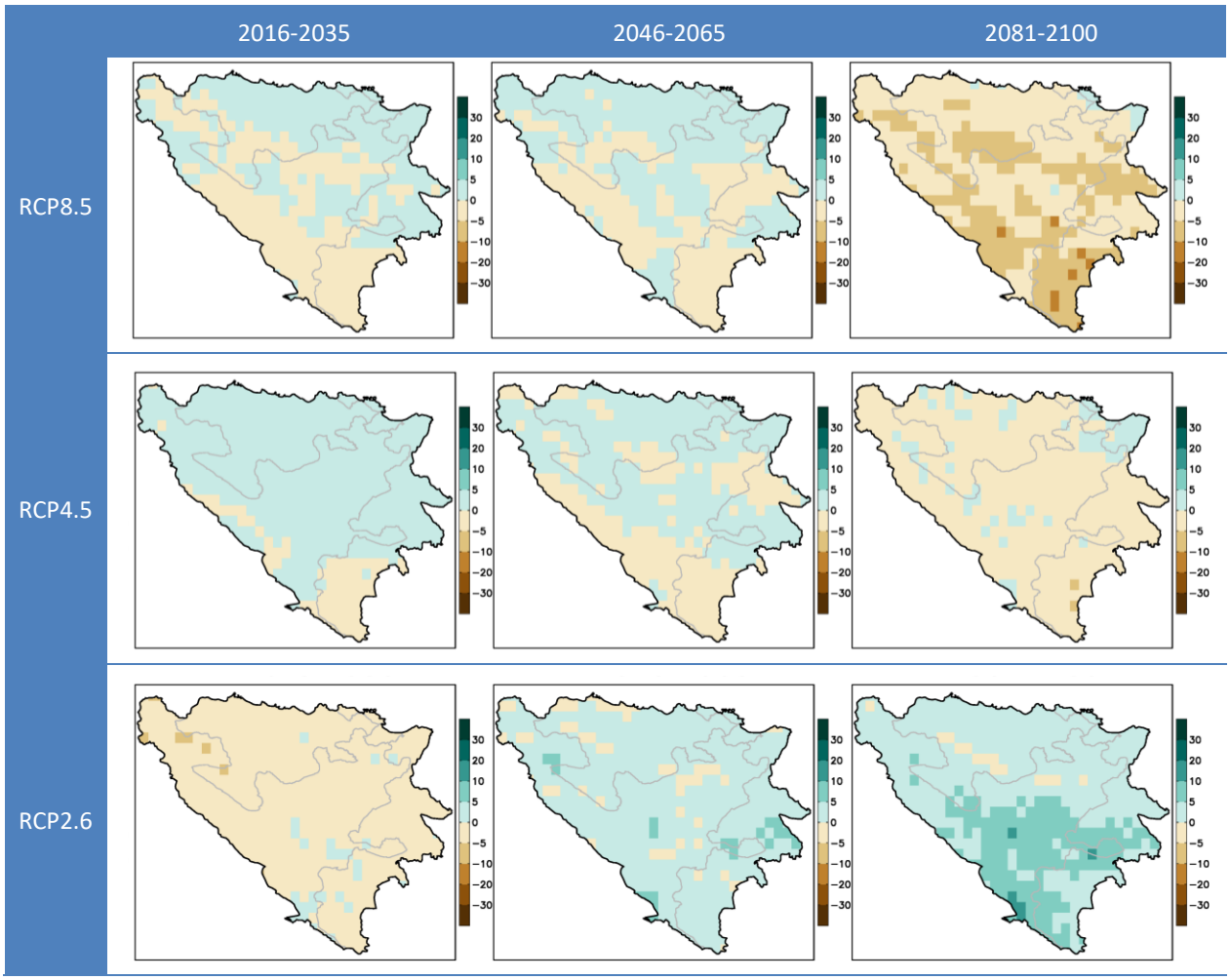


Figure 31: Change in mean daily precipitation (in %) compared to the reference period 1986-2005, for scenarios RCP8.5, RCP4.5 and RCP2.6, on an annual basis, for the three selected future periods 2016-2035, 2046-2065 and 2081-2100

In the case of scenarios RCP4.5 and RCP8.5, precipitation change for the last analysed period 2081-2100 is negative, and in the case of the RCP8.5 scenario it is less than -10% in some parts of the country. Also, for scenarios RCP4.5 and RCP8.5, it is characteristic that the season with the highest precipitation loss is JJA, which is especially pronounced for scenario RCP8.5 for which, during the last period, possible precipitation reduction is less than -30% in the south of the country. This deficit of summer precipitation is obviously the main contribution to the negative change in total precipitation on an annual basis. In the case of scenario RCP2.6, this negative change in precipitation for the JJA season is not noticeable, although during the last analysed period most of the territory has a negative change.

A common feature of all three scenarios is that for all three analysed periods, the DJF season has a positive change in precipitation, in most parts of Bosnia and Herzegovina, and that it is most pronounced for the last analysed period and scenario RCP8.5. For the remaining two seasons, the precipitation change is variable and usually in the range of -10 to 10%, depending on the season and part of the country. For the MAM season another common feature that is consistent for all scenarios and all periods is that the southern parts of the country generally have negative changes, while the northern regions have positive ones, indicating that the southern regions are more likely to have a precipitation deficit during that season.

3.2.4.3 Climate indices

By the end of this century, according to all scenarios, the number of **frost days** will decrease. For the period of the near future, the change according to all three scenarios amounts to -10 days in most parts of the territory.

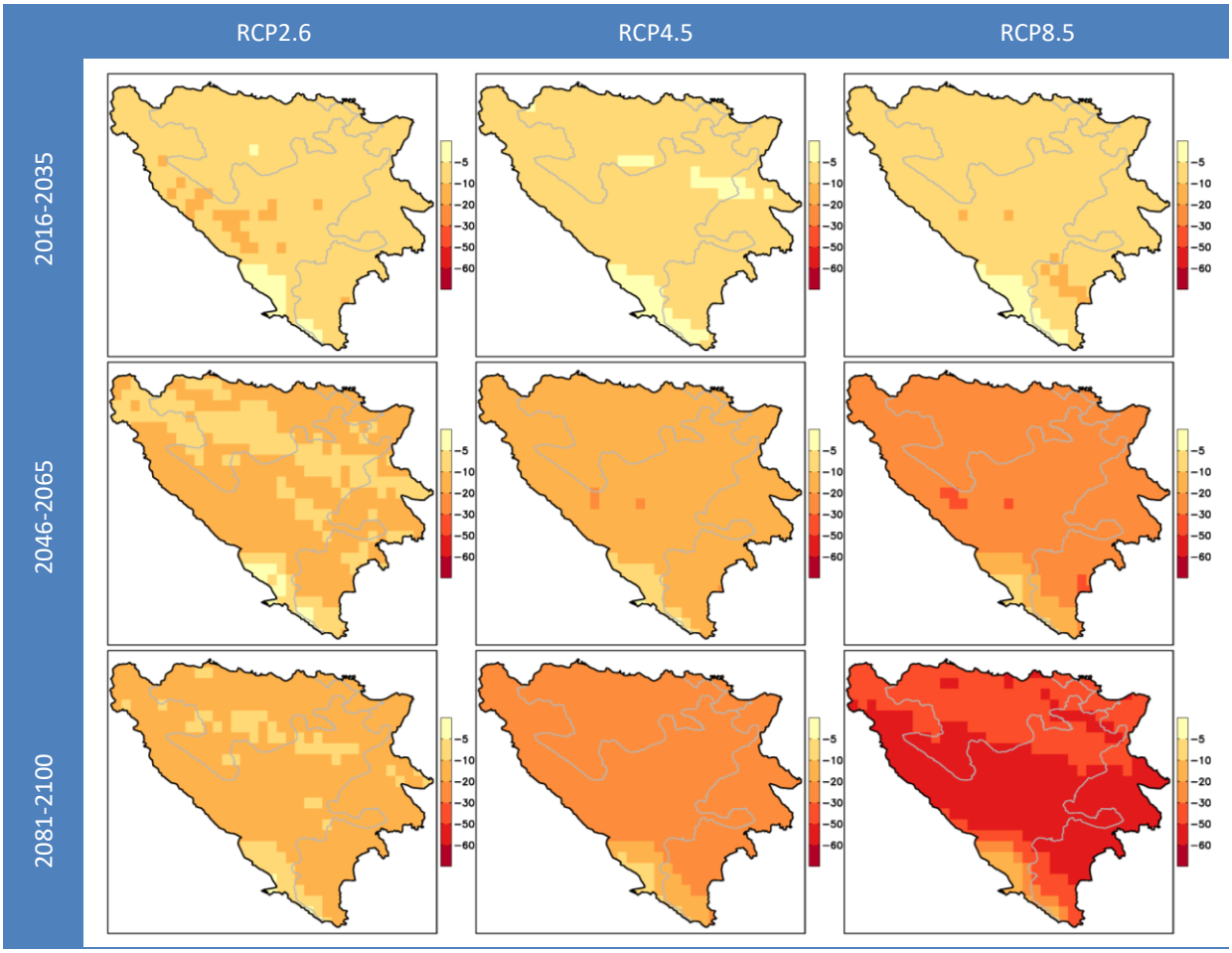


Figure 32: Change in the number of frost days (days/year) compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100

In the case of the RCP2.6 scenario, this change does not differ significantly and for the other two time periods is up to -20 days. In the case of the RCP4.5 scenario, for the middle century this change is up to -20 days, while for the last time period the change is up to -30 days. Finally, for the RCP8.5 scenario, the change in the number of frost days is significantly reduced for further time horizons and for the period 2046-2065 it amounts to -30 days, while for the last period of change it is most pronounced in the southern parts of the country and amounts to -60 days.

By the end of this century, according to all scenarios, the number of **icing days** will decrease. For the period of the near future, the change according to all three scenarios amounts to -5 days in most parts of the territory. In the case of the RCP2.6 scenario, this change does not differ significantly for the other two time periods and amounts to -10 days. In the case of scenario RCP4.5, for the period 2046-2065 this change is up to -10 days, while for the last time period 2081-2100 the change is up to -20 days. Finally, for the RCP8.5 scenario, the change in the number of icing days decreases significantly for further time horizons and for the period 2046-2065 it is up to -20 days, while for the last period the change is most pronounced in the mountainous regions of the country and is up to -30 days, and in some smaller areas up to -50 days less, and in the northern parts the change is slightly milder - up to -20 days.

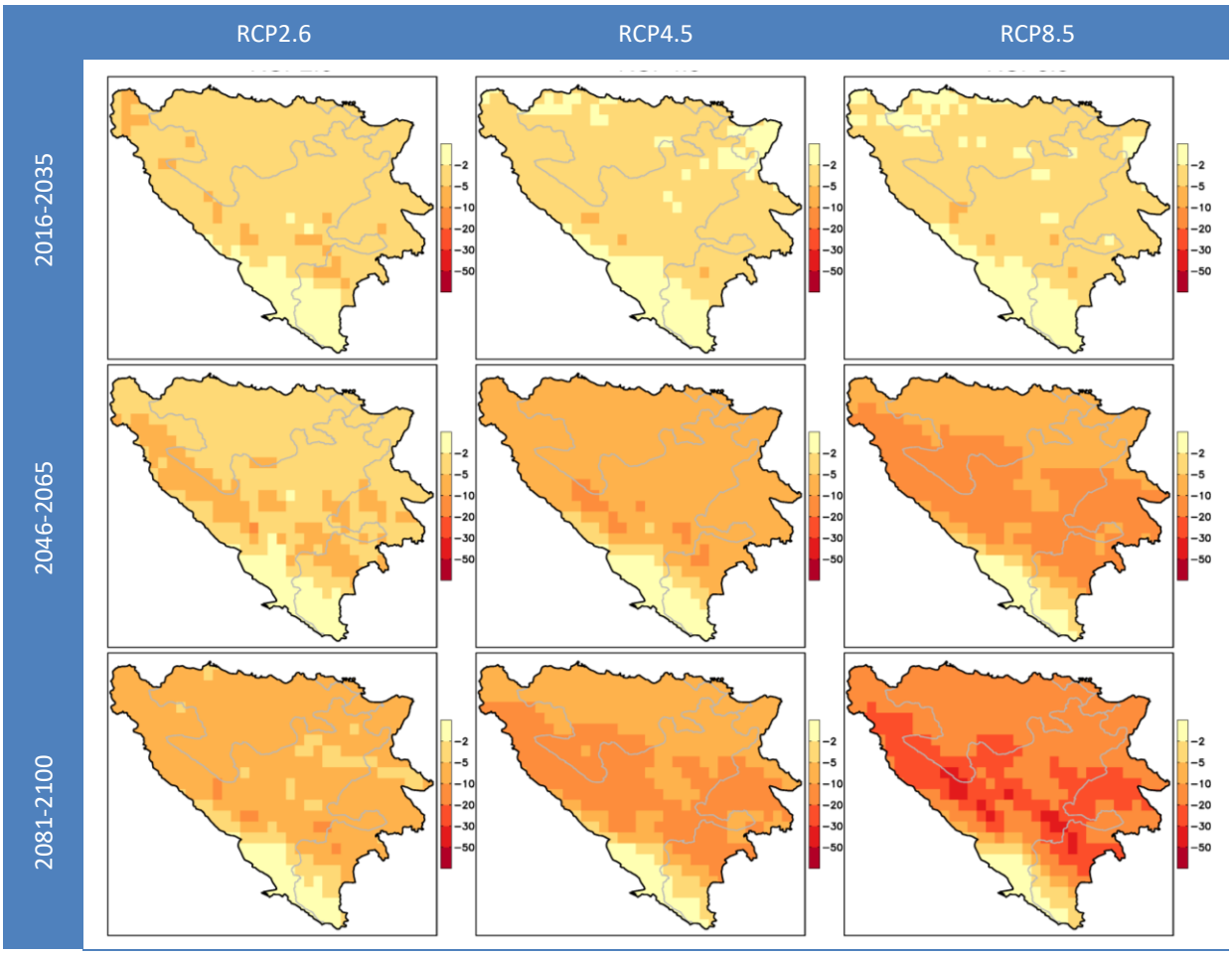


Figure 33: Change in the number of icing days (days/year) compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100

Figure 34 shows possible future changes in the number of **summer days** in relation to the reference period 1986-2005 for three climate scenarios RCP8.5, RCP4.5 and RCP2.6 and three future periods, 2016-2035, 2046-2065 and 2081-2100.

By the end of this century, according to all scenarios, the number of summer days will increase. For the near future, the change according to all three scenarios is up to 20 days more in most parts of the territory. In the case of RCP2.6 scenario, this change does not differ significantly for the other two time periods. In the case of RCP4.5 scenario for the period 2046-2065 this change is up to 30 days more, while for the last time period 2081-2100 the change is up to 50 days more for certain parts of the country. Finally, for the RCP8.5 scenario, the change in the number of summer days increases significantly for further time horizons and for the period 2046-2065 it is up to 40 days more, in some parts up to 50 days more, while for the last period the change is most pronounced and amounts to 60 days, almost throughout the country.

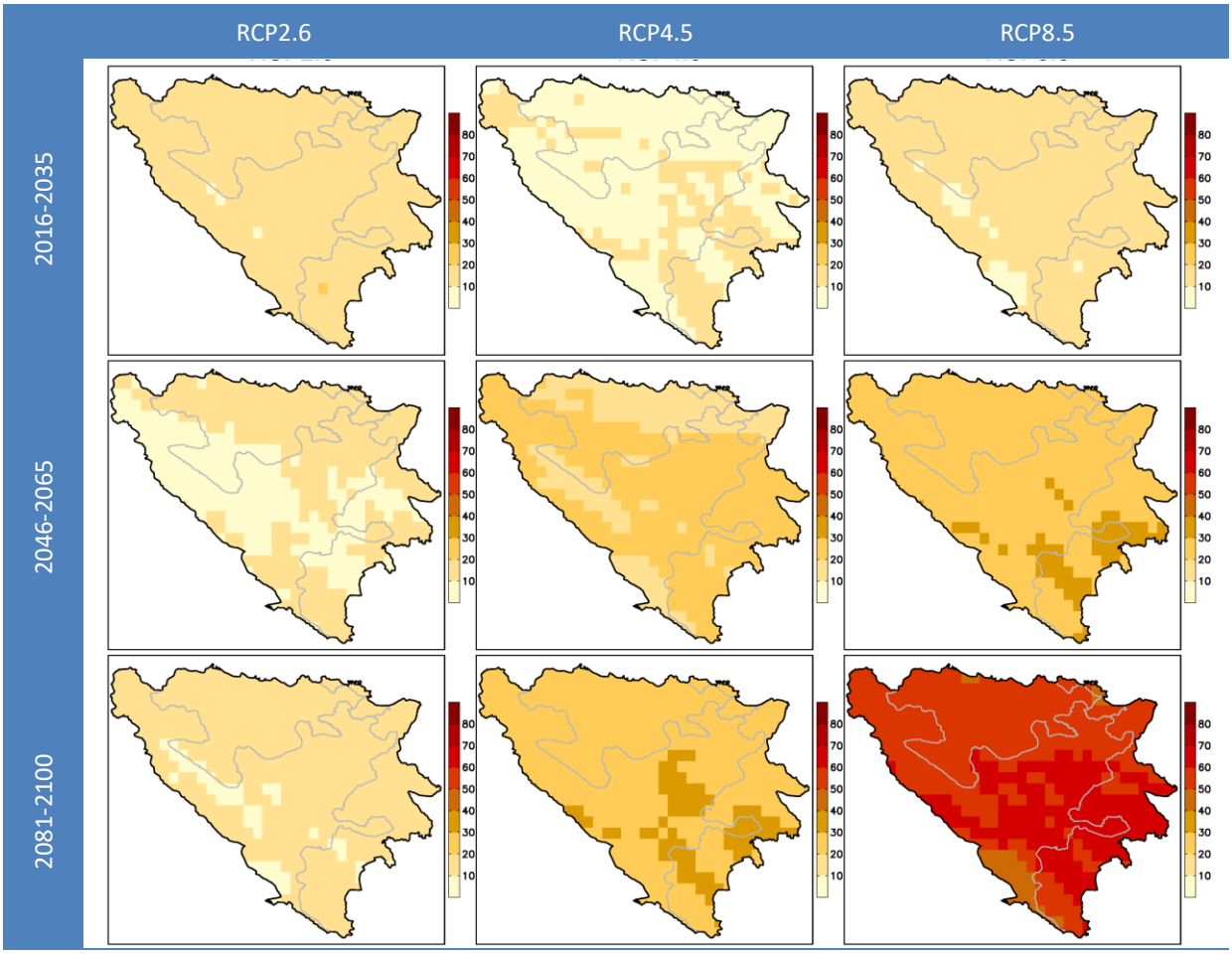


Figure 34: Change in the number of summer days (days/year) compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100

Figure 35 shows possible future changes in the number of **days with precipitation greater than 20 mm**, compared to the reference period 1986-2005 for three climate scenarios RCP8.5, RCP4.5 and RCP2.6 and three future periods, 2016-2035, 2046-2065 and 2081-2100.

According to all scenarios, the number of days with precipitation greater than 20 mm will generally increase by the end of this century. It is interesting that the changes are very similar for all three scenarios and all three periods and that in the territory of Bosnia and Herzegovina they range up to +5 to +20% (in most parts where the changes are positive) and mostly up to -5% (in parts on which the change is negative). Only in the case of RCP8.5 scenario, for the time period 2081-2100, this change is somewhat more pronounced in most parts of the territory and amounts to +20%, and in some smaller areas even over +30%.

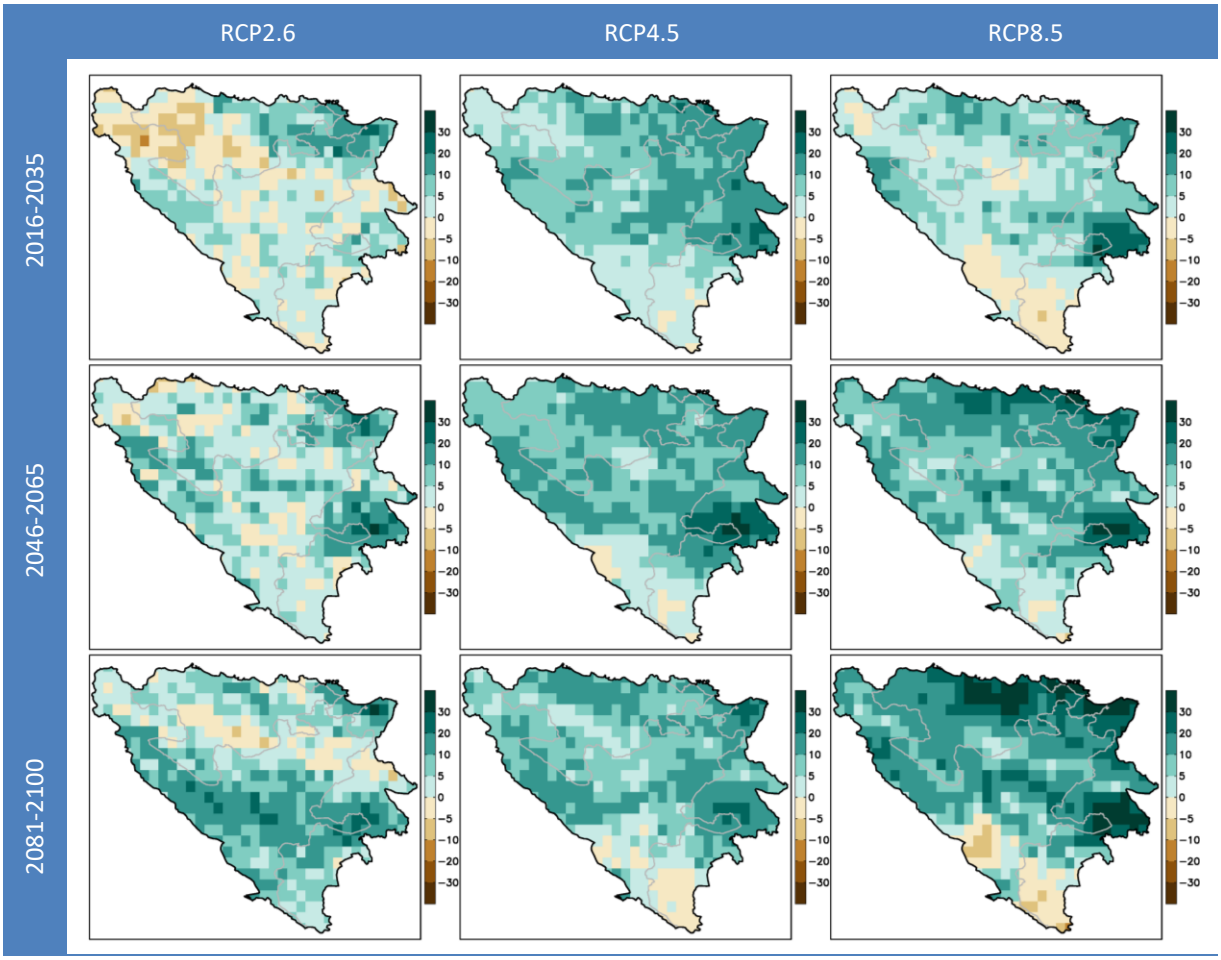


Figure 35: Change in the number of days with precipitation greater than 20 mm (in %) compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100

Figure 36 shows possible future changes in the **maximum daily accumulated precipitation** during one year, in relation to the reference period 1986-2005 for three climate scenarios RCP8.5, RCP4.5 and RCP2.6 and three future periods, 2016-2035, 2046-2065 and 2081-2100.

By the end of this century, according to all scenarios, the maximum daily accumulated precipitation will generally increase. As in the case of changes in the number of days with accumulations greater than 20 mm, the changes are very similar for all three scenarios and all three periods, ranging up to +5 to +20% almost in the entire territory of Bosnia and Herzegovina, while only in some localised cases the change is negative ranging up to a value of -5%. Again, only in the case of the RCP8.5 scenario, for the time period 2081-2100, this change is somewhat more pronounced and in most parts of the territory it amounts to + 20%, and in some smaller areas even over +30%.

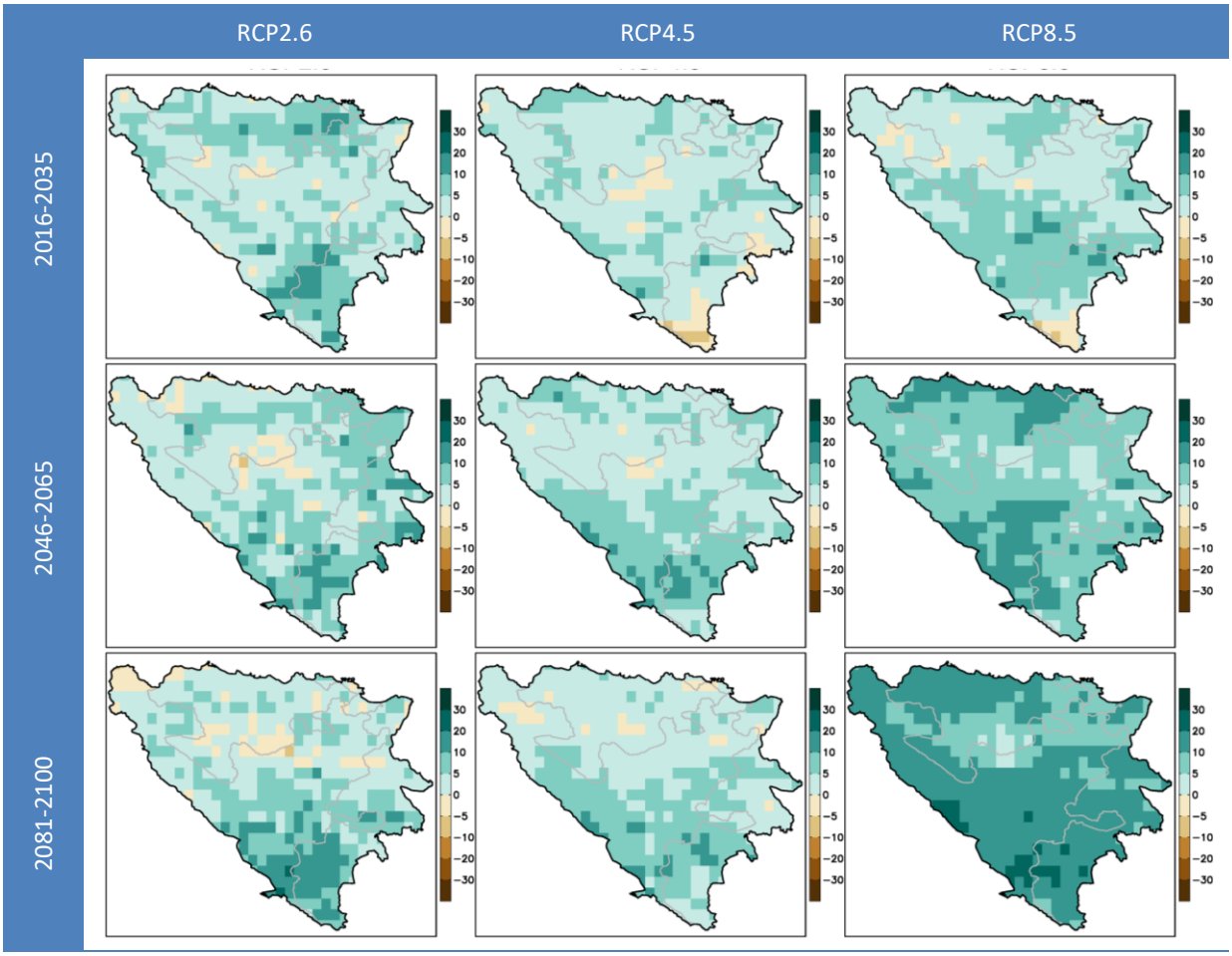


Figure 36: Change in maximum daily precipitation (%) in the year compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100.

Figure 37 shows possible future changes of consecutive **dry days**, compared to the reference period 1986-2005 for three climate scenarios RCP8.5, RCP4.5 and RCP2.6 and three future periods, 2016-2035, 2046-2065 and 2081-2100.

As can be seen from the picture, by the end of this century, according to all scenarios, the number of consecutive dry days will mostly increase, with the exception of some smaller parts of the territory of Bosnia and Herzegovina. For the period of the near future, the change according to all three scenarios is in most parts of the territory from 0 to 5% more these days, while only in smaller areas the change is from 0 to -5%. In the case of RCP2.6 scenario, this change does not differ significantly for the other two time periods. In the case of scenario RCP4.5 for the period 2046-2065, this change is 5 to 10 days more in most of the territory, while for the last time period 2081-2100, the change for the most part is from 10 to 20% more days. Finally, for the RCP8.5 scenario, the change of consecutive dry days increases significantly for further time horizons and for the period 2046-2065 it amounts to 10 to 20% more of such days, while for the last period, the change is most pronounced and amounts to 20 to 30% more of such days, in most of the country.

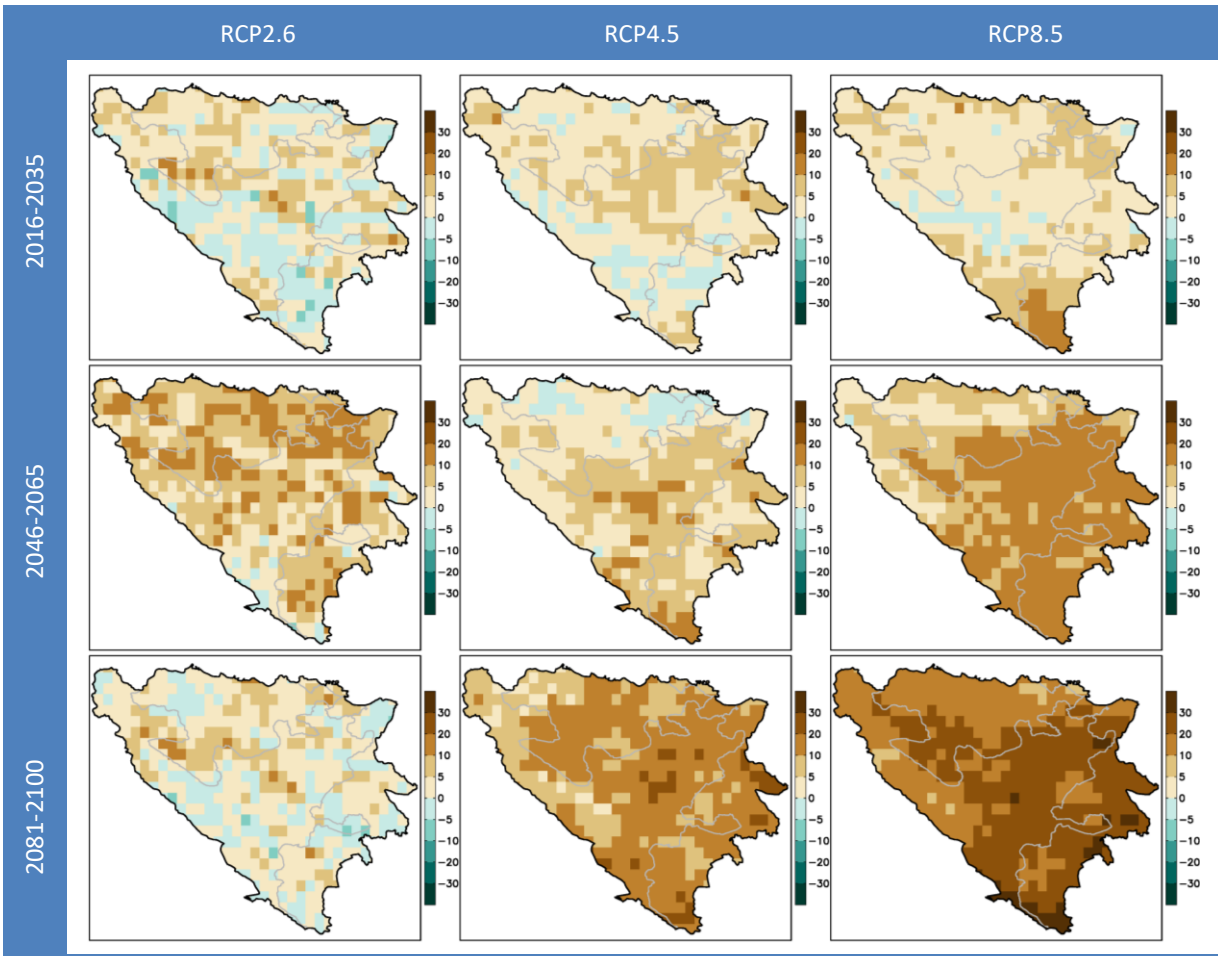


Figure 37: Change in the number of consecutive dry days in the year compared to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100.

Figure 38 shows possible future changes in the **length of the growing period**. As can be seen from the picture, by the end of this century, according to all scenarios, the length of the growing period will be extended. For the period of the near future, the change according to all three scenarios amounts to a longer growing period of 5 to 20 days in most parts of the territory. In the case of RCP2.6, this change does not differ significantly for the other two time periods. In the case of scenario RCP4.5, for the period 2046-2065, this change is from 15 to 20 days in most of the territory, while for the last time period 2081-2100, the change is from 20 to 40 days extension of the growing period for the most part. Finally, for the RCP8.5 scenario, the change in the length of the growing period increases significantly for further time horizons and, for the period 2046-2065, it amounts to 20 to 40 days, while for the last period the change is most pronounced and amounts to up to 60 days of extension of the growing period, mainly for mountainous parts of the country.

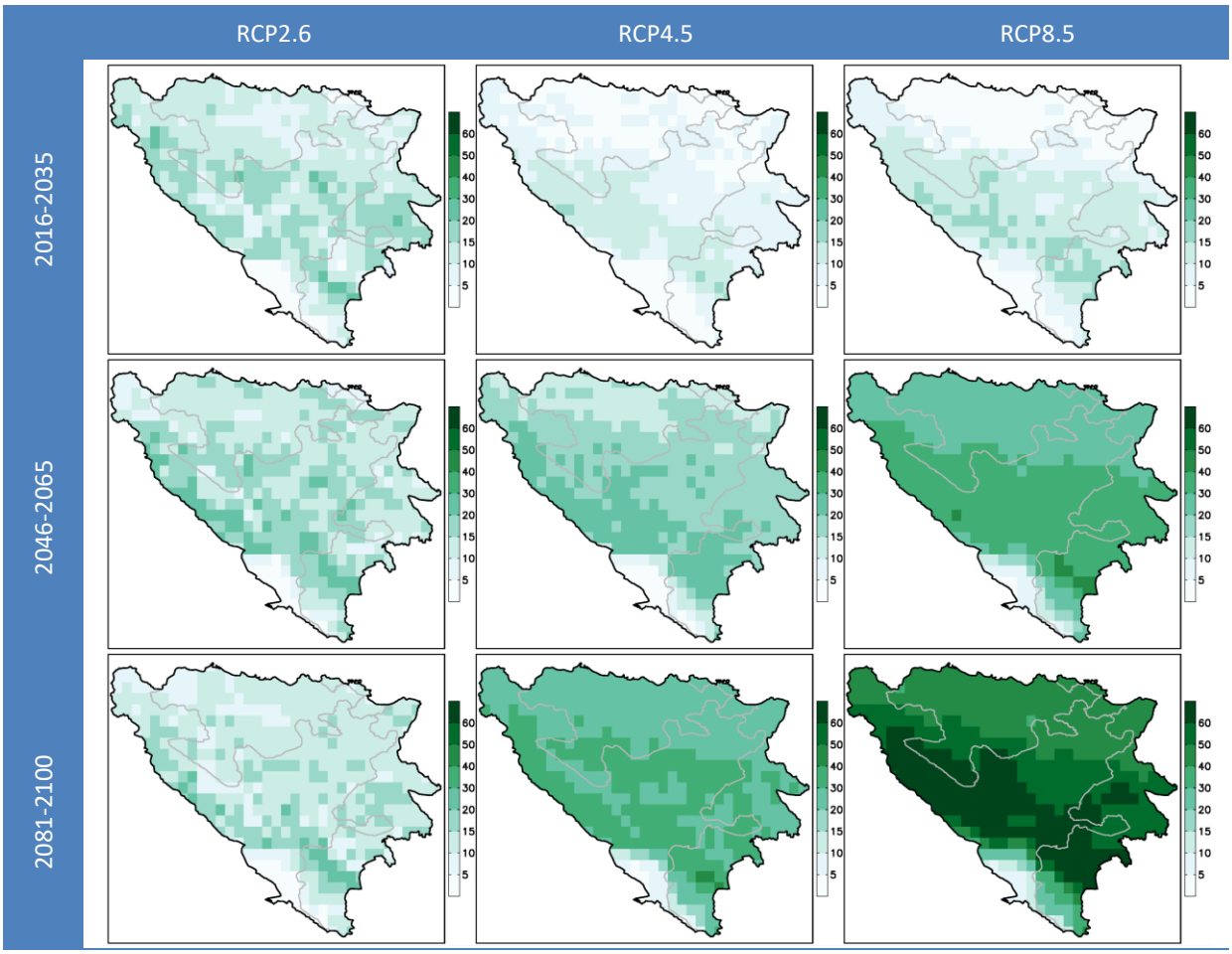


Figure 38: Change in the length of the growing period (number of days) in relation to the reference period 1986-2005, for scenarios RCP2.6, RCP4.5 and RCP8.5 and three selected twenty-year periods, 2016-2035, 2046-2065 and 2081-2100

3.3 Analysis of vulnerability and adaptation opportunities to climate change per sectors

3.3.1 Agriculture

3.3.1.1 Climate change impact on agriculture

From the point of view of spatial vulnerability, four agro-ecological areas can be distinguished in Bosnia and Herzegovina (division by Čustović et al., 2015)[55]: high karst area with karst fields, low Herzegovina area (including the upper Neretva River and karst fields), central hilly-mountainous river valley area and lowland mountain area (including serpentine and flysch zones), as shown in Figure 39.

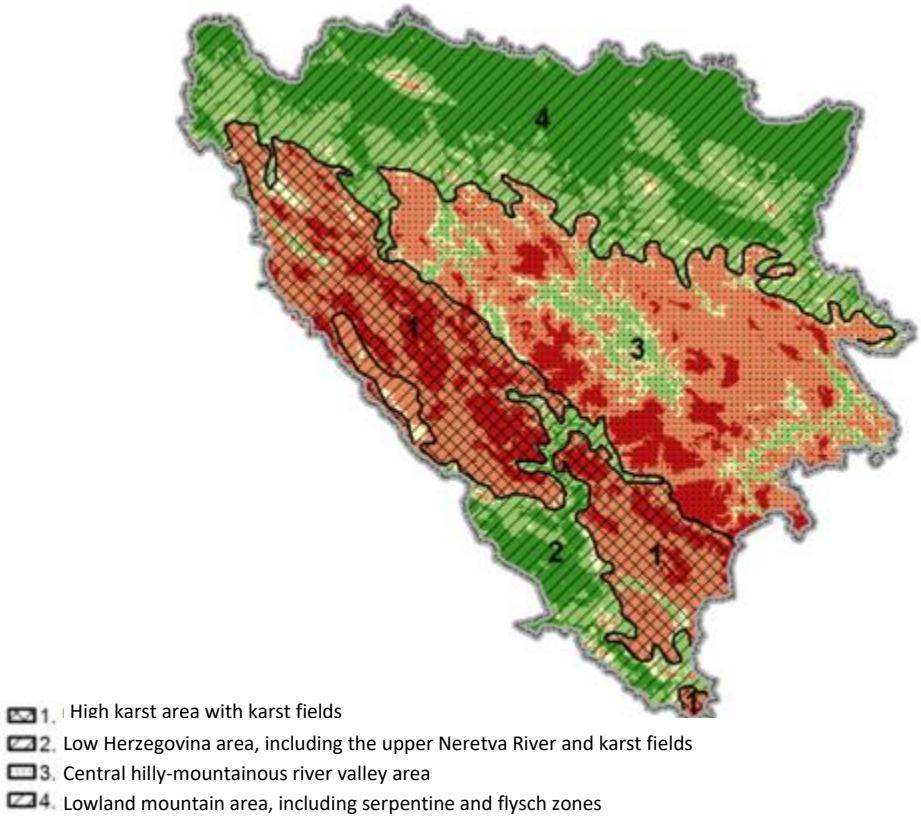


Figure 39: Agro ecological zones of Bosnia and Herzegovina
/Source: Hamid Čustović-author of the map/

A characteristic agricultural production in the area of *high karst with karst fields* is cattle breeding with all associated productions for feeding domestic animals. The area of *low Herzegovina (including the upper Neretva River and karst fields)* is from the point of view of agriculture a very important area with livestock production and fodder production, fruit and vegetable production in lower forms of terrain. The *central hilly-mountainous river valley area* mainly comprises passive areas, on a sloping terrain except on plateaus and river valleys where agriculture can be intensive. Cattle breeding and production of fodder, winter cereals, potatoes and continental fruits are mainly developed. The *lowland mountain area, including serpentine and flysch zones*, is the most important area in Bosnia and Herzegovina, from the point of view of agricultural production. Agriculture is rather

[55] Čustović H., Ljuša M., Bishal K. Sitaula (editors): *Adaptacija na klimatske promjene u sektoru poljoprivrede (Vrijeme je da djelujemo odmah),* Poljoprivredno-prehrambeni fakultet Univerziteta u Sarajevu, novembar 2015.

well developed and intensive. These are sloping hilly areas towards Semberija and Posavina, and plain areas and river valleys that gravitate towards the Sava River. Agricultural areas are suitable for all types of field production, fruit growing and fodder production for livestock.

The consequences of climate change on the agricultural sector can be twofold, or positive and negative. Changes in agri-environmental conditions will have a greater impact on maize (as an important crop) than wheat. There are several reasons for this, and one of the key ones is that it is a spring crop, root crop, and the maize has a great need for water. The projected water reduction scenarios during the growing period differ significantly from the needs of maize for intensive and high-yield production. In the continental part of the country, climate change particularly affects certain phenophases of maize development. Within the scenario of climate change in the continental areas of Bosnia and Herzegovina, growing starts earlier, lasts shorter (photoperiodism accelerates), which ultimately leads to a decline in yield[56]. Thus, some projections indicate that the northern part of Bosnia and Herzegovina will have a reduction in maize yields ranging from 10% to 25%, while the central part of the country has the potential to increase yields. According to research in the Republic of Croatia, by 2050 the yield of the most important agricultural crops could be reduced from 3 to 8%, and a similar situation can be expected in Bosnia and Herzegovina[57]. According to other scenarios, such as e.g. analysis of changes in Seljanin's hydrothermal coefficient (HTC) and annual yield of cereals, and according to climate scenarios A1B and A2, at the end of this century in Bosnia and Herzegovina it is expected that annual yields decline by up to 50%[58].

Heat stress is one of the biggest problems in agriculture, especially in the sub-Mediterranean part of Bosnia and Herzegovina. This problem is especially present in the last two decades, and it is best noticed in fruit, vineyard and, more recently, olive production.

Climate change is expected to have a positive effect on yields and quality of winter (but not spring) crops due to the extended growing period. Areas of fruit and grape growing will expand to the north and to higher altitudes due to the disappearance of very cold winters and late spring frosts but the question arises of adaptation to the conditions of long droughts, high temperatures and stress that plants survive due to such conditions. In addition, due to frequent droughts, there is a greater need for water for irrigation, especially for spring crops that will be exposed to high temperatures and lack of soil moisture during the summer months. There will also be a reduction in yield and quality of grazing, fodder (especially spring crops), impoverishment of pastures due to heavy rains and strong winds. Also, after extreme drying of the soil and a long dry period, very intense precipitation can be expected resulting in accelerated excessive erosion and soil erodibility, changes in the way of use[59]. Negative consequences are also reflected in frequent floods that inevitably lead to crop destruction due to stagnation of surface water and created anaerobic conditions. Such conditions have a very negative effect on the yield, especially if the period of stagnation is longer than one day.

Climate change increases the spatial distribution and intensity of disease development and spread, pests (e.g. more intensive spread of Capondis tenebrionsis) and invasive thermophilic weeds such as Amorpha fruticosa (acacia), Ambrosia artemisiifolia (ragweed), Helianthus tuberosus (Jerusalem artichoke) and others. Weeds and pests are likely to spread to the north. It is possible that the introduction of a new disease in Europe, the Zebra

[56] Abramović V., Jacimović D., Jocović M., (2016): Klimatske promjene i njihov uticaj na zemlje regiona

[57] Gajšak M., Šubić M., (2018): Utjecaj klimatskih promjena na poljoprivredu, Časopis „Gospodarski list“, Hrvatska

[58] Third National Communication and Second Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change, 2016

[59] Čustović H., Ljuša M., Bishal K. Sitaula (urednici): *Adaptacija na klimatske promjene u sektoru poljoprivrede (Vrijeme je da djelujemo odmah),* Poljoprivredno-prehrambeni fakultet Univerziteta u Sarajevu, novembar 2015.

chip in the near future could prevent the previous cultivation of potatoes, and newer diseases include Flavescence dorée with grapevine and Diplocarpon mali and Alternaria with apples[60].

Changes in agricultural technologies, especially more intensive irrigation, may increase the incidence of some other phytopathogenic bacteria. Treating these bacteria can increase production costs, thus directly impacting energy efficiency and greenhouse gas emissions. Increased use of pesticides can have a negative impact on human health and the environment.

Soil degradation causes the emission of greenhouse gases into the atmosphere and contributes to the further process of climate change which can be the cause of various natural disasters and catastrophes such as field and forest fires, floods, landslides, pests and the like. The consequences of degradation are also defined through the deterioration of the state of biodiversity and the services that the soil provides to the ecosystem.

Restoration of degraded soils leads to the absorption of greenhouse gases from the atmosphere, enabling the growth of trees and other vegetation. The created vegetation has even greater carbon uptake for its further growth and development, which contributes to the reduction of greenhouse gases in the atmosphere (a process known as carbon sequestration).

A relevant concept that is increasingly advocated through the United Nations Convention to Combat Desertification (UNCCD) is the concept of Land Degradation Neutrality (LDN), where the Convention defines neutrality of land degradation as "a state whereby the amount and quality of land resources, necessary to support ecosystem functions and services and enhance food security, remains stable or increases within specified temporal and spatial scales and ecosystems".

Impact on livestock production

The impact of climate change on the cattle breeding sector is reflected not only through the occurrence of heat stress in animals, which significantly affects the production and quality of animal products, but also through the availability and quality of feed whose production is also threatened. A big problem with nomadic cattle breeding is the drying up of ponds and watering holes for cattle. Due to the poor quality of fodder, the final weight of animals is less, and the quality of the meat is poorer.

Climate change, which includes an increase in temperature, as well as a change in the spatial (geographical) and temporal pattern of precipitation, leads to an increased occurrence and spread of new exotic animal diseases. During the last decade, significant changes have been recorded in the occurrence and distribution of some vector-borne diseases, including *Lyme disease, Leishmaniasis, Trypanosomiasis, Dengue fever*, etc.

The spread of the disease is also facilitated by mass migration of animals in search of new habitats for grazing food. In this way, foot-and-mouth disease and LEN ovine rinderpest/peste des petits ruminants (IUCN, 2010) are being spread. On the other hand, areas with abundant precipitation are conducive to spreading of Anthrax.

The direct effects of climate change on animals are also reflected in temperature (heat) stress, which leaves negative consequences on both animal production (fertility and reproduction) and the quality of animal products. In general, increasing the temperature, as well as increasing the humidity in cows reduces food consumption and milk production (1.5-2 litres per cow per day, in some cases as much as 50%). The problems are more pronounced in animals that are constantly outdoors. During heat stress, broilers reduce food consumption by up to 50%, laying hens by 20-50%, while insufficient consumption of nutrients reduces egg production from 80-90% to 50-60%. Heat stress in pigs causes low growth in piglets, poor physical condition,

[60] Gajšak M., Šubić M., (2018): Utjecaj klimatskih promjena na poljoprivredu, Časopis „Gospodarski list", Hrvatska

increased sensitivity and mortality. According to FAO (2018), traditional breeding of indigenous breeds of pigs has a low agri-environmental impact, is resistant to climate change and can contribute to the restoration of agricultural ecosystems and increase biodiversity[61].

Impact on fisheries

The problem of vulnerability is also reflected in fisheries. In Bosnia and Herzegovina, there is sea fishing on a very small scale in the area of Neum Bay. Only twenty small fishermen work at sea and use standing nets. The reported catch is very small, about 5 tonnes[62].

Recreational fishing is a popular activity throughout Bosnia and Herzegovina. For this reason, the only legal users of running fresh water are fishing organisations. According to the FAO analysis of the Fisheries and Aquaculture Sector in Bosnia and Herzegovina (2015), there are a total of 154 fishing associations in Bosnia and Herzegovina (95 in the Federation of Bosnia and Herzegovina, 58 in the Republika Srpska and 1 in the Brčko District of Bosnia and Herzegovina). These fishing associations have a total of 17,000 sport fishermen. In addition to registered members of fishing associations, there are also unregistered fishermen. The annual amount of fish caught ranges between 160 and 170 t, while the amount of unreported, illegally caught fish in freshwater can be as high as 150 t per year.

From 2,853 to 3,760.5 t of fish are produced in Bosnia and Herzegovina through pool farming and caging, on an area of about 20 ha (BHAS, 2017; Fisheries and Aquaculture Sector in Bosnia and Herzegovina, FAO, 2015).

Freshwater fisheries are very sensitive to climate change and human activities. The lack of precipitation in the spring-summer period lowers the biological minimum in all water courses, which adversely affects the process of reproduction and sustainability of the fishing ecosystem. Also, unpredictable climatic phenomena and environmental accidents have a very unfavourable effect on the reproductive and biological survival of fish stocks. Due to increased air temperatures and amount of sunshine, in caging and pool farming, water heats up faster, which can negatively affect the appearance of various diseases and pathogens. Water in smaller lakes and artificial reservoirs heats up quickly with increasing temperatures and tropical heat, and ecosystems are very sensitive from the point of view of climate change.

Vulnerability and selection of species and varieties

When choosing species and varieties, one should choose those that have proven to be resistant to high temperatures, drought, floods, but also to diseases and pests. It is known that maize varieties with strong rooting, upright leaves, larger tassels and deeply planted grain have a higher tolerance to stress and drought. The possibility of growing some new crops and varieties that have not been grown in a certain area so far can be mentioned as a positive effect. However, one should be careful here as well because the process of adaptation to new agro-ecological conditions can be very slow and arduous.

Plant species that originate from the southern meridians, generally have a higher tolerance to higher temperatures, and the following ones can be grown in our country: sweet potatoes, soybeans, sesame, sorghum, tobacco, cassava and others.

Crops and plantations that reach technological maturity early (early potatoes, lettuce, spring onions, early fruits, etc.) can be used to avoid drought.

[61] FAO (2018): Climate smart agriculture, case studies 2018

[62] FAO (2014): The State of World Fisheries and Aquaculture (SOFIA)

Varieties that have a short growing period often provide drought resistance because they yield before the hottest part of summer begins, e.g. early wheat varieties such as Simonida and Dragana can ripen 15 to 30 days before late or early maize hybrids belonging to FAO ripening groups 100 to 400 (e.g. ZP196, ZP260, ZP360, ZP434). Changes in agro-climatic conditions will have a greater impact on maize, as a larger consumer of water, compared to wheat. Preliminary research suggests the possibility of shifting the spring sowing calendar in terms of its earlier onset.

Some local (indigenous) or old varieties and populations of plants (such as onions, legumes (string beans, pean, broad beans), cabbage plants, cucurbits (pumpkins, melons and watermelons) and vegetables with fruits (peppers, tomatoes)) have specific forms of adaptation to local conditions of production, including adaptation to the diseases and climate variation, i.e. high temperatures and drought.

In areas where there is a summer deficit or shortage of water for normal development of agricultural crops, and there are no opportunities for irrigation, the selection of crops should be adapted to the natural distribution of precipitation, or the dynamics of *rainfed agriculture*.

3.3.1.2 Vulnerability analysis

Bosnia and Herzegovina is very vulnerable to climate change. The forecasted rise in temperature, combined with changes in precipitation and evaporation rates, is likely to have a significant negative impact on agricultural systems in Bosnia and Herzegovina[63]. In the future, we can expect the occurrence of droughts during the summer months, as well as the occurrence of extremes in terms of the amount, distribution and intensity of precipitation, which means that agriculture, which in Bosnia and Herzegovina takes place mainly in the conditions of natural water supply, will fight for water but also with water.

The expected changes according to the RCP8.5 scenario in agro-ecological areas are shown below.

According to scenario RCP8.5 for the period 2016-2035 on an annual basis, the area of high karst with karst fields has a dominant change or decrease in mean daily precipitation at the annual level of -5%, while the dominant increase in precipitation of + 5% is in the part of the zone around Drvar. In the June-July-August season, the reduction in precipitation is up to -10%. When it comes to the change in the mean daily temperature on an annual basis, this scenario shows an increase of +1°C in the entire zone compared to the reference period (1986-2005). In the June-July-August season, this increase is +1.5°C. However, if the same scenario is considered, but for the period 2046-2065, an average temperature increase of up to 2.5°C can be expected. In terms of precipitation, the percentages as well as the distribution remain rather the same as in the scenario for the period 2016-2035.

In the Lower Herzegovina Area (including the upper Neretva River and karst fields), according to scenario RCP8.5 for the period 2016-2035 on an annual basis, the mean daily precipitation in the entire zone has a dominant decrease of -5%. In the June-July-August season, the reduction of precipitation is up to -20% with the dominance of the reduction down to -10%. When it comes to the change in mean daily temperature on an annual basis, the scenario shows the same values as for the high karst area. According to the same scenario, but for the period 2046-2065, an average temperature increase of up to 2°C can be expected. As for precipitation, a completely different situation is expected in most of this zone, with a decrease of -5% to an increase of + 5% in the period 2046-2065.

[63] Majstorović Željko, 2017: *Unapređenje poljoprivrede, šumarstva i vodoprivrede u skladu sa klimatskim promjenama u Bosni i Hercegovini*, Posebna izdanja ANUBiH, OPMN 26, p. 115-124

According to scenario RCP8.5 for the period 2016-2035 on an annual basis, the Central Hilly Mountain Area with river valleys has an equal increase in mean daily precipitation of up to +5%, but also a decrease of -5%. The increase mainly dominates in eastern Bosnia (e.g. Rudo, Goražde, Višegrad, Srebrenica), and in the wider area of Sarajevo and around Jajce. The decrease is evident in the area of Mrkonjić Grad, Kneževo, and the central parts (Travnik, Vitez, Zenica, etc.). In the June-July-August season, the reduction in precipitation is up to -10%. When it comes to the change in the mean daily temperature on an annual basis, the scenario shows an increase of +1°C, or an increase of +1.5°C in the June-July-August season. However, if the same scenario is considered, but for the period 2046-2065, an average temperature increase of up to 2.5°C in the entire zone can be expected. As for precipitation, the percentage values remain the same as in the scenario for the period 2016-2035, with their distribution being somewhat different in the sense that there will be a sporadic increase in the amount of precipitation in the central parts.

The lowland mountainous area, including serpentine and flysch zones, according to the RCP8.5 scenario for the period 2016-2035, has a positive change in mean daily precipitation at the annual level of up to +5%, while the change in mean daily temperature at the annual level shows an increase of +1°C. In the June-July-August season, the temperature increase is up to 2°C, while the precipitation is reduced to -5%, with the exception of the area around the Brčko District of Bosnia and Herzegovina, Bijeljina and Tuzla, as well as Velika Kladuša, Bihać and Bosanska Krupa, and the surroundings of Mrkonjić Grad. According to the same scenario, but for the period 2046-2065, an average temperature increase of 2 to 2.5°C can be expected. As for precipitation, the percentages remain the same as in the previous scenario, with the distribution of precipitation changing in the north-western part of this zone.

Although climate change is very pronounced, it is not necessarily negative for agriculture. Climate change in the future will lead to an increase in the growing period and a shift in the onset of growing. It is expected that climate change will have a positive effect on yields and quality of winter crops due to the extended growing period. However, due to high temperatures, heat stress and shortage of precipitation, there will be a reduction in the variability of yields, the quality of field, vegetable and fruit crops, the occurrence of diseases and pests, soil degradation and other problems. Nevertheless, estimates from a number of studies covering many regions and crops show that negative impacts of climate change are more common than positive ones[64].

Rising temperatures and droughts will certainly jeopardise fruit production, with the additional occurrence and development of diseases and pests. The cultivation of certain crops and vines can be expected to move from the Mediterranean to the continental parts (e.g. peaches and apricots) or to higher altitudes (e.g. apples). Newer diseases include Flavescence dorée with grapevine and Diplocarpon mali and Alternaria with apples[65].

Maize is one of the most important agricultural crops, especially in livestock production, whether it is the production of silage or grain. Different projections indicate different reductions in the production of this crop. However, regardless of different predictions, it is certain that maize is one of the most endangered agricultural crops.

Vegetable production is the first victim of climate change and climate extremes, primarily due to high water needs. Increased temperatures, especially in dry years, certainly have an impact on vegetable production. The greenhouse type of production is also threatened due to ventilation problems and relative humidity. It is possible

[64] IPCC (2017): Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (SR2)

[65] Gajšak M., Šubić M., 2018: *Utjecaj klimatskih promjena na poljoprivredu*, Časopis „Gospodarski list“, Hrvatska.

that the introduction of a new disease in Europe, the Zebra chip in the near future could prevent the current cultivation of potatoes[66].

Climate change increases the spatial distribution and intensity of development and spread of diseases, pests (e.g. more intensive spread of Capondis tenebrionsis) and invasive thermophilic weeds such as Amorpha fructicosa (acacia), Ambrosia artemisiifolia (ragweed), Helianthus tuberosus (Jerusalem artichoke) and others. Weeds and pests are likely to spread north.

The possible effects of climate change on food production are not limited to plant production but also have far-reaching consequences for the production of milk, meat and other animal products, primarily through the impact on animal feed production, health and reproduction of domestic animals. Also, due to heat stress, animals reduce food consumption, which further affects the production and quality of the products.

Climate change is also leading to an increased spread of various diseases but also the emergence and spread of new unusual animal diseases for our area. This primarily refers to transmissible or vector-borne diseases; viral, bacterial and parasitic. During the last decade, significant changes have been recorded in the occurrence and distribution of some vector-borne diseases, including Lyme disease, Leishmaniasis, Trypanosomiasis, Dengue fever, etc.

Fisheries are also at risk. The shortage of precipitation in the spring-summer period lowers the biological minimum in all water courses, which adversely affects the process of reproduction and sustainability of the fishing ecosystem. Unpredictable floods also have a very adverse effect on the reproductive and biological survival of the fish ecosystem. The waters in smaller lakes and artificial reservoirs heat up quickly with increasing temperatures and tropical heat.

It is common knowledge that land degradation is one of the major problems of mankind, which is further accelerated by weather disasters. According to a new IPBES report, the main global driver of land degradation is the expansion and unsustainable management of agriculture, driven by unprecedented level of consumption in a growing global economy. This causes, as stated, a significant loss of biodiversity and ecosystem services such as providing sufficient quantity of food, water purification and energy supply[67]. It is estimated that due to soil degradation and climate change by 2050, the world yield of agricultural products could decrease by approximately 10%. This will mainly happen in India, China and sub-Saharan Africa, where due to soil degradation crop production could be halved[68]. According to IPBES[69], land degradation is a major contributor to climate change, while the impact of almost all direct drivers of land degradation will be exacerbated by climate change. These include, among other things, accelerated erosion on degraded land as a result of climate extremes, increased risk of forest fires and changes in the distribution of invasive species, pests and pathogens.

However, land degradation cannot be attributed to climate change as the only factor. The most important factor in the degradation process is man. For that reason, land degradation can go in the opposite direction, in the direction of climate change for which it can be said to be two interrelated and dependent processes.

[66] Gajšak M., Šubić M., 2018: *Utjecaj klimatskih promjena na poljoprivredu*, Časopis „Gospodarski list“, Hrvatska.

[67] https://www.sei.org/featured/ipbes-land-degradation/

[68] EU 2018 press release, https://europa.eu/rapid/press-release_IP-18-4202_hr.htm

[69] The assessment report on Land degradation and restoration summary for policymakers, IPBES, 2018

3.3.1.3 Adaptation opportunities

In line with climate change and the extreme situations so far, it is to be expected that Bosnia and Herzegovina will fight two key problems: droughts and floods.

The answer to reducing high vulnerability in the agricultural sector should focus on important issues such as human capacity building to understand this issue, increase soil retention capacity for water, application of conservation tillage measures, cultivation of adequate species and varieties resistant to climate change, introduction of irrigation systems in all agricultural areas of Bosnia and Herzegovina, construction of water reservoirs and ponds for irrigation, application of anti-erosion measures and introduction of agroforestry as measures to mitigate the effects of high temperatures, biodiversity protection and landscaping.

Changing agricultural practices and adopting different strategies, in order for agricultural production to cope with climate change, is determined by the prevailing conditions, previous experiences and access to resources. However, adequate improvements in the processes of monitoring, analysis and modelling of data are needed to adequately assess climate change and its impact on the agricultural sector.

Continuous training and capacity building of agricultural producers is needed. Extension services should play a key role in promoting agricultural practices and disseminating knowledge and skills regarding adaptation measures. In this regard, it is necessary to strengthen the capacity of the extension services themselves.

Irrigation will certainly be one of the key mechanisms for adaptation. Crop yields and their requirements for irrigation are not only influenced by climate change, but also by agricultural practices and socio-economic factors[70]. However, flood protection and drainage of excess water from the plot, and in general the regulation of the water-air regime is a priority issue in the further development of the agricultural sector. The construction or completion of complex hydromelioration systems, as well as the catchment approach to spatial planning is posed as a key strategic issue. Firstly, existing systems could be properly maintained.

In order to achieve the previous objectives, a strong institutional, policy and legislative framework for risk management and adaptation to climate change as well as sustainable financial mechanisms for their implementation are needed.

These conclusions are in line with the generally accepted position on climate change and the need to adapt production to the resulting changes, whereas the changes and adaptation will be much more successful if monitored and adapted in the lower regional and production area, rather than globally. According to many opinions, the future of agriculture belongs to genetics and irrigation.

Recently, one of the most frequently mentioned options for adaptation to climate change is Climate Smart Agriculture. According to FAO (2018), Climate Smart Agriculture is an approach that helps guide the actions needed to transform and reorient agricultural systems to effectively support the development and ensure food security in a changing climate. This approach calls for three goals: sustainable food security through increased productivity and income, building resilience and adaptation to climate change, and reducing greenhouse gas emissions from business as usual or baseline scenarios.[71].

[70] EEA Report (2016): Climate change, impacts and vulnerability in Europe 2016, An indicator-based report

[71] Lipper L., McCarthy N., Zilberman D., Asfaw S., Branca G., Editors (2018): Climate Smart Agriculture Building Resilience to Climate Change, FAO, Springer.

3.3.2 Water resources

3.3.2.1 Climate change impact on water resources

Trend analysis – precipitation

Precipitation analysis in Bosnia and Herzegovina was performed for two main catchment areas, the Sava (Danube) River Basin and the Adriatic Sea Basin. Selected available annual data sets were used, from meteorological stations in Bihać, Sanski Most, Sarajevo, Zenica and Tuzla for the Sava River Basin precipitation, and Banja Luka, and data from the station in Mostar for the Adriatic Sea Basin. The periods 1961-1990 and 1991-2018 were analysed, and the trend is shown for the entire period of available data, from 1948. In relation to the Third National Communication, the series of precipitation and flows up to the year of 2018 have been supplemented and analyses have been performed, the results of which can be compared with the results of analyses from the previous report.

The calculation of the basic statistical parameters of these series is shown in Table 13, and the trends of annual precipitation amounts inFigure 40, Figure 41 and Figure 42.

Table 13: Statistical parameters of the series of annual precipitation in BiH, for the periods 1948-2018, 1961-1990, 1991-2010, 1991-2014 and 1991-2018

Statistical parameter[72]	Annual precipitation in Sava River Basin (mm)					Annual precipitation in Adriatic Sea basin (mm)				
	1948-2018	1961-1990	1991-2010	1991-2014	1991-2018	1948-2018	1961-1990	1991-2010	1991-2014	1991-2018
Mean value	1011.7	990.4	1040.9	1034.3	1037.0	1475.2	1523.8	1456.5	1469.1	1454.5
Median	1005.9	989.3	1033.3	1020.1	1033.3	1468.0	1584	1412.4	1412.4	1394.9
Stand.dev.	134.91	104.38	144.08	172.62	161.09	316.50	282.71	371.1	398.4	370.6
Variance	18199	10896	20759	29795	25950	100174	100174	137749	158692	137358
Kurtosis	1.3070	-0.2116	0.0197	0.5623	0.9503	0.6497	0.6497	1.8350	0.5427	1.1539
Skewness	0.3141	-0.5703	0.1961	0.1349	0.0872	0.2712	0.2712	1.1432	0.8045	0.9586
Range -scope	768.94	406.56	582.66	768.94	768.94	1651.20	1146.7	1594	1619.2	1618.2
Minimum	653.9	754	768.46	653.86	653.86	840.50	841	897	872.5	872.5
Maximum	1422.8	1161	1351.1	1422.8	1422.8	2491.7	1987	2491.7	2491.7	2491.7

[72]Variance, kurtosis and skewness are dimensionless statistical parameters

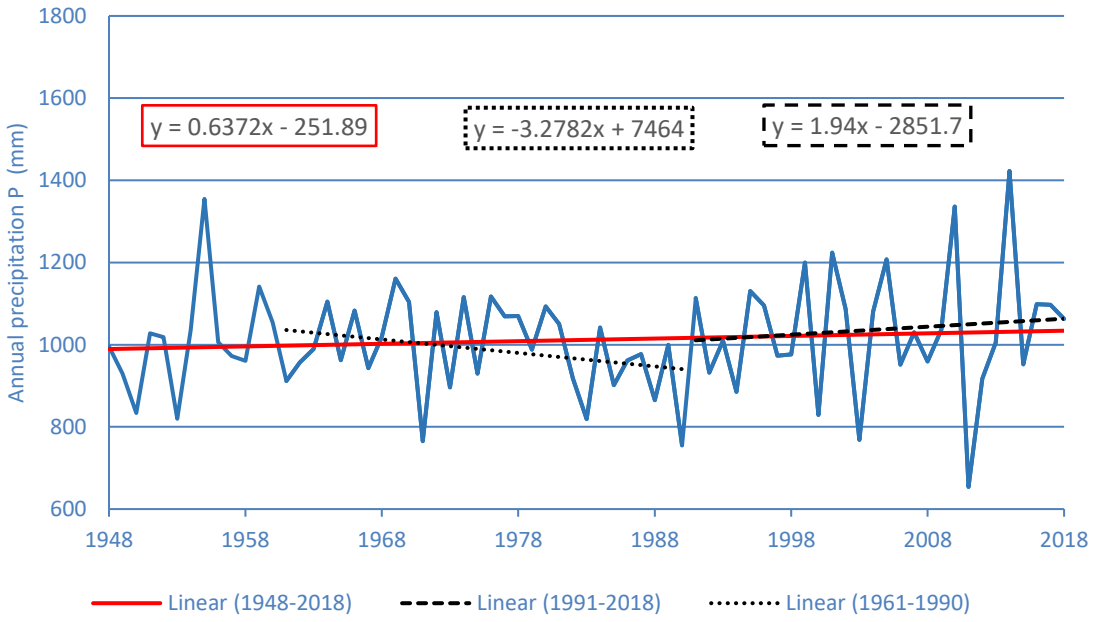


Figure 40: Annual precipitation in the Danube basin in Bosnia and Herzegovina (average from MS Bihać, Sanski Most, Sarajevo, Zenica and Tuzla), with linear trends (y – annual precipitation; x – year)

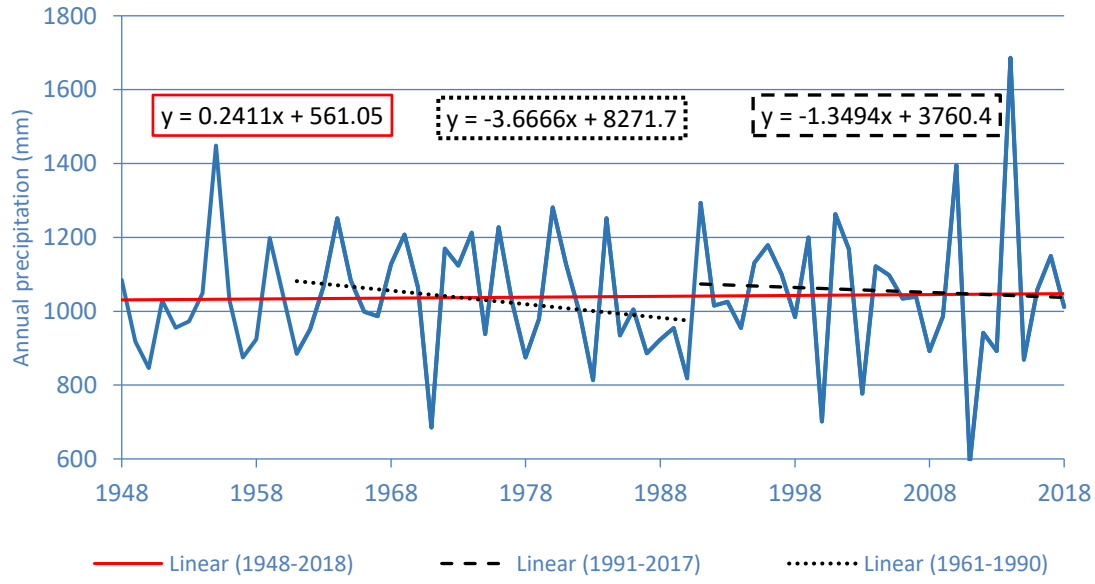


Figure 41: Annual precipitation at MS Banja Luka, with linear trends for different periods of processing (y – annual precipitation; x – year)

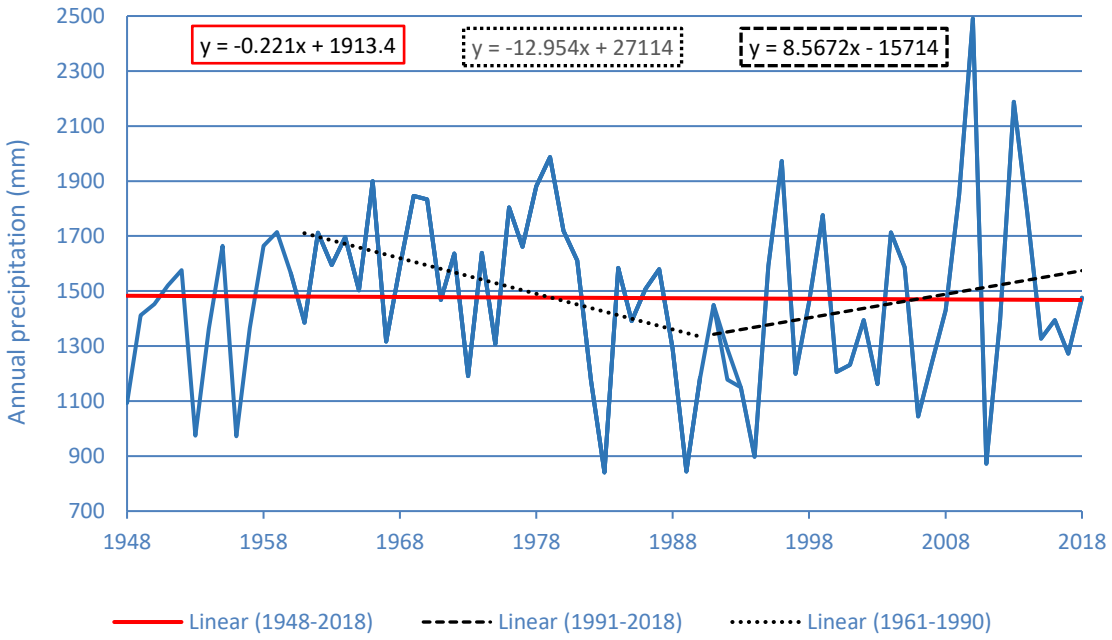


Figure 42: Annual precipitation in the Adriatic Sea basin in Bosnia and Herzegovina (MS Mostar), with linear trends for different periods of processing (y – annual precipitation; x – year)

By analysing the series of annual precipitation supplemented by values for the period 2015-2018, for both the Sava River Basin and the Adriatic Sea Basin, it can be immediately noticed that the extreme values of the total series have not changed (in the Sava River Basin maximum values were recorded in 2014 and minimum in 2011; the maximum value of the Adriatic Sea basin was also recorded in 2014, and the minimum in 1983. The values of volume (distribution) decreased compared to the period 1991-2014 but are still significantly higher compared to the period 1961-1990. Compared to the 1961-1990 series, in the period 1991-2018 in the Sava River Basin the mean annual precipitation was higher by 46.6 mm than in the period 1961-1990, which is slightly higher than in the period 1991-2014. However, the average value of annual precipitation recorded in Mostar in the period 1991-2018 was 69 mm less than in the period 1961-1990, and about 15 mm lower than in the period 1991-2014.

For the same series (periods of 1948-2018, 1961–1990 and 1991-2018), an analysis of trends was performed (Figure 40 and Figure 42). It can be seen that the series 1961-1990 is characterised by negative trend of annual precipitation in both the Sava River Basin and the Adriatic Sea Basin, and in the period 1991-2018 the trend is positive, with the exception of Banja Luka (Figure 41). Looking at the series 1948-2018, in the Sava River Basin the trend has a much smaller slope but it has a positive sign. However, in the Adriatic Sea Basin the trend for the overall analysed period is slightly negative.

Trend analysis – flows

The series of river observations in Bosnia and Herzegovina were interrupted in the 1990s, making the analysis of flow trends very difficult. The flow trends have been analysed for the Bosna River in Maglaj, the Sava River Basin, where the interruption of observations in the period 1987-2000 was supplemented using the hydrological HBV model for the Bosna River Basin (Figure 43), while for the purposes of the model, data on precipitation were used from MS in Tuzla, Zenica and Doboj. The flows of the Neretva River in Žitomislići were analysed in the Adriatic basin (Figure 44). It should be noted that the Neretva River in Žitomislići has been flowing with an artificial regime since 1954. However, since all reservoirs located upstream of Žitomislić work with levelling

within one year, a review of available flows for the period 1926-2017 is made here, in order to compare the average annual flows for different periods.

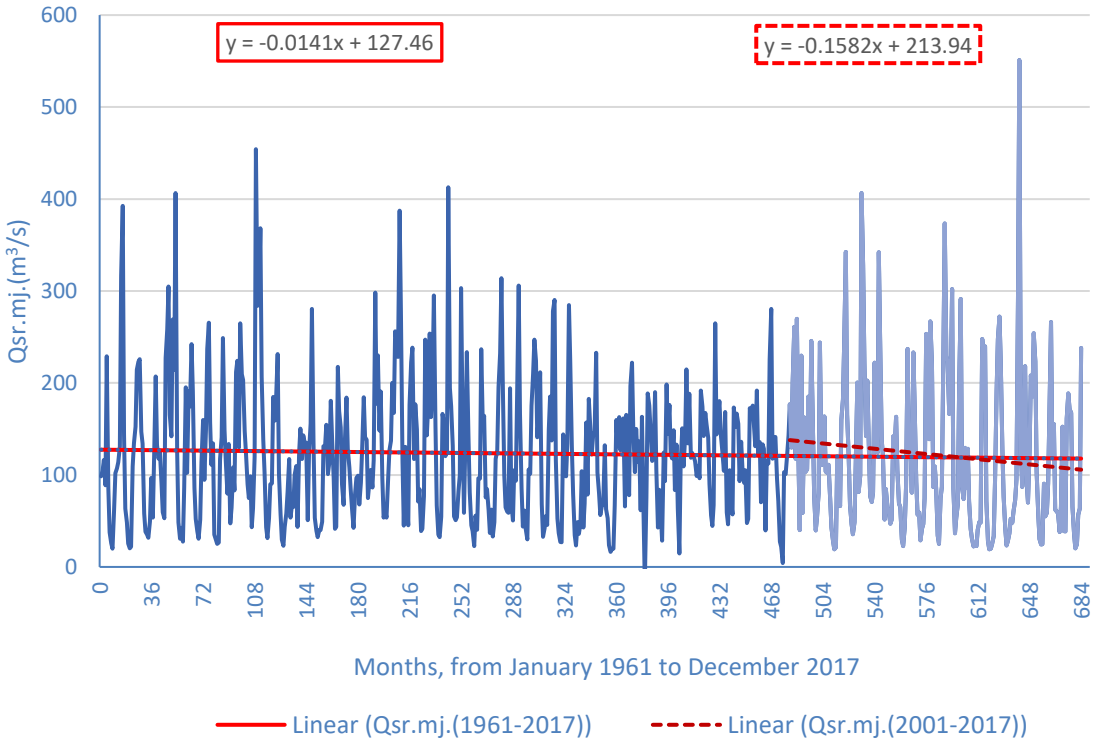


Figure 43: Bosna River, HS Maglaj: Average annual flows with the trends, for various periods

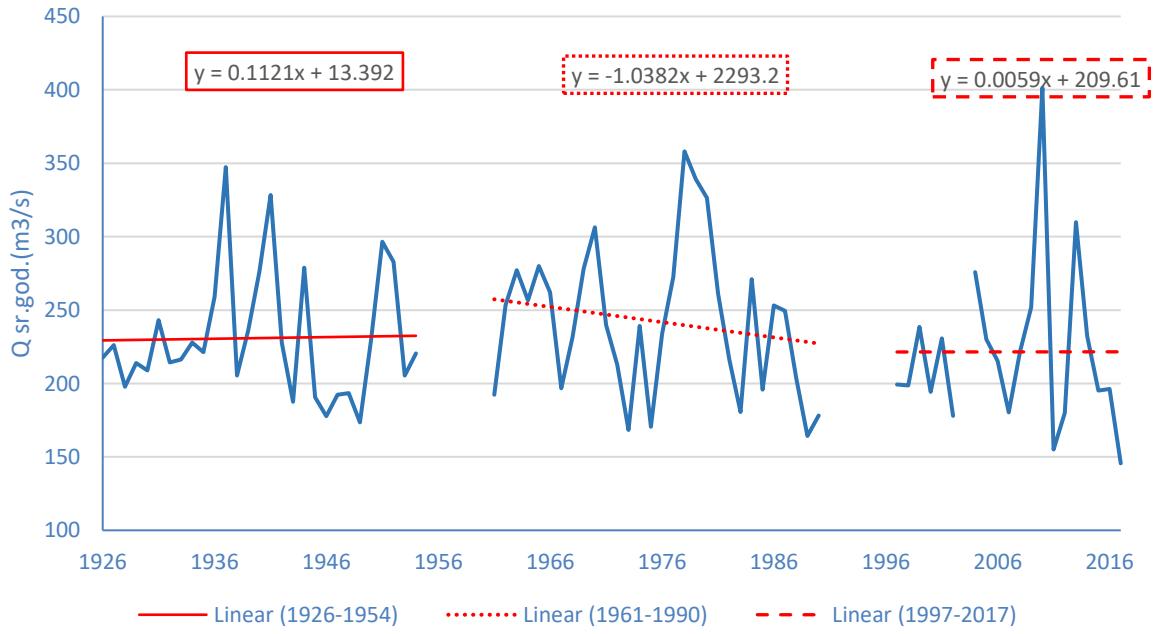


Figure 44: Bosna River, HS Žitomislići: Average annual flows with the trends, for various periods

Table 14: Bosna River, Maglaj, characteristic flows for different periods (m^3/s)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
Av. monthly 1926-1990	131	162	188	210	171	109	73.5	51.6	55.7	77.9	105	145	123
Max monthly 1961-1990	1181	1164	1173	1118	2177	838	766	746	570	1578	1233	1680	2177
Min monthly 1961-1990	27.5	19.4	38.2	45.8	39.3	27.6	16.0	11.8	11.8	12.2	19.0	29.7	11.8
Av. monthly 2001-2017	139	138	221	210	163	108	64.2	47.9	61.6	74.6	97.7	136	122
Max monthly 2001-2017	1571	1303	1383	1360	3579	1558	2243	1042	729	1044	1177	991	3579
Min monthly 2001-2017	18.9	26.4	50.8	49.0	44.6	32.0	19.7	16.1	15.2	16.1	21.0	22.0	15.2

Table 15: Neretva River, Žitomislići, characteristic flows for different periods (m^3/s)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
Av. monthly 1926-1954 Prirodni režim	273	251	309	339	317	175	87.3	55.6	73.1	185	364	345	231
Max monthly 1926-1954 Prirodni režim	1502	1524	1306	884	1116	704	225	152	1175	1726	1726	1707	1726
Min monthly 1926-1954 Prirodni režim	41.2	51.5	57.3	122	95.5	59.3	41.2	34.0	30.3	31.5	42.8	47.8	30.3
Av. monthly 1961-1990 Vješt. režim	305	303	290	353	319	194	114	99	126	202	301	333	245
Av. monthly 1997-2017 Artif.regime	317	281	304	335	234	135	85	77	111	184	254	345	222

The results show that the overall change in annual flows is small but strong changes in the seasonal regime and extreme events are expected. Observing the seasons, the most significant change is the increase in runoff in the winter season. This change is the result of a significant rise in temperatures, which either lead to less snow and more precipitation in the winter months or to accelerated snowmelt in early spring. This significantly reduces river flow in the spring and summer seasons.

Floods

In the last two decades, Bosnia and Herzegovina has been hit by several extreme floods (2004, 2010, 2014). There are also more frequent and extreme droughts in Bosnia and Herzegovina (2000, 2003, 2007, 2012, 2015, 2017).

Significant floods were recorded in April 2004 affecting 48 municipalities in the Una, Vrbas, Bosna and Drina basins. About 20,000 hectares of agricultural land and 300,000 people were threatened by floods, of which several hundred families were evacuated. In early December 2010, after heavy rains, there were floods, particularly in the Drina River Basin and in eastern Herzegovina. The towns of Goražde, Zvornik and Bijeljina were flooded, as well as several smaller settlements. In the Republika Srpska and the Federation of Bosnia and Herzegovina, an area of over 240,000 hectares was flooded, of which a large part of agricultural land, houses, roads and bridges were destroyed or damaged.

In mid-May 2014, extreme floods affected Bosnia and Herzegovina and the wider region. The floods followed several days of rain (the highest precipitation ever recorded since the beginning of the organised measurement, i.e. the last 120 years), which coincided with the field water saturation, which contributed to an extreme rise in

water levels in a very short time, especially on the Bosna and Sava rivers, and Drina River to a lesser extent, as well as their tributaries. So, in the period 17-18 May 2014 embankments were breached in several places along the Sava River and its main tributaries, or the embankment overflowed on sections that did not have sufficient protective elevation, causing floods and great material damage in the area of Central Posavina, Odžačka Posavina and Semberija. Additional damage to the basin was caused by the occurrence of a large number of landslides, some of which completely reshaped the environment. Floods, erosion, torrents and landslides marked the year of 2014. After the floods in May, already in July, August and September 2014, precipitation caused new flooding problems in areas that had already been devastated by previous floods.

In the Adriatic basin in Bosnia and Herzegovina, where multi-purpose water management systems[73] have been built, the hydrological regime is more or less influenced by the management of these systems. In December 1999, there was a large flood wave of the Neretva River, which caused enormous damage in Mostar but also in the entire lower course of the Neretva River. In 2004, when large river overflows occurred in the Sava River Basin in Bosnia and Herzegovina, extremely high water levels were recorded in the Neretva River Basin as well, with occasional overflows.

The events of recent decades show that in Bosnia and Herzegovina, more and more frequent floods are caused by heavy regional precipitation, which can surpass the previous catastrophic floods. The danger of floods is also increased by mild winters with little snow, with the appearance of heavy rain that falls for hours, or heavy snow with extreme temperature oscillations.

Flash floods

In recent years, flash floods have occurred frequently in Bosnia and Herzegovina. Flash flood generally occur from rain of high intensity and short duration, which is a characteristic of a tropical climate. Such rain in a short time causes the appearance of flash flood that destroy everything in their path.

The concept of flash floods is much broader than in the case of river floods, so we often talk about "flood processes", given that it is a set of phenomena that occur in ephemeral water courses and coastal areas, in case of large oncoming waves of water. In addition to the outpouring of large waters from the riverbed, in parallel, the water carries large amounts of debris, the so-called debris torrent. Flood waves are characterised by great destructive power, when the head of the wave destroys trees, undermines the shores, creates avalanches and landslides. The hydrological regime of ephemeral water courses is also specific. It is manifested by a large range of flows and a characteristic form of high water hydrograms, with a short time base. The ratio of large and small water flows is Qmax/Qmin ~ 10^3, in contrast to large alluvial water courses where Qmax/Qmin ~ 10. On the other hand, the duration of large waters is very short, several hours. In the hydrograms of torrent water courses, the rise time (ascending line) is particularly short, meaning the rapid formation and sudden arrival of large waters. The curves of the duration of ephemeral water courses during the year also have a characteristic shape, with a very short duration of large waters. With the appearance of flash floods, there is also soil erosion. Erosion processes are difficult to notice and slow and are most often noticed only when large areas are exposed. The relief of Bosnia and Herzegovina is characterised by a large presence of sloping terrain, so for example the analysis of certain classes of terrain slopes of the Federation of Bosnia and Herzegovina, found the highest representation of the class of very steep slopes with pronounced erosion processes, which occupies 22.9% of the study area.[74]

[73] Most of these systems were initiated by the construction of large hydropower facilities.

[74] Multipurpose land valuation in the Federation of Bosnia and Herzegovina, 2013

In recent years, floods have become more frequent in Bosnia and Herzegovina in urban areas - cities; depending on the capacity of the existing sewerage network, and an increase in precipitation intensity results in increased overflow and flooding, usually on roads. This can lead to significant infrastructure problems and damage to housing.

Droughts

The occurrence of extreme droughts in Bosnia and Herzegovina has intensified in the last few decades, when several drought years were recorded (2000, 2003, 2007, 2011, 2012, 2017). The climate projections indicate that the dramatic consequences of climate change will intensify in the coming period. Climate change scenarios show a significant reduction in precipitation in the region during the summer season, which can lead to an increase in the frequency and intensity of drought, and thus to an increase in the impact of this phenomenon.

Damage – vulnerability indicator

Economic losses - damage caused by climate extremes, is one of the indicators of the European Environment Agency (EEA) from the group of CLIM indicators on the state of vulnerability and impacts. Based on this indicator, the vulnerability/exposure of the community to hazards, as well as the success of actions and measures taken in the processes of adaptation and risk management, and should be understood as a warning to be prepared for more frequent and/or more serious events in the future.

Extreme weather conditions cause great damage in Bosnia and Herzegovina, however, there is a lack of official statistics on damage, i.e. data that would bring the damage in the context of climate change. This type of data is still not collected through entity and state statistical institutions.

Drought has been one of the most significant threats to Bosnia and Herzegovina in the past, causing great economic, environmental and social damage. Extremely high temperatures and heat stress are some of the biggest problems in agriculture, especially in the sub-Mediterranean part of Bosnia and Herzegovina. This problem is particularly present in the last two decades, with the most intense impact in fruit, vegetable and vineyard production. In 2012, Bosnia and Herzegovina faced a prolonged period of severe drought that caused losses in agricultural production of about BAM 1.65 billion, grain and vegetable yields were reduced by about 70%, and energy production was reduced by about 25%.[75] This drought had a major impact on grain prices, which reached extremely high levels. The severity and frequency of droughts in Bosnia and Herzegovina have increased over the past few decades, and climate projections claim that the dramatic effects of climate change will intensify in the coming years. Climate change projections show a significant reduction in precipitation in the region, especially during the summer, which could lead to an increase in the frequency and intensity of drought. This highlights the urgent need to prioritise coping with droughts.[76]

On the other hand, more frequent precipitation of higher intensity expected in the future will cause more intense runoff, often accompanied by floods. According to the data from the *Action Plan for Flood Protection and River Management in Bosnia and Herzegovina 2014-2017,* catastrophic floods[77] caused by precipitation in the period from 14 to 19 May 2014, which exceeded the hitherto recorded phenomena, affected the entire area

[75] Source: Drought Conditions and Management Strategies in Bosnia and Herzegovina - Concise Country Report, 2013, https://www.researchgate.net/publication/270816670_Drought_Conditions_and_Management_Strategies_in_Bosnia_and_Herzegovina_-_Concise_Country_Report

[76] Source: Drought Conditions and Management Strategies in Bosnia and Herzegovina - Concise Country Report, 2013, https://www.researchgate.net/publication/270816670_Drought_Conditions_and_Management_Strategies_in_Bosnia_and_Herzegovina_-_Concise_Country_Report

[77] The May floods are an event that has not been recorded since 1892, when the systematic measurement of meteorological and hydrological phenomena in Bosnia and Herzegovina was initiated.

of Bosnia and Herzegovina belonging to the Sava River Basin and caused the loss of 23 lives and enormous material damage. According to data from the document *Recovery and Reconstruction Needs Assessment in Bosnia and Herzegovina*[78] prepared with the assistance of the EU, UN and WB, it is estimated that the total consequences of this natural disaster in Bosnia and Herzegovina amount to € 2,037 million, or € 1,040 million in the Federation of Bosnia and Herzegovina, € 968.30 million € in Republika Srpska and € 29.6 million in Brčko District of Bosnia and Herzegovina.

Figure 45: Zgošća water course, Kakanj Municipality (February 2019)

Figure 46: Bileća Lake after water withdrawal due to drought (October 2017)

Climate Risk Index (CRI) data for Bosnia and Herzegovina are taken from the Global Climate Risk Index report (Table 16 and Table 17). CRI analyses the effects of losses cause by weather conditions (storms, floods, heat waves, etc.). The CRI was derived from the average ranking of the country in all four, below mentioned categories of indicators, according to the following weighting: Fatalities, 1/6; Fatalities per 100.000 inhabitants, 1/3; absolute losses in PPP[79], 1/6; losses per unit GDP, 1/3.

In terms of future climate change, the Climate Risk Index can serve as an indicator of existing vulnerabilities that may increase further.

Table 16: Bosnia and Herzegovina - Climate risk index per years (Climate Risk Index - CRI)[80]

CRI rank	Year	CRI score	Fatalities		Fatalities per 100.000 inhabitants		Losses in million US$ (PPP)		Losses per unit GDP in %	
			Total	Rank	Total	Rank	Total	Rank	Total	Rank
132	2013	108.17	0	56	0.000	106	0.02	143	0.000	119
3[81]	**2014**	**11.50**	**26**	**39**	**0.672**	**10**	**3.584.776**	**8**	**9.3617**	**11**
56	2015	58.17	1	102	0.03	90	308.306	39	0.7565	14
120	2016	109.50	0	99	0.000	99	0.000	120	0.0000	120
58	2017	61.00	0	108	0.000	108	772.36	28	1.723	7

[78] Bosnia and Herzegovina authorities, European Union, United Nations and the World Bank (2014): Bosnia and Herzegovina Floods 2014: Recovery Needs Assessment

[79] Purchasing power parity (PPP) is a way of measuring economic variables in different countries so that irrelevant exchange rate variations do not distort comparisons

[80] Germanwatch publications, 2015, 2016, 2017, 2018, 2019

[81] Rank 3 means that BiH is in third place in 2014 in terms of total losses and damages. The countries most affected in 2014 were Serbia, Afghanistan and BiH. CRI Rank for Croatia for 2014 is 25.

Table 17: Bosnia and Herzegovina - Climate risk index per periods (Climate Risk Index - CRI)[82]

CRI rank	Year	CRI score	Fatalities		Fatalities per 100.000 inhabitants		Losses in million US$ (PPP)		Losses per unit GDP in %	
			Avg.	Rang	Avg.	Rang	Avg.	Rang	Avg.	Rang
89	1994-2013	94.67	1.00	131	0.026	150	185.06	63	0.605	37
68	1995-2014	72.17	2.30	125	0.0599	119	383.100	38	1.292	16
70	1996-2015	72.50	2.35	127	0.06	119	397.971	40	1.3076	15
69	1997-2016	72.00	2.35	127	0.061	118	392.935	41	1.2383	14
67	1998-2017	72.00	2.35	127	0.063	117	428.442	41	1.291	15

(Avg. = average value for a 20-year period. For example, 20 people died in BiH from extreme weather events in the period 1994-2013. Therefore, the average death toll was 1.00)

3.3.2.2 Vulnerability analysis

Chapters 3.2.3 and **Error! Reference source not found.** analyse the change in mean annual and mean seasonal a ccumulated precipitation in the territory of Bosnia and Herzegovina in relation to the reference period 1986-2005, for the scenario RCP8.5 and for the three future time horizons, 2016-2035, 2046 -2065 and 2081-2100. Precipitation change for the last analysed period 2081-2100 is negative, and in the case of the RCP8.5 scenario it is less than -10% in some parts of the country. The season with the largest precipitation loss is JJA, which is especially pronounced for the RCP8.5 scenario for which, during the last period, the possible precipitation reduction is less than -30% in the south of the country. This deficit of summer precipitation is obviously the main contribution to the negative change in total precipitation on an annual basis.

These changes will have a strong impact on water resources, in terms of use, conservation of water resources and water protection. The impacts on the hydrological regime/hydrological extremes, on the water supply and flood protection are analysed below, also providing a review of the impacts on the coastal areas in Bosnia and Herzegovina.

Hydrological extremes

Changes can be expected in terms of time of occurrence, frequency and intensity of extreme events - floods and droughts. The largest increase in air temperature is predicted in the growing period (June, July and August), and a slightly milder increase during March, April and May, which will result in increased evapotranspiration and more pronounced extreme minimums of water levels in water courses. This will result in a general reduction in the availability of water resources in the growing period, when the needs are greatest, in terms of water quantity and quality, because in low-water periods the potential danger of water quality degradation increases. A significant increase in air temperature during the winter season (December, January and February) will result in a decrease in snowfall, i.e. a decrease in flow in most water courses in the spring months. On the other hand, the expected more frequent precipitation of higher intensity will cause greater runoff, often accompanied by floods.

In the analyses of river flows in Bosnia and Herzegovina at the level of mean values, no significant changes in water quantities[83] can be observed, however, the frequent occurrence of extreme values and an increase in the difference between the minimum and maximum values in the analysed series is evident. This is especially

[82] Germanwatch publications, 2015, 2016, 2017, 2018, 2019

[83] This should be taken with some reservations, given the availability of data. For the Sava River Basin, although the length of the post-war series is increasing (as of 2018, the length of the series is 18 years), these are series that are rather short for trend analysis. For the Adriatic Sea basin, the situation is worse for assessment, as there is not a single batch suitable for analysis. The results of analyses from neighbouring country Serbia are interesting. The observed long-term trend for the Danube and Sava rivers in Serbia is negative, amounting to about 1% per decade. (Source: Second Communication of the Republic of Serbia under the UN Framework Convention on Climate Change, 2015)

unfavourable given that the runoff regimes of even larger rivers in Bosnia and Herzegovina are of a torrential nature, with a very fast concentration of flows.

With the increase of time inequality, the problems related to the pronounced spatial inequality are exacerbated - the parts with the greatest need for water are the poorest, i.e. the valleys where the population is the largest and where the land potentials for intensive agriculture are the largest, with the necessary irrigation[84].

Impact on water supply

Due to the uneven flow, with increasingly longer low-water periods, increasing problems can be expected at numerous water supply sources, both in terms of water quantity and quality. Periods of reductions in water supply systems have become common in low-water periods throughout Bosnia and Herzegovina, whereby, with a decrease in the yield of the spring, physical water losses in the systems are much more responsible thereof.[85]

In the runoff cycle, groundwater represents a very important phase because they are almost always of better quality than the waters of surface water courses that feed them, thanks to the filtration characteristics of the environments through which they move. When choosing a source for drinking water supply, preference is given to the highest quality water, which is, as a rule, groundwater. In Bosnia and Herzegovina, groundwater is predominantly used for water supply, through abstraction directly from the underground or in places where groundwater comes to the surface, i.e. from springs/water sources. Thus, in 2017, abstraction from underground with abstraction at springs together amounted to 83.4% of the total abstraction for the needs of water supply in Bosnia and Herzegovina (Figure 47).

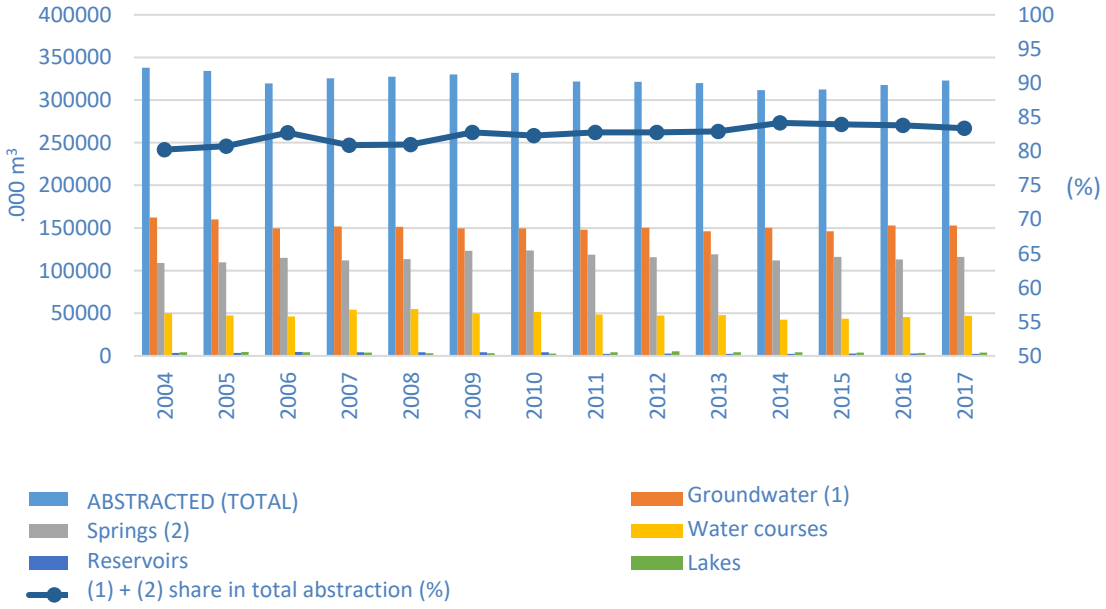


Figure 47: Representation of groundwater and springs in total quantity of water abstracted for public water supply systems in Bosnia and Herzegovina
/Source: Agency for Statistics of Bosnia and Herzegovina/

[84] About 40% of the population lives in the Bosna River basin, while about 14% of the total available flow in BiH comes from the Bosna River basin.

[85] It is estimated that about 3/4 of the water supply system can supply the settlements for about 22 hours a day. This reliability of about 90% is not satisfactory reliability of water supply because modern systems require a reliability of over 98% - Water Management Strategy of the Republika Srpska 2015-2024

In the Federation of Bosnia and Herzegovina, in the total amount of water abstracted for water supply, groundwater has a share of 85%. Groundwater from fissure-karst environments, which are particularly vulnerable to pollution input, accounts for 52%. Systematic monitoring of groundwater quality has only recently begun, and conclusions on the quality of this water resource can be drawn on the basis of data of quality of water abstracted for the needs of public water supply, which show that the quality of groundwater resources is still good, mostly[86]. The ratio of abstracted waters for water supply in the Republika Srpska is such that 31% of the total abstracted amount of water is provided by water intake at springs, 46% by water intake through wells, and 23% by water intake from rivers, lakes and reservoirs[87]. The quality of springs in the river alluvium is endangered in low-water periods, and in some cases in the case of floods (the case of Doboj).

Water supply in rural areas is very vulnerable to climate change due to the increased risk of water quality and quantity disruption during prolonged dry periods. Worsening of the problems in the water supply of the water industry in Bosnia and Herzegovina in the future can be expected in terms of reducing the amount of available water, which will depend on the growth of water consumption and industrial production.

Average water losses in water supply systems in the Republika Srpska are about 48%[88]. According to the data for the Sava River Basin in the Federation of Bosnia and Herzegovina, the losses amount to an average of 57% of the total abstracted quantities, while in some water courses in the Federation of Bosnia and Herzegovina the losses amount to up to 80% of the total abstracted water[89]. Water losses have a trend of slight growth (Figure 48).

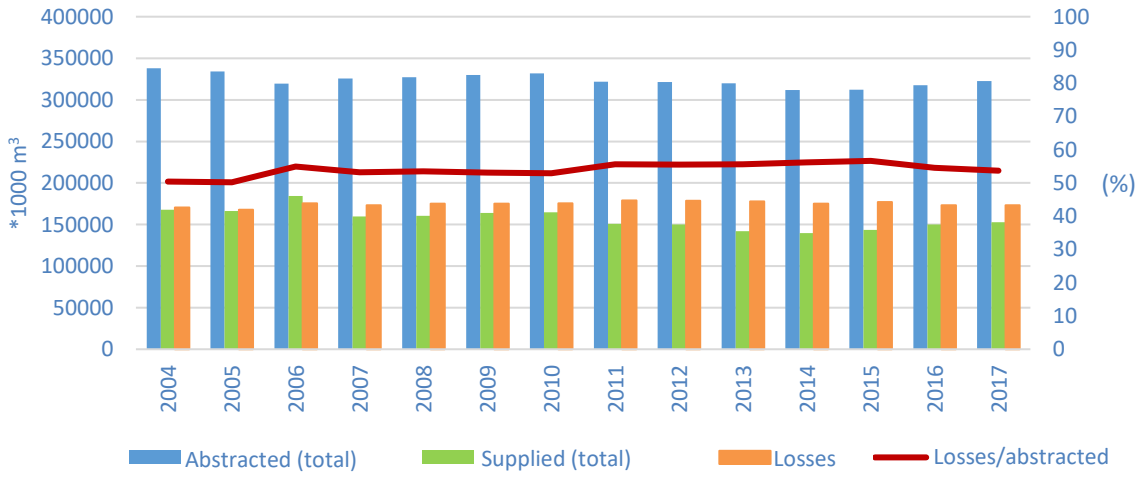


Figure 48: Total abstracted quantities of water for public water supply systems in Bosnia and Herzegovina, total supplied quantities and losses of water, and the ratio of losses and abstracted waters expressed as a percentage, for the period 2004-2017

/Source: Agency for Statistics of Bosnia and Herzegovina /

Based on the data presented above on water losses in water supply systems in the Federation of Bosnia and Herzegovina and the Republika Srpska, it is evident that the growing demand for water in the future is in conflict with the reduction of available water under the influence of climate change. Providing additional water by expanding the capacity of existing water sources or creating new ones does not make a long-term sustainable solution to the water supply problem. At the same time, the current state of water supply is characterised by

[86] Water Management Strategy of the Federation of BiH 2010-2022

[87] Strategy of Integrated Water Management in the Republika Srpska 2015-2024

[88] Strategy of Integrated Water Management in the Republika Srpska 2015-2024

[89] Water Management Strategy of the Federation of BiH 2010-2022

inefficiency in terms of large losses in the systems, non-economic prices of water and poor organisation of public companies in charge of water supply.

In climate change projections, even greater demand for groundwater abstraction can be expected. Namely, the increase in global temperature affects the hydrological cycle, which leads to: changes in total precipitation, increase in the intensity and frequency of extreme events; reduced snow cover; sea level rise; changes in soil moisture and regime of runoff / discharge and recharge /, and renewal of groundwater resources. Increased evaporation and the risk of floods and droughts negatively affect the security of water supply. Due to these pressures, as well as population growth and/or concentration, the demand for larger amounts of groundwater is likely to increase in Bosnia and Herzegovina as well.

Flood protection

After the 2010 and 2014 floods, it is clear that Bosnia and Herzegovina is in a region that is particularly vulnerable to the effects of climate change: floods that were previously very rare have now become more frequent and devastating.

In areas where the primary function of the construction of protection facilities was the protection of agricultural land, the most commonly used solution was the construction of embankments, and often as part of the solution to the problem of water protection, hinterland waters evacuation facilities were built. Polders/cassettes with independent flood protection systems have been formed in the mentioned flood protection facilities. The total length of the embankment in Bosnia and Herzegovina in the Sava River Basin is approximately 203 km[90], of which along the Sava riverbed in Bosnia and Herzegovina (as well as in the border states) in the total length of 175 km (in Bosnia and Herzegovina). This amounts to about 50.7% of its total length in Bosnia and Herzegovina because this area is the most fertile agricultural land.[91] In addition to the areas along the Sava River, embankments in Bosnia and Herzegovina partially protect areas along rivers in the Neretva River Basin, while on the tributaries of the Sava River protection systems are incomplete or non-existent, with the exception of urban units. On sections of water courses where these facilities are designed to protect urbanised, built-up areas, solutions are usually designed so that increasing the depth of existing riverbeds and lining the banks increased flow capacity and thus prevent water spills, while occupying the smallest possible (urban) areas.

After the 2014 floods, on the Sava defensive embankments in Bosnia and Herzegovina, reconstruction was performed and additional elevation built on sections that did not meet the criteria of additional elevation for large waters for protection against waters with the occurrence of 1/100 years (hundred-year event). It is very important that the reconstruction is done in Croatia as well, where with the completion of the works that are currently in progress (February 2019), 70 percent of the Sava embankments, of 170 kilometres, will be renovated.

It is considered that the reconstruction and construction of an additional elevation of 1.20 m above the hundred-year events provides protection from large waters of the Sava River with the occurrence of 1/1000 years (thousand-year event). However, the actual level of protection is unknown, due to the scope and quality of the data used for the calculations for sizing purposes. With the frequent occurrence of extreme flow values, the distribution of the probability of occurrence changes, in such a way that even greater additional elevation is required for protection against large waters of a certain rank of occurrence.

Due to the growing population, larger and more expensive facilities that are protected, vulnerability is growing, so flood protection can no longer be done successfully only by passive measures (which include the construction

[90] Water Management Plan for the Sava River Basin in the Federation of BiH 2016-2021

[91] Sava River Basin Management Plan, Republika Srpska, 2015

of embankments). Experience has shown that existing passive protection measures increase the risk downstream, indicating the need to focus on active measures, with the provision of areas for reservoirs or retentions. As part of the activities on the implementation of the EU Directive on flood risk assessment and management, several important documents have been prepared or are being prepared in Bosnia and Herzegovina, which are the basis for assessing actual or potential damage and drafting Flood risk management plans: Preliminary risk assessments have been made, Flood Hazard and Risk Maps have been prepared, according to the adopted unique methodology for Bosnia and Herzegovina, as a basis for the development of flood risk management plans. Several projects are being implemented to establish a system for hydrological flood forecasting and early warning in the Sava River Basin.

The appearance of more intense precipitation exacerbates the problems of floods in cities. The causes of frequent floods in larger and smaller cities in Bosnia and Herzegovina are mainly related to non-maintenance, and even to insufficient drainage capacity, when the sewerage system cannot receive a large amount of water in a short time (example: Banja Luka on 29 August 2000, within half an hour 102 l/m^2 of rain fell[92]). Infrastructure roads are the first to be affected. However, due to the constant increase in the value of urban infrastructure and property of citizens, the damage is growing, i.e. vulnerability is growing along with the growth of population in cities and river valleys, so the need for their protection in the future is growing.

Deforestation, land conversion without hydro-technical and other arrangement of potential gullies, result in increased occurrence of torrents, which cause great damage in a very short time, often in urban areas and on roads.

Impact on coastal areas

The coastal areas of Bosnia and Herzegovina are exposed to additional impacts of climate change through sea level change/rise and salinisation (Figure 49 and Figure 50).

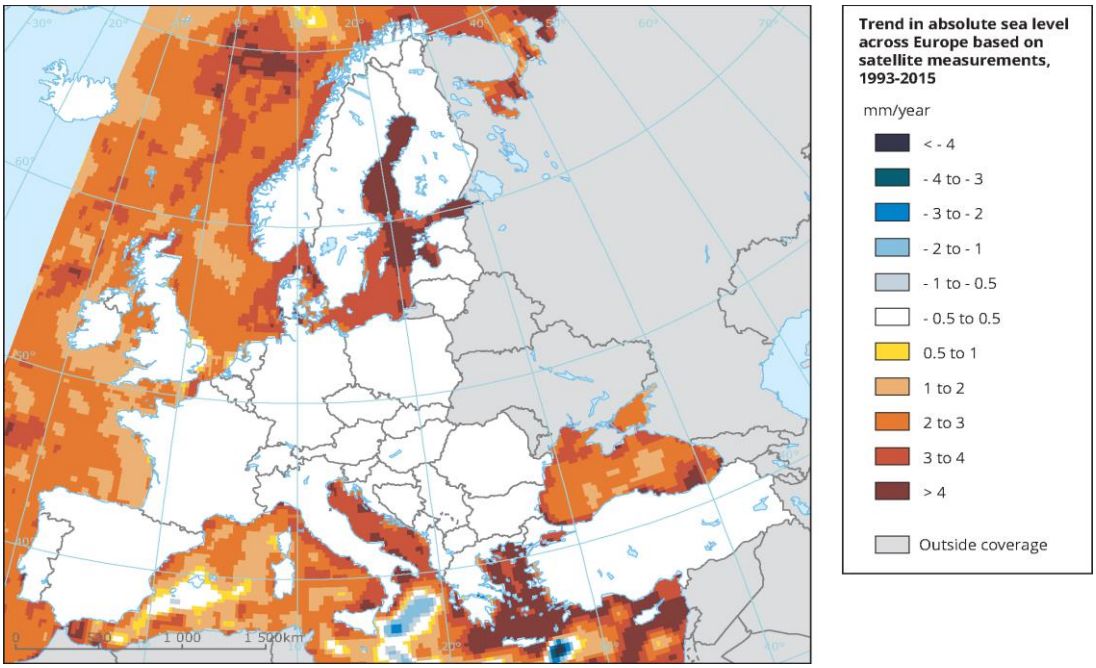


Figure 49: The trend of sea level change in Europe, based on satellite measurements, 1993-2015
/Source: European Environment Agency, *2017*/

[92] Republika Srpska - Assessment of vulnerability to natural disasters and other accidents, 2013

Figure 50 shows the projected relative changes in mean sea level in the period 2081-2100 in relation to the period 1986-2005. Taking into account a certain linear trend of sea level increase during the 21st century, by 2040 the global mean annual sea levels of the Adriatic Sea could increase by about 20 cm (minimum), and by 2070 by about 30 cm (minimum).

In critical dry periods, which are becoming more pronounced due to climate change, salt water penetrates into groundwater. Soil salinisation reduces arable agricultural land in the Neretva River valley intended for intensive planting of vegetable crops.

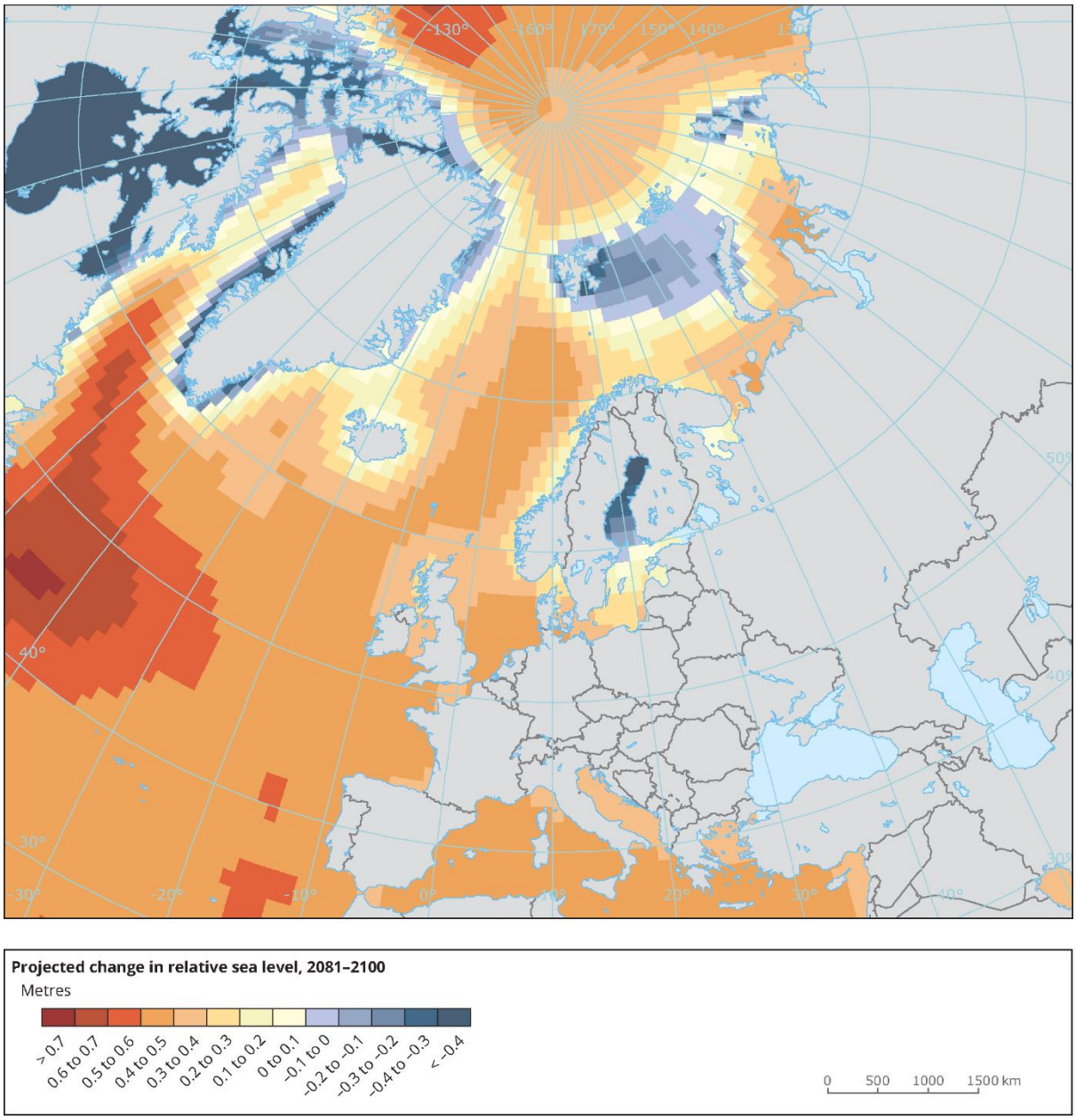


Figure 50: Projected relative shift of sea levels during the period 2081-2100 in relation to the period 1986-2005
/Source: European Environment Agency, *2017*/

3.3.2.3 Adaptation opportunities

Institutional and organisational measures

These measures improve preparedness of the society to reduce disaster risks and impacts by developing prevention and preparedness, through the provision of climate-related information, the establishment of meteorological and hydrological forecasting systems, awareness raising and the establishment of mechanisms for efficient societal responses to extreme events. These measures generally affect participants, including strengthening the administrative and technical capacity of relevant public institutions. They also include the preparation of study and technical bases and the development of legal regulations that, on the one hand, are in line with the real needs of adaptation to climate change, and on the other hand respond to the requirements of Bosnia and Herzegovina in the process of accession to the European Union.

Structural measures

In the long run, structural measures are of great importance for water resources. The use of multi-purpose infrastructure could reduce the risk of adverse effects of climate change in the future.

Having in mind the spatial and temporal unevenness of available waters in Bosnia and Herzegovina, it is necessary to provide basic information on water reservoirs. Their role in the transformation of the available hydrological regime into the desired one is irreplaceable, with a tendency of increasing importance in the circumstances of adaptation to climate change.

The total volume of constructed water reservoirs in Bosnia and Herzegovina is 3,851.40 x 10 m^3. Most of the reservoirs were built in Herzegovina, with about 90% of the total accumulation volume. As the extremely low level of levelling of the water regime (9%) has been implemented in Bosnia and Herzegovina, the need to build a larger number of reservoirs was noticed long ago. In Bosnia and Herzegovina, it would be possible to reach a total volume of about 10000 x 10^6 m^3 of accumulation space. In the more immediate future, it would be necessary to build about 2000 x 10^6 m^3 of accumulation space, especially on water courses in the Sava River Basin. This would reach the level of total construction of about 5800 x 10^6 m^3 of accumulation space, or a ratio of about 14.4% of the volume of the average annual flow.[93] However, it should be noted here that there is great resistance from local communities to build both small and large hydropower plants, so their implementation is questionable.

3.3.3 Forest ecosystems

3.3.3.1 Climate change impact on forest ecosystems

In Bosnia and Herzegovina, there is very little research and specific data on the impact of climate change on forest ecosystems in terms of their vulnerability, variability, adaptation and possible scenarios. Therefore, this section presents the assessment as a result of international results, experiences and specific characteristics of domestic forest ecosystems.

Analysing the situation of forests and forest land with the expected climate change, and the results of research so far, the following changes are expected in forest ecosystems in Bosnia and Herzegovina:

[93]Source: SIZ Vodoprivreda Bosne i Hercegovine: Basic characteristics of water management of Bosnia and Herzegovina, Sarajevo, February 1981

- Shifting the boundaries of certain types of forests in relation to latitude and altitude, or withdrawal of certain communities under pressure from others;
- Changes in the areas of certain species (ecotypes) of flora and fauna (e.g. European silver fir as an economically important species);
- Extinction of certain species (e.g. Pančić spruce as a protected and rare species);
- Changes in the qualitative and quantitative composition of biocenoses;
- Habitat fragmentation;
- Changes in the functioning of ecosystems;
- Soil erosion as a result of a lower degree of "cover" or fire;
- Decreased productivity of some forest ecosystems (e.g. oak forests);
- Reduction of biodiversity – of ecosystem and species and the genetic one (taking into account the key messages of the European Environment Agency report);
- Migration of harmful insects and pathogens, including invasive species;
- Shifting the phenological phases of forest tree species (earlier leafing and flowering, longer growing season);
- Damage to forest ecosystems as a result of the frequency of extreme weather events (e.g. windfalls, icebreaks, floods);
- Reduced value of generally useful forest functions (due to negative impacts such as fires, windfalls, icebreaks, floods);
- Poorer quality of wood raw materials, which is an indirect impact on the economy of Bosnia and Herzegovina;
- Risk of forest ecosystem transformation that would result in large-scale drying of trees;
- Difficult execution of works (measures of cultivation, protection and use) due to frequent extreme disasters (high temperatures, insect infestations, floods, landslides ...);
- Increased frequency and intensity of forest fires.

3.3.3.2 Vulnerability analysis

According to the most extreme scenario (RCP8.5), the average temperature in Bosnia and Herzegovina by 2035 will be higher by +0.5 to + 1.5^{0}C. For the period 2046-2065, changes range from 1.5 to 3^{0}C while for the period 2081-2100, the temperature rise ranges from 2.5 to 5^{0}C. Temperatures projected in this way (from +5 to -20% of precipitation) indicate that drastic changes in forest ecosystems would occur. Generally speaking, the projected scenario would have unforeseeable consequences for forest ecosystems in Bosnia and Herzegovina. According to the available models, by increasing the mean annual temperatures, fundamental changes in forestry, as well as in general land use and management, can be expected and required. This carries with it the burden of socio-economic and environmental consequences.

The predicted climate changes will not have the same impact on all forest ecosystems in Bosnia and Herzegovina (some are at higher altitudes, deeper pedological profile, with more species and single individuals, some are less sensitive, i.e. formed by more tolerant species…), which means that the reaction of each community should be analysed separately. This claim is supported by the fact that the survival of forest communities is related not only (or exclusively) to the mean annual temperature in the area inhabited by a given community, which means that an increase in mean annual temperature will not be the only factor influencing change. A special impact that can occur as a result of climate change is "multiple stress", which at the same time causes changes in soil moisture, changes in average and extreme temperatures, as well as changes in the amount and distribution of precipitation (snow-rain, drought-flood) and in that regard also the number of pests and pathogens. All together it contributes to the high mortality rate of trees.

Species that are at the centre of their natural distribution will be more tolerant of climate change, while those near the edges (marginal populations) will be very vulnerable. Also, species with a small range and "barriers" in migratory flows are more endangered. In this scenario, the dominance of thermophilic sessile oak forests with hornbeam, downy oak and holm oak can be expected. Some endemic species currently found in forest ecosystems are also expected to disappear.

At present, it is not possible to accurately predict the success of adaptation to life in new habitats caused by climate change. Significant changes are expected in the species that inhabit the mountainous areas of Bosnia and Herzegovina, especially the migration of some woody species in the direction of the Dinarides to the northwest, with possible local depletion of flora. A reduction in the number of herbaceous species in the narrow ecological niche of the highest mountain areas can be expected, which will not be able to adapt their range quickly enough. Therefore, in the territory of Bosnia and Herzegovina, it is not possible to determine exactly which change is more probable in terms of: yield, mortality, changes in stocks or prospects for economically important species. In the canyon parts of relict-refugial landscapes, shallow soils are usually formed, subject to erosion by wind and water. By drying trees in canyons, soils can be exposed to even greater erosion, which would lead to stronger temperature extremes of the substrate. This can cause even greater drying of trees, i.e. prevent the recovery of refugial forest communities.

The response of individual species to climate change depends on their adaptive capacity. The biggest threat will be to fir forests that are predisposed to be severely affected by climate change. These forests occupy a very narrow ecological niche due to their growth in mixed stands with beech. Beech forests have the potential to displace fir in stands due to changes in humidity and temperature. Species with narrow niches are likely to face decline or loss and may, in the case of Bosnia and Herzegovina, begin to move to the edges of their habitats, indicating a shift in vegetation due to climate change, making other species more dominant (this may again reduce the economic value of these forests).

Taking into account the latest world research, the results of the impact of climate change and possible scenarios, surely the dynamics of growth and production of wood mass in the forests of Bosnia and Herzegovina in the coming period will fall and that it will be among the first and most disturbed parameters. In some parts of Bosnia and Herzegovina, an increased risk of forest fires caused by rising temperatures and changes in precipitation is expected, which calls for an expansion of fire protection capacity. All these aspects (weather, pests, pathogens, fires) can, over a long period of time, lead to reduced productivity and poorer forest health in Bosnia and Herzegovina. Only in rare cases can climate change have some positive effects on forests and forestry: the productivity of certain species can increase in areas with sufficient precipitation (spruce forest belt), which would result in faster growth rates and migrations of more productive species to these habitats.

In short, due to the multiple stresses to which forest habitats and trees are exposed, climate change is likely to affect some more sensitive ecosystems. The ecological and economic importance of forests in Bosnia and Herzegovina means that these impacts could cause serious consequences for the entire country. Approaches to climate change adaptation will require better information in the forest management process, in order to provide support in adaptation processes.

3.3.3.3 Adaptation opportunities

Table 18 sums up and provides an overview of the numerous opportunities of adapting forest ecosystems to climate change with almost all possible measures proposed by a group of authors in the USA (Swanston et al., 2016).

Table 18: Possible adaptation strategies (according to Swanston et al., 2016)

Strategy 1: Sustain fundamental ecological functions. 1.1. Reduce impacts to soils and nutrient cycling. 1.2. Maintain or restore hydrology. 1.3. Maintain or restore riparian areas. 1.4. Reduce competition for moisture, nutrients, and light. 1.5. Restore or maintain fire in fire-adapted ecosystems. **Strategy 2: Reduce the impact of biological stressors.** 2.1. Maintain or improve the ability of forests to resist pests and pathogens. 2.2. Prevent the introduction and establishment of invasive plant species and remove existing invasive species. 2.3. Manage herbivory to promote regeneration of desired species. **Strategy 3: Reduce the risk and long-term impacts of severe disturbances.** 3.1. Alter forest structure or composition to reduce risk or severity of wildfire. 3.2. Establish fuelbreaks to slow the spread of catastrophic fire. 3.3. Alter forest structure to reduce severity or extent of wind and ice damage. 3.4. Promptly revegetate sites after disturbance. **Strategy 4: Maintain or create refugia.** 4.1. Prioritize and maintain unique sites. 4.2. Prioritize and maintain sensitive or at-risk species or communities. 4.3. Establish artificial reserves for at-risk and displaced species. **Strategy 5: Maintain and enhance species and structural diversity.** 5.1. Promote diverse age classes. 5.2. Maintain and restore diversity of native species. 5.3. Retain biological legacies. 5.4. Establish reserves to maintain ecosystem diversity.	**Strategy 6: Increase ecosystem redundancy across the landscape.** 6.1. Manage habitats over a range of sites and conditions. 6.2. Expand the boundaries of reserves to increase diversity. **Strategy 7: Promote landscape connectivity.** 7.1. Reduce landscape fragmentation. 7.2. Maintain and create habitat corridors through reforestation or restoration. **Strategy 8: Maintain and enhance genetic diversity.** 8.1. Use seeds, germplasm, and other genetic material from across a greater geographic range. 8.2. Favor existing genotypes that are better adapted to future conditions. **Strategy 9: Facilitate community adjustments through species transitions.** 9.1. Favor or restore native species that are expected to be adapted to future conditions. 9.2. Establish or encourage new mixes of native species. 9.3. Guide changes in species composition at early stages of stand development. 9.4. Protect future-adapted seedlings and saplings. 9.5. Disfavor species that are distinctly maladapted. 9.6. Manage for species and genotypes with wide moisture and temperature tolerances. 9.7. Introduce species that are expected to be adapted to future conditions. 9.8. Move at-risk species to locations that are expected to provide habitat. **Strategy 10: Realign ecosystems after disturbance.** 10.1. Promptly revegetate sites after disturbance. 10.2. Allow for areas of natural regeneration to test for future-adapted species. 10.3. Realign significantly disrupted ecosystems to meet expected future conditions.

3.3.4 Biodiversity and sensitive ecosystems

3.3.4.1 Climate change impact on biodiversity

Bosnia and Herzegovina has a particularly rich biodiversity, with a high level of biotope diversity and a large number of endemic plant species (it is estimated that a total of 5,000 species of vascular plants exist in Bosnia and Herzegovina and 30% of the total endemic flora in the Balkans). The Biodiversity Strategy defines those areas in Bosnia and Herzegovina that are most sensitive to climate change: high mountain systems (above 1,600 m); mountain ecosystems (900–1,600 m); sub-Mediterranean ecosystems (300–800 m); highlands (600–900 m), ecosystems of the Peripannonian area (200–600 m) and Pannonian ecosystems (up to 200 m). Available data suggest that climate change may threaten all three macro-regions in Bosnia and Herzegovina (Pannonian, mountainous and Mediterranean). The Dinarides, one of the Balkans' richest areas of endemic species, will be particularly vulnerable to climate change. This mountain range is an area of special biological and geomorphological significance.

3.3.4.2 Vulnerability analysis

Anthropogenic pressures on habitats, the spread of invasive species, the use and management of natural resources, unbalanced practices in agriculture and forestry, and the consumption of natural resources together with climate change are the strongest and key pressures on ecosystems.[94] Climate change has a significant impact on ecosystems and biodiversity, and thus on their capacity to provide environmental services. According to the RCP8.5 scenario, a temperature increase in the range of +1.6 to +2°C is predicted for the first period of 30 years, while for the last period of 30 years this increase would be from +5.4 to +5.6°C.

Ecosystems are able to cope to some extent with emerging changes. However, climate change is taking place much faster than in the past, which calls into question the ability of ecosystems to adapt. Often, migrations of the species are much slower in relation to climate change, which is, among other things, a consequence of the increase in the magnitude and scope of other anthropogenic pressures. The combination of these pressures results in declining biodiversity especially in highland areas. According to this scenario, climate change will continue to be a key driver of change in ecosystems. It is estimated that about 14% of habitats and 13% of species of importance to Europe are already exposed to pressure due to climate change (EEA, 2016).

Species that have lived at high latitudes or higher altitudes will be replaced by species whose range shifts from the south or from lower altitudes, which may lead to the extinction of certain species, especially those associated with high mountains, such as species from habitat types: *4070 - Bushes with Pinus mugo and Rhododendron hirsutum, 95A0 - High oro-Mediterranean pine forests, 6150 - Siliceous alpine and boreal grasslands, and 8210 - Calcareous rocky slopes with chasmophytic vegetation. Vegetation models predict further shifts in ecosystems to higher altitudes, meaning that the upper limit of forest ecosystems will shift to the detriment of subalpine grassland communities. Increasing the concentration of CO_2 in the atmosphere will allow more efficient use of water by plants because they will be able to absorb the same amount of CO_2 with less opening of the stoma. In this way, plant species will be able to grow in areas that were once too arid for them.

Climate change is leading to an increase in extreme events such as forest fires. Hot and dry summers and strong winds increase the risk of fires that can spread quickly and cover large areas. Five fire zones have been identified in Bosnia and Herzegovina: Low Herzegovina, High Herzegovina, Centre, West and North.

3.3.4.3 Adaptation opportunities

Climate change will have a number of negative consequences for ecosystems and their services which represent a significant economic resource. The extent and economic value of these damages is much more difficult to define compared to conventional goods. Climate change can be seen as economic impacts that need to be adapted, which includes a wide range of measures and actions aimed at managing, restoring and conserving biodiversity and ecosystem services that provide diverse benefits to human society and represent significant natural capital. All these activities should be based on an ecosystem approach that is key to conserving biodiversity as a whole.

The key functions of the ecosystem are ensured through the continuous circulation of matter that takes place through a one-way flow of energy. Therefore, in the context of climate change, the conservation of ecosystems is very important for the conservation of carbon stocks, the regulation of water flow and storage, the improvement of the degree of conservation of biological diversity, and the provision of health and recreational benefits.

[94] Walter V. Reid and et al. (2005): Millennium Ecosystem Assessment

Conservation of significant amounts of carbon - sequestration potential can be achieved through protection and conservation of peatlands, ponds and wetlands that include specific habitat types such as Turloughs (habitat type *3180), Active raised bogs (habitat type *7110), and Degraded raised bogs still capable of natural regeneration (habitat type 7120), and alkaline fens (habitat type 7230). The Ministry of Environment and Tourism of the Federation of Bosnia and Herzegovina, as well as the institutions for the management of protected areas, are responsible for this measure.

Migrations of species that respond to climate change are often further complicated by anthropogenic pressures that manifest primarily through habitat fragmentation or destruction. In practice, this means interrupting the corridor of unhindered movement of animal species due to the construction of roads, the expansion of urban areas and agricultural land. Therefore, it is necessary to develop an ecological network by connecting protected areas and the network of Natura 2000 sites in order to minimise habitat fragmentation as much as possible. Spatial plans of the entities of the Federation of Bosnia and Herzegovina and of the Republika Srpska identify protected natural areas. In these development planning documents, special emphasis is put on protected natural areas which have formal protection determined by special regulations and established on the basis of categorisation according to the principles of the International Union for Conservation of Nature. In addition, areas for the protection of natural heritage have been defined, consisting of natural landscapes and values of special scientific, educational, cultural, ambient, recreational and other social significance.

3.3.5 Tourism

3.3.5.1 Climate change impact on tourism

For a large number of tourists, climate is one of the crucial elements when choosing a destination, which indicates a direct link between climate change and the sustainability of the tourism industry. In recent years, the connection between tourism and climate change has become an increasingly hot topic of scientific research (Agnew, Viner, 2001; Scott et al., 2004; Berrittella et al., 2006; Amelung et al., 2007), while in the domestic scientific literature there are only a few papers on the impact of climate change on tourism development.

Most studies point to serious consequences for the winter tourism sector in the event of more intense climate change. Some tourist centres will be able to survive with certain adaptation measures, while others will feel the serious consequences of moving the snow line. Urban tourism (e.g. Sarajevo and Mostar) will feel certain negative consequences of climate change, especially during the summer season, caused by rising summer temperatures and reduced precipitation. Lower water levels of rivers will reduce the abundance of springs but also tourist activities on the water.

Kruse et al. (2015) summarise the effects of climate change, and take changes in the amount and height of snow cover as one of the main factors for the economic sustainability of winter tourism. A rise in temperature of 1°C will also cause the snow line to shift by 150 meters, which means that more than 10% of alpine ski resorts will no longer be "reliable" ski destinations. If the temperature increases by 2°C, the share of "unreliable" centres will increase to about 33%. In the case of this climate scenario, the snow line in the Central Alps would increase by 300m i.e., if the temperature rose by 2ºC only ski resorts with a minimum altitude of 1500m would be commercially viable.

In Bosnia and Herzegovina, climate change has a particularly negative impact on winter ski tourism, which traditionally develops in the area of the Olympic mountains Bjelašnica and Jahorina, as well as Vlašić, Kupres, Ravna planina and many other smaller ski centres. Increasing the mean daily and annual air temperatures, reducing the amount of snowfall, and the height and duration of the snow cover, already has a negative impact on the business of winter tourist centres in Bosnia and Herzegovina.

Tourist offer of mountain tourist centres of Bosnia and Herzegovina is almost entirely oriented to the winter tourist season which is unsustainable, taking into account the negative climate change. While winter mountain tourism is very sensitive to climate change, warmer and drier summers can increase the attractiveness of mountains as summer tourist destinations, which is a chance for mountain tourism in Bosnia and Herzegovina.

The winter mountain centres of Bjelašnica with Igman and Jahorina with Trebević were the main Olympic arenas during the Winter Olympic Games in 1984, while Vlašić had the status of a reserve centre. Researchers from the University of Waterloo analysed in their study the impact of climate change on the possibility of holding the Winter Olympics in the future. A team of researchers from Canada, Austria and China pointed to the fact that if global GHG emissions do not decrease significantly, only 8 of the 21 host cities so far would have favourable climatic characteristics to be hosts again in this century. In the next few decades, 13 of the 21 cities will be able to host the Olympic Games, which no longer include centres such as Chamonix, Grenoble, Sochi, etc. Sarajevo is also in the risk group for the period until 2050.

In addition to the unforeseeable consequences for the natural environment, climate change significantly affects financial flows, so the world's monetary institutions are investing less and less in winter tourist centres located below 1,200 meters above sea level.

Researchers (Köning, Abegg, 1997; Elsasser, Bürki, 2002) define “reliable” winter tourist centres as those that can provide a continuous 100-day ski season, with at least 30 cm of snow on the slopes, in 7 out of 10 seasons. In the late 1990s, the above criteria were met in the Alps with natural snow in areas above 1200 meters above sea level. This limit is expected to climb to a minimum altitude of 1500 meters with a temperature increase of 2°C. In Europe, mountain centres at altitudes higher than 1300 meters, usually meet this criterion with some regional variations. Witmer (1986) was the first to propose this so-called "100-day rule", according to which the operation of a winter mountain ski centre requires a snow cover sufficient for skiing (i.e. 30 cm) for at least 100 days per season (from 1 December to 1 April).

As already mentioned in the example of Alpine tourist centres, climate change that causes a lack of snow and shortening of the winter tourist season is trying to compensate by creating new tourist products, investing in the summer tourist offer, and better promotion. High vulnerability in the tourism sector of Bosnia and Herzegovina is a direct consequence of the tourist offer not being suitable to projected climate scenarios. Winter mountain centres in Bosnia and Herzegovina should mostly work on diversifying their offer and developing tourist activities that are not related to traditional ski tourism. Research conducted during the winter season in South Tyrol has shown that skiing is not the main motive for visiting for more than 40% of guests.

Climate change will lead to various implications for tourist destinations, however not all are necessarily negative. Increasing the average annual temperature could create more favourable conditions during spring and summer, and in this way could alleviate the current problem of mountain tourism - dependence on the winter season. Alpine countries have already recognised the importance of expanding the main tourist product, so they are developing an additional offer based on cultural and historical heritage and other products and services. One of the more successful examples are the mountain centres of Arosa and Gstaad, which develop cultural tourism by promoting various events, such as music festivals.

In addition to extending the season, the increase in summer temperatures in cities and lower regions will contribute to the attractiveness of mountain centres, as tourists will seek refreshment at higher altitudes. Mountain destinations will need to improve the offer of selective forms of tourism, develop and promote rural tourism in rural households (e.g. Bjelašnica or Vranica), create a tourist offer based on natural tourist motives, active holidays (mountaineering, hiking, mountain biking, canyoning, paragliding, etc.). The base for these tourist activities already exists but the offer of mountainous areas outside the winter season is not sufficiently

developed. Thus, climate change can (with adaptation measures) also bring positive effects, i.e. the gain made in the summer season can compensate to some extent for the losses in the winter season. Also, high-altitude lakes located in mountainous areas, which are not sufficiently popular with tourists, will have more favourable climatic conditions. These areas are characterised by a wealth of biodiversity and landscape values significant for the development of new tourism products. If adequate tourist facilities are developed, lake tourism could record positive developments.

Climate change can have positive effects on the tourism sector in Bosnia and Herzegovina, taking into account the regional effect. Namely, the increase in temperature in the summer season in the Republic of Croatia may bring new opportunities for the development of tourism in the continental and mountainous area of Bosnia and Herzegovina. Taking into account the fact that the countries of the region, especially Croatia, record a higher growth rate in the number of tourists, the increase in the number of tourists in our country is partly a consequence of the spillover of trends in the region. Bosnia and Herzegovina is often a transit country, especially for tourists on the way to the Adriatic, and climate change in the coastal area (increased temperatures during the summer season and rising sea levels) could contribute to a longer stay of this segment of tourists in our country. Switzerland also took advantage of the regional effects of climate change, developing the summer offer of alpine centres and promoting the winter tourist offer of the centres at higher altitudes.

3.3.5.2 Vulnerability analysis

Scenario RCP8.5 indicates the fact that in the conditions of a warmer climate on the territory of Bosnia and Herzegovina, as a consequence of the constant increase of greenhouse gases, there would be an intensification of extreme precipitation. In the last two decades, many extreme climatic events have been recorded, such as heat and cold waves, droughts, floods and the occurrence of absolute temperature maximum and minimum, which has a negative impact on the development of tourism. The occurrence of extreme precipitation also increases the probability of floods, given the increase in the frequency of intense precipitation.

In the tourism sector, precipitation has a negative impact primarily on outdoor tourist activities, and the ambience in the destination, because nice weather (clear and sunny without precipitation) is one of the main motives for visiting. The analysis of the number of arrivals and overnight stays of tourists in Bosnia and Herzegovina proves that the months with favourable climatic elements have a larger number of tourists. In the summer season, frequent rains affect its success, while on the other hand, snowfall, as already pointed out, is a prerequisite for a successful winter tourist season. In the 2007/2008 season, there was enough snowfall for a successful season, while the 2015/2016 season on Bjelašnica lasted only 69 days, and the 2016/2017 season 102 days. The winter season 2013/2014 on Bjelašnica lasted 96 days, and on Jahorina 66 days. Among the more successful winter seasons on Jahorina was 2014/2015, and on Bjelašnica 2012/2013.

In Bosnia and Herzegovina, no research has been conducted among tourists on optimal holiday temperatures, nor has it been determined to what extent climate change will change the perception of optimal temperature as a factor in choosing a holiday destination. Nevertheless, projections of an increase in mean maximum daily air temperatures in summer and a decrease in the height of the snow cover indicate changes that could negatively affect tourist demand. The tourism sector in Bosnia and Herzegovina will be forced to constantly enrich the tourist offer and create new tourist products, which will have a positive impact on the competitiveness of domestic destinations, both regionally and internationally, and on the structure of guests. Different tourist products and a richer offer will attract new tourists of different profiles. In addition to existing products, Bosnia and Herzegovina will need to develop forms of tourism that do not depend on weather conditions, such as wellness and spa tourism, congress tourism, visits to museums, galleries, etc., which could attract more tourists.

3.3.5.3 Adaptation opportunities

Due to insufficient research in this area, recommendations and adaptation measures in tourism are quite limited. Nevertheless, it is possible to take certain steps in order to overcome climate change in the tourism sector of Bosnia and Herzegovina. Approaches to adaptation should primarily relate to reducing seasonality, i.e. extending the tourist season, and improving tourist infrastructure and capacity. Also, it is necessary to work on the energy efficiency of hotel capacities, which would lead to a reduction of harmful gas emissions.

In order to solve the problem of vulnerability of the tourism sector, it is necessary to invest in scientific research and develop a system of informing all stakeholders in tourism about climate change and its impact. The efforts and cooperation of the Government of the Federation of Bosnia and Herzegovina, the Government of the Republika Srpska and the Government of the Brčko District in formulating strategies and measures to facilitate adaptation to climate change in the tourism sector are of key importance.

In the tourism sector, adaptation measures include two main categories: the first, which aims to address exposure to climate change (e.g. for winter mountain tourism, reducing the number of snow days) and the second, which aims to address economic dependence (e.g. over-dependence on skiing as the main source of income for the winter tourism sector). For the first category of adaptation measures, Abegg et. al. (2007) defined four groups of technological adaptation solutions, which are already used in the Alps: landscaping of trails to reduce the height of snow cover required for skiing, relocation of ski slopes to higher altitudes and their orientation to the north, glacier skiing, and the production of artificial snow, which is currently the most common adaptation measure in Bosnia and Herzegovina. The second category of adaptation measures, which is becoming increasingly important, includes the development of tourism activities that do not depend on weather conditions, promoting the development of year-round tourism, and products adapted to climate change.

3.3.6 Health

3.3.6.1 Climate change impact on health

The effects of climate change on human health are direct and indirect. We classify as direct: high heat and cold, floods and other extreme weather events, and ultraviolet radiation. Indirect effects of climate change are visible through a change in the vector image of infectious diseases, a higher incidence of cardiovascular and respiratory diseases, malnutrition due to loss of arable land, and deterioration of mental health of the affected population.

Climate change indirectly affects water availability, crop yields, food production and quality, higher incidence of disease due to poor water supply and unhealthy food. The impact on food and water, and the diseases associated with them, is reflected not only in a reduction in their availability but also in a reduction in quality and an increase in contamination. Soil pollution during floods, as extreme weather conditions (e.g. faecal spills, industrial waste) is also an indirect effect of climate change on health. Increased UV radiation, as a result of ozone depletion caused by greenhouse gases, affects the frequency of skin cancer (melanoma) and skin damage caused by direct sunlight (burns, dermatitis), and damage to the mucous membranes of the eye and the decline of the immune system.

Of all extreme meteorological events, heat waves are most associated with population disease, and affect vulnerable population groups the most - young children and the elderly, pregnant women, the chronically ill, especially those suffering from cardiovascular and respiratory diseases, and people working outdoors such as construction and agriculture. workers. Heat waves in the last decade have caused increased mortality, especially

among vulnerable population groups.[95] Due to the intense influence of heat waves, heat stroke can occur, as the most serious disorder, as well as sunburn and heat cramps. Heat waves have an extremely detrimental effect on chronic cardiac patients. Myocardial infarction can also occur due to the action of heat waves in people who do not normally have heart problems. In addition, they can be the cause of cerebrovascular accident, epileptic seizures, and dehydration due to increased sweating, or if people do not get enough fluids into the body.

Cardiovascular, cerebrovascular diseases and malignant neoplasms account for almost three quarters of all causes of death in Bosnia and Herzegovina. The leading causes of death are diseases of the circulatory system. The mortality rate from diseases of the circulatory system in the Federation of Bosnia and Herzegovina and in the Republika Srpska in the period from 2013 to 2017, shows a trend of gradual growth which, in addition to the possible effects of climatic factors, is significantly affected by improper eating habits, smoking, physical inactivity, etc.[96] (Figure 51 and Figure 52).

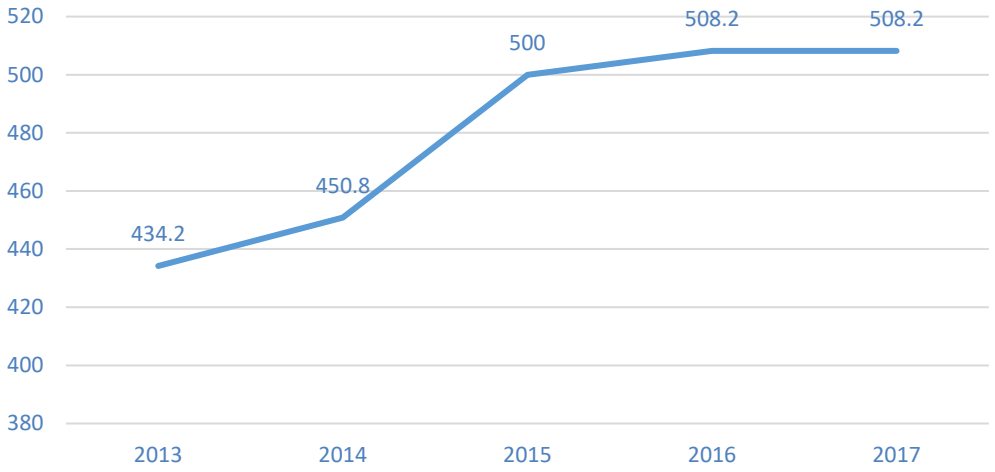


Figure 51: Standardised mortality rate from diseases of the circulatory system per 100,000 inhabitants in the Federation of Bosnia and Herzegovina, 2013-2017
/Source: Reports on the health status of the population of the Federation of BiH, 2013-2017/

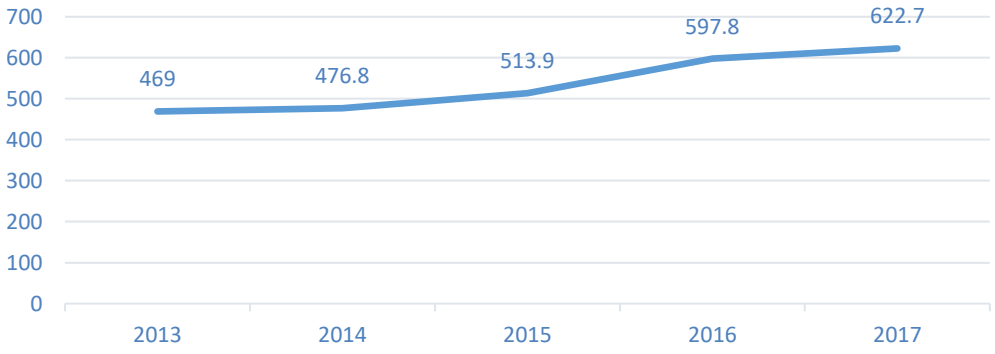


Figure 52: General mortality rate from diseases of the circulatory system per 100,000 inhabitants in the Republika Srpska, 2013-2017

[95] Kovats SR, Ebi KL. Hetawaves and public health in Europe. Eur J of Pub Health. 2006;6:592-599.

[96] Public Health Institute of the Federation of BiH, Reports on the health status of the population of the Federation of BiH, 2013-2017
Public Health Institute of the Republika Srpska, Reports on the health status of the population of the Republika Srpska, 2013-2017

/Source: Reports on the health status of the population of the Republika Srpska, 2013-2017/

In the Federation of Bosnia and Herzegovina, the mortality rate from stroke shows a trend of slight decline in the last five years, unlike the mortality rate from acute myocardial infarction, which in the same period shows a slight increase.[97]

As part of the "Pilot Study on the Impact of Climate Change on Human Health", conducted within the project "Preparation of the Fourth National Communication and the Third Biennial Update Report on Greenhouse Gas Emissions of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change", a pilot study on the possible impact of climate change on the occurrence of stroke was developed at the University Clinical Centre in Banja Luka. The study included all patients who had a stroke or bleeding in Banja Luka in the period 2011-2017. The results showed that there is no clear significance on the possible increase in strokes in the period when there were unfavourable bioclimatic conditions (extremely high temperatures, vapours, extremely low temperatures) in the observed period.[98]

Among the five leading causes of death in Bosnia and Herzegovina are diseases of the respiratory system. The mortality rate from respiratory diseases in Bosnia and Herzegovina also shows a trend of gradual growth in the period 2013-2017. (Figure 53).[99]

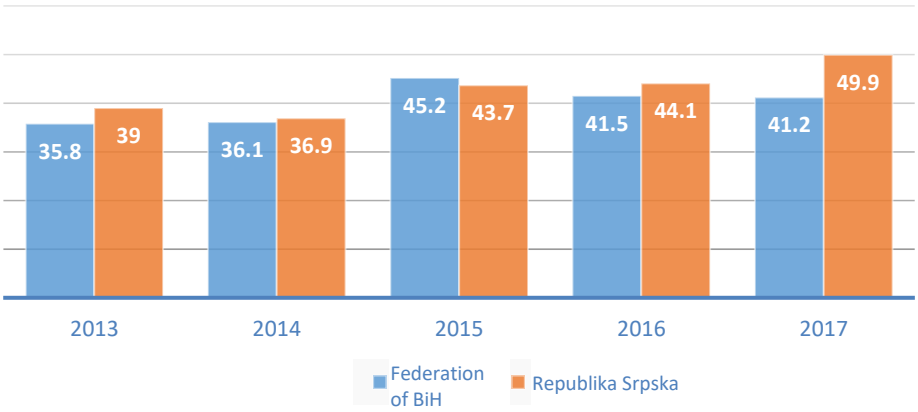


Figure 53: Trends in the mortality rate from respiratory diseases per 100,000 inhabitants in Bosnia and Herzegovina, 2013-2017

/Source: Reports on the health status of the population of the Federation of Bosnia and Herzegovina, 2013-2017, Reports on the health status of the population of the Republika Srpska, 2013-2017/

In the same period, the incidence rate of chronic obstructive pulmonary diseases registered in the outpatient polyclinic activity of primary health care in the Federation of Bosnia and Herzegovina had a trend of gradual growth. Risk factors for developing these diseases are active smoking, genetic predisposition, allergies, viral and fungal infections, as well as environmental factors, which include climate. Given the high prevalence of smoking among the population (44.1%), with increasing air pollution, monitoring of chronic obstructive pulmonary disease is of increasing importance.[100]

Air pollution due to the increased concentration of allergens of plant origin also leads to the frequency of allergic diseases (allergic rhinitis and allergic asthma) because, as a result of climate change, spring begins earlier and

[97] Public Health Institute of the Federation of BiH, Reports on the health status of the population of the Federation of BiH, 2013-2017

[98] Preparation of the Fourth National Communication of Bosnia and Herzegovina under the UN Framework Convention on Climate Change: Report no. 4 - Pilot study on the impact of climate change on human health, Enova, Ceteor and Jozef Stefan Institute, 2019

[99] Public Health Institute of the Federation of BiH, Reports on the health status of the population of the Federation of BiH, 2013-2017
Public Health Institute of the Republika Srpska, Reports on the health status of the population of the Republika Srpska, 2013-2017

[100] Public Health Institute of the Federation of BiH, Reports on the health status of the population of the Federation of BiH, 2013-2017

summer ends later. In Bosnia and Herzegovina, there are no official statistics on the number of allergy sufferers that could be linked to climate change, so it is not possible to speak more precisely about the prevalence and trend of these diseases among the population of Bosnia and Herzegovina, related to climate change. Nevertheless, most domestic experts agree that there has been a significant increase in respiratory allergy in recent years.

Due to the expected, more frequent floods and other natural disasters, more frequent and extensive occurrences of hydric and alimentary epidemics can be expected. In the last five years, a trend of gradual increase in the incidence of acute enterocolitis has been recorded in Bosnia and Herzegovina, while the incidence of alimentary toxic infections shows an uneven trend. (Figure 54).[101]

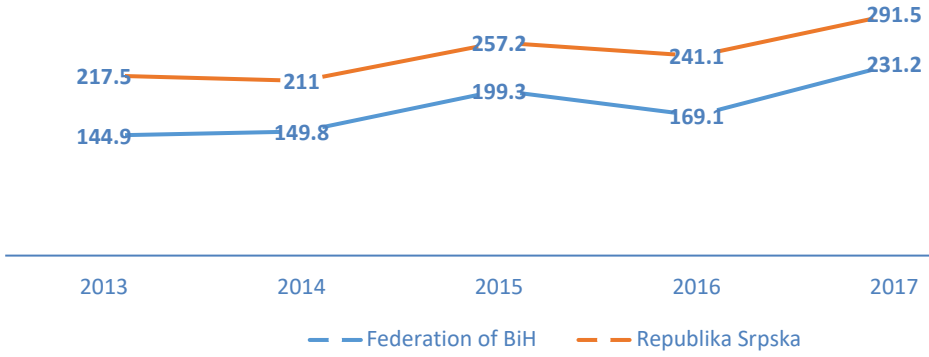


Figure 54: Trends in the incidence of acute enterocolitis per 100,000 inhabitants in Bosnia and Herzegovina, 2013-2014
/Source: Reports on the health status of the population of the Federation of Bosnia and Herzegovina, 2013-2017, Reports on the health status of the population of the Republika Srpska, 2013-2017/

Altered climatic conditions can cause a change in the prevalence and frequency of certain infectious diseases, i.e. vectors that transmit such diseases (transmissible diseases). These are e.g. Lyme disease, West Nile fever, malaria, dengue fever, chikungunya fever, etc. Warm and humid weather is ideal for the development of mosquitoes and ticks, which are the most common carriers of these diseases.

According to the results of a survey conducted by the Veterinary Institute "Vaso Butozan" from Banja Luka in the summer of 2015, the presence of the Asian tiger mosquito "Aedes albopictus" was determined at five locations in the Republika Srpska: Laktaši, Bijeljina, Brod, Gradiška and Banja Luka. This species of mosquito is known to play an important role as a vector of microorganisms that cause viral transmissible infectious diseases such as dengue, chikungunya, West Nile fever. In the Republika Srpska and throughout Bosnia and Herzegovina, some other species and genera of mosquitoes have been detected, which are important for human health. A larger population of these mosquitoes was found in the areas of Gradiška, Brod, Srbac and Kozarska Dubica.

According to the Reports on the health status of the population of the Public Health Institute of the Federation of Bosnia and Herzegovina and of the Public Health Institute of the Republika Srpska, a total of 3 cases of West Nile fever were registered in the Federation of Bosnia and Herzegovina in 2013 and 2014, while 10 probable cases of this disease were recorded in the Republika Srpska in 2014, none of which were confirmed. Patients were registered in three regions (Banja Luka, Doboj and Trebinje), of different ages, and the largest number of patients was registered in May. According to the same reports, in the last ten years in Bosnia and Herzegovina there has been an increase in the incidence of Lyme disease (Borreliosis), an infectious disease caused by the

[101] Public Health Institute of the Federation of BiH, Reports on the health status of the population of the Federation of BiH, 2013-2017 Public Health Institute of the Republika Srpska, Reports on the health status of the population of the Republika Srpska, 2013-2017.

bacterium Borrelia burgdorferi transmitted by infected ticks. The increasing frequency of this disease is associated with an increase in temperature and consequently higher tick activity. Although there is still no scientific evidence that communicable diseases are spreading in Bosnia and Herzegovina due to climate change, given global trends this can be expected.[102]

3.3.6.2 Vulnerability analysis

According to a report by the European Environment Agency (EEA), European areas are facing rising sea levels and increasingly extreme weather conditions, such as frequent and intense heat waves, floods, droughts and storms caused by climate change. All areas in Europe are subject to climate change but some of them will feel the harmful effects more than others. The focal point of climate change is predicted to be southern and south-eastern Europe, as most adverse impacts are expected in the area. It is known that climate change already has a measurable impact on weather conditions in Europe in the form of increasing mean temperatures and changes in precipitation, so more frequent heat waves, drought and floods are expected.

Although climate change is usually slow and lasts for centuries (with an increase in mean temperature of 1°C for 1,000 years), recent research shows that global temperature has risen by 0.7°C in the last 100 years, and by 1°C in Europe. According to the mildest climate scenario, global temperatures will increase by an average of 1.5°C at the end of the 21st century, and according to the worst scenarios, by more than 2°C compared to the period from 1850 to 1900. Heat waves will occur more often and last longer. As the Earth warms, current wetlands are expected to have more precipitation and dry areas less, although there will be exceptions. Any increase in global warming, even a half-degree increase, can affect human health. 1.5°C warming is not considered "safe" for most nations, communities, ecosystems and sectors and poses a significant risk to natural resources and human health.[103]

Public health is highly exposed to climate change, and the consequences can cause serious disruptions to the functioning of society as a whole. The main expected impacts of climate change that cause high vulnerability in the health sector are: increased mortality and changes in the epidemiology of chronic noncommunicable diseases and acute infectious diseases, and the impact on the epidemiology of diseases associated with climatological factors (vector diseases). Diseases caused by environmental, as well as meteorological and climatological factors, significantly contribute to the burden on the health of the population and the health system itself because they lead to high costs of health care, overexploitation of key potentials, prevent optimal health and well-being, and undermine social and economic development.

Of all the extreme meteorological events, heat waves are mostly associated with population morbidity but also with a high mortality rate, and represent an important and global public health problem. Climate change and excessive heat as a consequence thereof, mostly affect vulnerable population groups - small children and the elderly, pregnant women, the chronically ill, and people who work outdoors, such as construction and agricultural workers.

The predicted temperature rise is expected to particularly affect patients with cardiovascular, cerebrovascular, respiratory and neurological problems, allergic reactions and other acute reactions to the impact of heat waves, as well as the elderly population. Population growth, aging and urbanisation will further increase the number of people at risk. By 2050, it is estimated that there will be almost 3 times more people over the age of 65 living in

[102] Public Health Institute of the Federation of BiH, Reports on the health status of the population of the Federation of BiH, 2013-2017.
Public Health Institute of the Republika Srpska, Reports on the health status of the population of the Republika Srpska, 2013-2017.
Institute of Public Health (2015): Infectious and parasitic diseases in the territory of the Republika Srpska
[103] IPCC, Climate change 2013: The Physical Science Basis

cities around the world. All of this can lead to a significant increase in the number of heat-related deaths globally. In contrast, the predicted milder winters are likely to lead to reduced mortality and cold-related illnesses.[104]

Climate change indirectly affects water availability, crop yields, food production and quality. In the context of climate change in the future, insufficient supply of healthy drinking water, which is difficult in extreme droughts, especially in rural areas, and in conditions of major floods, as well as the supply of healthy food (due to presence of microbiological and chemical pollutants) could have a significant impact on the health of the population. Higher temperatures can also contribute to the spread of disease vectors, resulting in an increased incidence rate of infectious diseases, especially those caused by contaminated water and food. Due to the expected, more frequent floods and other natural disasters (e.g. extreme heat and drought), more frequent and extensive occurrences of hydric and alimentary epidemics can be expected. Due to the increase of organic matter in the contaminated water, the consumption of chlorine and chlorine preparations during disinfection has increased, which can lead to increased exposure to trihalomethanes (carcinogenic unwanted disinfection products).

Climate change is expected to have a major impact on the movement of vector (transmissible) diseases, the causative agents of which are transmitted by mosquitoes, ticks and other insect species. Appropriate temperature and humidity are the basic preconditions for the development of insect eggs and larvae in adults, so that in conditions of high temperature and high humidity, their number can increase several times. It is estimated that any increase in air temperature by 0.1^0C expands the mosquito habitat by up to 150 kilometres in the direction of the northern latitude of the globe. Expanding the habitat of ticks and Asian tiger mosquitoes, and other disease vectors, increases the risk of Lyme borreliosis, tick-borne meningoencephalitis, West Nile virus, dengue fever, chikungunya fever, and leishmaniasis. Therefore, further research is needed on the epidemiology and ecology of infectious diseases that are likely to be affected by climate change.[105]

Continuation of the existing trends of global warming will lead to an increase in air pollution by inorganic and organic pollutants, which may also cause an increase in morbidity and mortality from respiratory, cardiovascular and malignant diseases. Measures to reduce emissions of black carbon, ozone or ozone precursors have a positive impact on human health and the climate. Greenhouse gases and air pollutants are emitted by the same sources. Therefore, limiting the release of one or the other can bring benefits. Combustion of fossil fuels simultaneously affects the health of the population and results in climate change. Gradual closure of coal-fired power plants, i.e. replacing black coal with sustainable renewable energy sources, as a measure of protection against climate change, would also have a positive impact on the health of the population.

Bosnia and Herzegovina has not established a system for monitoring the movement of diseases that can be linked to climate change, nor has a clear methodology been developed to respond to the impact of climate change on the health of the population. The leading causes of morbidity and mortality in Bosnia and Herzegovina (cardiovascular, cerebrovascular diseases and malignant neoplasms) cannot be reliably linked to climate change because to date no scientific research has been conducted to confirm their connection. However, although there is no data based on scientific research, climate change certainly affects the health of the population in Bosnia and Herzegovina. As the European Environment Agency (EEA) predicts in its reports that the focal point of climate change will be southern and south-eastern Europe, it is expected that in the future the impact of climate change on the health of the population in this area will be even more intense.

In the publications of the World Health Organization (WHO) there are estimates of the impact of climate change on human health obtained on the basis of health statistics on the rates of morbidity and mortality from non-communicable diseases (primarily respiratory, cardiovascular and cerebrovascular diseases) and infectious

[104] World Health Organization Regional Office for Europe (2012), WHO Statement on the state of the global climate in 2012

[105] Tatem AJ, Hay SI, Rogers DJ. Global traffic and disease vector dispersal. PNAS 2006 ; 103: 6242 – 7

diseases (malaria, borreliosis, dengue, haemorrhagic fever and other vector-borne diseases transmitted by mosquitoes, ticks, rodents, etc.) as well as data on the movement of the rates of morbidity and mortality from diseases of the gastrointestinal system caused by the consumption of contaminated food and water. Estimates of the impact of climate change on health are based on the quantification of risk factors that contribute to the growth of mortality and morbidity rates of climate-sensitive diseases and on the analysis of existing trends in these diseases. They are presented as a projection of the expected impact on population health for the period up to 2030 and 2050. According to these estimates, many deaths from climate change (especially in children) can be prevented by specific targeted prevention activities in countries within the European region and beyond (e.g. implementing good hygiene practices, improving access to sanitation and safe drinking water, implementing measures to improve air quality etc.).

Therefore, in the long run - preventing increased morbidity and mortality caused by extreme temperatures, atmospheric pollution, increased natural disasters, and reduced arable land - is the only way to preserve global health. Public participation is crucial in defining efficient responses to climate change adaptation. Therefore, it is necessary to continuously inform the public about the possible impact of climate change on human health. The informed public, through appropriate measures, can have a significant impact on reducing high vulnerability in the health sector.

3.3.6.3 Adaptation opportunities

To assess the potential impact of climate change on health, and thus the response of the health sector, it is necessary to know the vulnerability of the population and the situation in the health care system of a country. In order to detect diseases caused by climate change at an early stage, it is necessary to collect adequate information on the exposure of the population to changed climatic conditions. This primarily involves defining health problems that are expected to have the most pronounced impact of climate change (diseases of the circulatory and respiratory systems, vector-borne diseases, allergies, diseases transmitted by contaminated water and food, etc.) as well as population groups whose health in these conditions will be the most endangered (children, pregnant women, the chronically ill, the elderly, workers who do their work outdoors, making them more exposed to the effects of temperature extremes). It is also important to define the most vulnerable areas in the country (e.g. areas exposed to floods).

1. The priority of public health is to minimise morbidity and mortality due to the effects of climate change, especially among vulnerable groups, such as the chronically ill and the elderly. According to the legislative framework, public health plays an active role in planning responses during emergencies. The existing capacities of the network of the Public Health Institute of the Federation of Bosnia and Herzegovina, Public Health Institute of the Republika Srpska and PHI “Zdravstveni centre Brčko” as well as Emergency Medical Institutes/Services in the Federation of Bosnia and Herzegovina, the Emergency Medical Services of the Health Centres in the Republika Srpska and the Emergency Medical Service of the PHI "Zdravstveni centar Brčko" are part of the health system that needs to be constantly improved. More funds need to be directed to informing and educating the population, as well as to scientific research. The Public Health Institute of the Federation of Bosnia and Herzegovina, the cantonal public health institutes, the Public Health Institute of the Republika Srpska and its 5 regional centres in Doboj, Istočno Novo Sarajevo, Foča, Zvornik and Trebinje, have experts who can use public campaigns and distribution of promotional materials (e.g. brochures, posters, leaflets) to educate the population on the application of hygiene principles and measures to protect health from diseases resulting from the effects of climate change (pollution of water, food, air, soil, ultraviolet radiation, heat waves, low temperatures, etc.).

2. The inclusion of climate change in health sector strategies is also crucial. Since strategic documents in the field of public health do not sufficiently address the climate change issues and their possible impact on the health of the population, the process should start with the development of strategies and plans for adaptation, i.e.

revision of existing strategic documents. In order to protect the health of the population from the effects of climate change, the health sectors in the Federation of Bosnia and Herzegovina, Republika Srpska and Brčko District of Bosnia and Herzegovina should adopt "Action plans to protect the health of the population from the effects of climate change". Existing documents in the field of health care that could be updated in terms of including aspects of climate change are: Order on the Programme of measures to protect health from harmful environmental factors (Official Gazette of the Federation of Bosnia and Herzegovina, No. 27/14), Law on Protection of the Population from Infectious Diseases (Official Gazette of the Federation of Bosnia and Herzegovina, No. 29/05), Strategic plan for health development of the Federation of Bosnia and Herzegovina 2008-2018, Law on Protection of the Population from Infectious Diseases (Official Gazette of the Republika Srpska, No. 90/17, 42/20, 98/20), Policy for improving the health of the population of the Republika Srpska until 2020, Action plan for prevention and control of noncommunicable diseases in the Republika Srpska 2019-2026, Programme of measures for prevention and control, elimination and eradication of infectious diseases for the Republika Srpska for 2020, Youth and Health Strategy of Bosnia and Herzegovina and others.

3. It is also very important to strengthen regional and international cooperation to manage the risks posed by climate change. Since climate change will have a similar impact on the health of the population in the neighbouring countries, it is useful to network and share experiences in solving problems for which public health care system is responsible. The development of international cooperation is necessary when it comes to infectious diseases, since with climate change, the spread of certain existing and the emergence of new infectious diseases is expected.

4. Cooperation of the Public Health Institute of the Federation of Bosnia and Herzegovina, the Public Health Institute of the Republika Srpska and cantonal/regional public health institutes with Hydrometeorological Service of the Federation of Bosnia and Herzegovina and the Hydrometeorological Service of the Republika Srpska is especially important, as within their activities they give forecasts of meteorological conditions and warn the public about the upcoming heat wave. Also important is the cooperation with services/institutes for emergency medical care. The aim is to take timely joint measures to protect the health of the population, especially vulnerable population groups (children, pregnant women, the elderly, people with chronic diseases and workers working outdoors).

5. The task of the public health institutes is continuous information (primarily through the media) and implementation of educational and promotional campaigns in order to improve the knowledge of the population about the impact of climate change on health. This includes making, printing and distribution of educational and promotional materials intended for vulnerable population groups and the general population - e.g. brochures, leaflets, posters with guidelines for health protection in times of extremely high or low temperatures and episodes of air pollution (high concentrations of sulphur dioxide, nitrogen oxides, particulate matter, pollen from allergenic plants and other air pollutants) as well as guidelines for protection against diseases transmitted by vectors - infected ticks and mosquitoes (e.g. proper procedure for tick bites, etc.). The inclusion of climate change adaptation in school and university curricula is also of great importance.

6. Continuous information of the population and implementation of educational and promotional campaigns to protect health from the effects of climatic factors implies the development of early warning systems, especially for vulnerable population groups of the danger of extreme weather (e.g. during high heat or cold, air pollution, floods, etc.) as well as strengthening the capacity of public health institutes and emergency services in terms of implementing staff training programmes on current climate change.

7. In accordance with the provisions of the Law on Occupational Safety (Official Gazette of the Federation of Bosnia and Herzegovina, No. 79/20) in the Federation of Bosnia and Herzegovina, Law on Occupational Safety (Official Gazette of the Republika Srpska, No. 01/08 and 13/10) in the Republika Srpska, Law on Safety and Health

Protection of Workers at Work (Official Gazette of Brčko District of Bosnia and Herzegovina, No. 34/19, 2/2021 and 6/21) in the Brčko District of Bosnia and Herzegovina, it is the obligation of employers to provide workers with working conditions in a manner that will not adversely affect their health and life. Particular emphasis should be placed on the importance of ensuring work without endangering the health and life of workers working outdoors. As always, prevention comes first, so one should try to organise working hours so as to avoid working in high heat or cold. The most important adaptation measure that needs to be taken in order to protect the health and life of workers from the effects of climate change in Bosnia and Herzegovina is the adoption of legislation in line with European Union legislation, which regulates working hours and work obligations in days of climate extremes, or the update of applicable laws in the field of protection of workers' health in the Federation of Bosnia and Herzegovina, Republika Srpska and Brčko District in order to harmonise with the legislation of the European Union on this issue.

8. The control and surveillance of vector-related diseases requires the cooperation of public health care system and the veterinary sector. This cooperation is very useful, since epidemics among animals precede the appearance of diseases in humans. Establishing an active animal health surveillance system to detect new cases of disease is very important as an early warning for the public health sector.

9. High temperature, increased precipitation and increased humidity in the air also affect the movement of diseases transmitted by contaminated water and food, as well as infectious diseases transmitted by air. One of the important challenges in controlling all infectious diseases is to predict their distribution in time and space, in order to enable targeted interventions and prevent epidemics.

10. In the context of future climate change, the supply of safe drinking water, which is difficult in extreme droughts, especially in rural areas, and in conditions of major floods, could also have a significant impact on the health of the population. Microbiological and chemical contamination of drinking water can result in epidemics of intestinal infectious diseases and diseases caused by toxic substances (heavy metals, pesticides, etc.), which requires investment in the construction of water treatment plants. Great importance of sustainability of water sources and deterioration of water quality due to climate change requires a review of technological processes of preparation of drinking water and the inclusion of a greater degree of resistance in the preparation of water for human consumption in public water supply.

11. It is necessary to develop a timely public health response to diseases associated with climate change, primarily diseases of the circulatory and respiratory systems, allergic diseases, psychological problems, etc. In order to adopt adequate measures for adaptation of the population to the impact of climate change, it is necessary to conduct scientific research to examine the mortality rate from diseases that are the leading causes of mortality in Bosnia and Herzegovina - diseases of the circulatory system (stroke, acute myocardial infarction) and diseases of respiratory system (primarily, chronic obstructive respiratory disease), during temperature extremes for a period of at least three years.

12. In order to monitor the impact of climate change on human health, it is necessary to establish a database of health statistics in the Public Health Institute of the Federation of Bosnia and Herzegovina and the Public Health Institute of the Republika Srpska on the development of mortality and morbidity rates from climate-sensitive diseases (cardiovascular, cerebrovascular, chronic obstructive respiratory diseases, intestinal infectious diseases, vector-borne diseases, allergic diseases, etc.). Currently, the Public Health Institute of the Federation of Bosnia and Herzegovina and the Public Health Institute of the Republika Srpska collect summary reports for all three levels of health care on an annual basis from the cantonal/regional public health institutes. If these reports were collected quarterly, it would be possible to monitor the development of mortality and morbidity rates from climate-sensitive diseases during the warmest and coldest months of the year, over a longer period of time.

13. In order to improve the system of keeping records in the field of health care, the Public Health Institute of the Federation of Bosnia and Herzegovina in 2019 purchased an IT/software solution that includes individual applications for the purpose of making registers and all summary reporting forms. Access to the software solution is achieved through a VPN (Very Private Network) connection, which includes all security standards of data protection. Cantonal public health institutes have access to data on health care institutions in their canton, while the Public Health Institute of the Federation of Bosnia and Herzegovina has access to data on all ten cantonal institutes and other health care institutions. All health institutions in the Federation of Bosnia and Herzegovina were granted access to the software via a VPN connection. In order to provide monthly reporting, it is necessary for the staff of the Public Health Institute of the Federation of Bosnia and Herzegovina - Health Statistics Service to conduct training through workshops. It is necessary to plan workshops with the aim of educating and presenting the use of the software solution, all with the aim that ultimately there are updated data related to morbidity in one place (Report on diseases and conditions identified in primary health care). The workshops would also include education on the proper methodological completion of the Report on diseases and conditions identified in primary health care through software. The goal is to educate the workshop participants to use the software and fill in the above summary reporting form methodologically. Part of the education would relate to the use of import forms. These are excel sheets that can be imported directly into the software, without typing. Workshop participants would be employees of cantonal public health institutes, as well as employees of other health care institutions working on data entry.

4 ESTIMATING THE POTENTIAL FOR CLIMATE CHANGE IMPACT MITIGATION

Achievement of the planned targets and tasks in the field of climate change mitigation that are contained in the Fourth National communication of Bosnia and Herzegovina under the United Nations Framework Convention on Climate Change is based on the results of the latest scientific research on emission scenarios, climate change mitigation potential and mitigation measures that have been achieved both at the level of Bosnia and Herzegovina and at the international level.

In the Fourth National communication, the chapter on climate change mitigation contains: a description and analysis of measures by individual sectors in Bosnia and Herzegovina, mitigation scenarios to model the possible greenhouse gas emission trajectories until 2050, as well as a review of activities, projects and initiatives that will contribute to the climate change mitigation.

Quantitative modelling of greenhouse gas emissions trajectories over time has been presented using three scenarios: S1 – Baseline (no change) scenario; S2 – medium scenario (with the partial application of incentives for reduction of greenhouse gas emission), and S3 – advanced scenario (with the more intensive application of incentives for reduction of greenhouse gas emission.) In considerations of the aforementioned emission scenarios, the initial data have been used for 2014, while emission calculations were made for five-year periods from 2010 to 2050 (i.e. for 2010, 2015, 2020…..2050). The competent state-level institutions, as well as the institutions of the Federation of Bosnia and Herzegovina, the Republika Srpska and the Brčko District have been actively involved in the FNC development project through collection of necessary data.

Like both in TNC and FNC BiH, the LEAP (Long Range Energy Alternatives Planning System) software was used. Through LEAP, the directions of development were modelled according to the above scenarios for the sectors of: electricity, district heating, buildings and transport. Other sectors were modelled using the tools that had already been developed through the SNC.

4.1 Electric power sector

4.1.1 Overview of situation in electric power sector

According to the Report on the activities of the State Electricity Regulatory Commission (SERC) in 2020, the total installed capacity of electric power generation units in Bosnia and Herzegovina amounts to 4,530.64 MW, with 2,076.6 MW, 2,065 MW and 92.85 MW installed in the major hydro power plants, thermal power plants and industrial power plants respectively. The total installed capacity of electric power generation units from RES (not including major hydro power plants) is 296.19 MW. Around 58% of capacity accounts for small hydro power plants, followed by wind power plants with a share of around 29%, and solar power plants with a share of around 12%. Biomass and biogas plants account for the smallest share.

Total gross electricity production in 2018 was 19.160 GWh in 2018, while the final consumption was approximately 11,456 GWh. Net exports of electricity amounted to 4,606 GWh (Agency for Statistics of Bosnia and Herzegovina, 2019a). At the same time, electricity consumption per capita is relatively low (compared to European states.) Per capita electricity consumption was 1,915 kWh in 2000, increasing to 2,840 kWh in 2013,

and 3,240 kWh in 2018, exceeding the world average. Electricity consumption increased by 15% in 2002-2018 from 9,150 GWh to 11,456 GWh, which is an increase by approximately 25%.

In 2018, 12,079 GWh or 63% of electricity was produced in thermal power plants using domestic coal that have high specific emissions of carbon dioxide (about 1.3 tCO_2/MWh). The remainder of electricity was produced in large hydro power plants, 6,519 GWh or 34%, and 562 GWh or 2.9% was produced in industrial power plants and renewable energy sources (solar and wind). Coal consumption in energy sector (thermal power plants and industrial power plants) amounted to around 13.4 million tonnes. Due to the large share of thermal power plants in production, the network emission factor for carbon dioxide amounted to about 820 kg/MWh in 2018 (in 2013, it was about 720 kg/MWh). Structure of electricity generation in Bosnia and Herzegovina in 2014-2018 is shown in Figure 58. The figure shows that, in the given period, the production of thermal power plants has a growth trend, which results in a growth trend of greenhouse gas emissions as well.

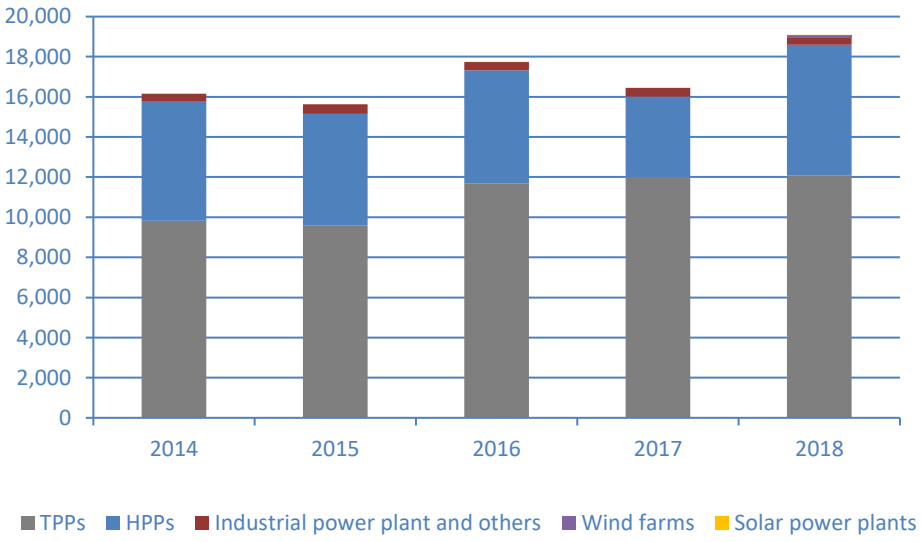


Figure 55: Structure of electricity generation in Bosnia and Herzegovina in 2014-2018 (GWh)

Bosnia and Herzegovina adopted the Framework Energy Strategy by 2035. Four scenarios were analysed in the electric power sector. Of the four developed scenarios, only one leads to some emission reduction (the moderate renewable scenario). Other scenarios are among other things based on significant capacity increase of thermal power plants and their production. The main disadvantage of these scenarios is that they predict an unrealistic increase in electricity production. According to the three scenarios, the coal-fired thermal power plants will continue to be a significant source of electricity until 2035. There are significant reserves of coal available and it is a sector which employs a relatively large number of people. However, the competitiveness of existing and new coal-fired power plants in Bosnia and Herzegovina is very low on the open market, which is emphasized in the Strategy. Therefore, in parallel with the construction of new (replacement) and closure of existing blocks in thermal power plants, building of capacities that use renewable energy sources should be intensified. The fourth scenario (moderate renewable) envisages the largest share of renewable energy sources, and this refers to hydropower plants, biomass power plants, wind power plants and solar power plants. The first wind power plant in Bosnia and Herzegovina was put in operation in 2018. Several other wind power plants are in the development phase[106]. The introduction of feed-in tariffs and a guaranteed period of purchase of electricity from renewable energy sources (RES) at the level of the Federation of Bosnia and Herzegovina and

[106] At the beginning of 2021, two wind power plants are in operation, and another one is in trial operation. The total capacity of the three wind power plants is 134.6 MW.

the Republika Srpska and the rising competitiveness of RES resulted in growth of electricity production from RES in Bosnia and Herzegovina. However, the share of electricity from coal-fired thermal power plants is still very large and ranges from about 60% to about 75%, depending on hydrological conditions.

When it comes to production from RES in 2020, the total production amounted to 661.25 GWh. Dominant share accounts for small hydropower plants with 341.02 GWh (497.99 GWh in 2019, 469.39 GWh in 2018), wind power plants produced 262 GWh (254 GWh in 2019), while solar power plants produced 45.62GWh (30.04 GWh in 2019, 20.65 GWh in 2018), biomass and biogas power plants generated 12.56 GWh (8.84 GWh in 2019, 8.15 GWh in 2018), and wind power plants connected to the distribution system generated 0.07 GWh (0.02 GWh in 2018).

4.1.2 Review of scenarios for reducing greenhouse gas emissions from the electricity sector by 2050

Measures to reduce greenhouse gas (GHG) emissions in the electricity sector that were analysed in the BiH Framework Energy Strategy until 2035 can be divided into:

1. Replacement of part of the existing thermal power blocks with new ones with significantly higher energy efficiency, which would reduce the specific GHG emission (tCO_2/MWh) and construction of new thermal power plants,
2. Building of new capacities that use renewable energy sources,
3. Construction of thermal power plants using natural gas.

In addition to these measures, the Framework Energy Strategy until 2035 also analyses measures related to the use of electricity and reduction of transmission and distribution losses. Within the development of the Fourth National communication on Climate Change in Bosnia and Herzegovina, three scenarios for GHG emissions in the electricity sector were analysed. These scenarios are based on the scenarios for the development of BiH's electricity sector from the Framework Energy Strategy of Bosnia and Herzegovina until 2035. The first two scenarios are referred to as reference scenario (S1) and moderate mitigation scenario (S2), and the third one is called mitigation scenario. The analysis of GHG emissions within these scenarios concluded that only the mitigation scenario brings emission reduction.

Reference scenario (S1) - is based on the scenario from the Strategy, which is referred to as the Indicative plan (IP) until 2035. It predicts an increase in total installed capacity, as well as an increase in the share of renewable energy sources. This scenario puts emphasis on replacement of old thermal power blocks with new ones using coal and natural gas. Carbon dioxide emission will increase significantly until 2025, when it will begin to decline due to the closure of a part of the existing thermal power plants. In 2025 – 2035, new coal-fired thermal power plants take over most of the production. Although production is growing significantly, emissions are declining slightly due to higher efficiency of new thermal power plants compared to existing ones that are gradually closing down.

Characteristics of this scenario are:

- installation of 2,283 MW of new capacities is planned,
- coal-fired thermal power plants are still dominant with 70% share, and RES power plants account for 30%,
- after 2025, additional 600 MW from renewable energy sources is expected to be commissioned,
- the amount of installed capacities in 2035 would be around 56% higher compared to 2016,
- reduction of relative share of large scale hydropower plants,
- the share of power plants using other renewable energy sources (except for large hydropower plants) will increase to about 15%,

- in 2035, the amount of gross generated electricity is 29.5 TWh, which is an increase by around 54% compared to 2018,

Carbon dioxide emission will increase significantly until 2025, when it will begin to decline due to the closure of a part of the existing thermal power plants. In 2025 – 2035, new coal-fired thermal power plants take over most of the production. Although production is growing significantly, emissions are declining slightly due to higher efficiency of new thermal power plants compared to existing ones that are gradually closing down. Emission in 2050 is slightly higher compared to 2010.

Moderate mitigation scenario (S2) - based on the scenario from the Strategy referred to as the cost optimised (CO) scenario. Carbon dioxide emission declines slightly by 2025, primarily due to reduced production from existing thermal power plants caused by environmental constraints and market conditions. Characteristics of this scenario are:

- construction of coal-fired thermal power plants, after 2025, no plans for construction of plants using natural gas,
- by 2025, 1,385 MW of new coal-fired capacities will be put in operation, while 370 MW will be decommissioned,
- in 2025 – 2035, coal-fired thermal power plants with a total capacity of 800 MW and 316 MW from HPPs and RES in the incentive scheme will be put in operation,
- the total installed capacity in this scenario would amount to 5,440 MW by 2025, and compared to 2019, there will be a net increase in capacity of about 20%,
- in 2035, the amount of gross generated electricity is 25.2 TWh, which is an increase by around 24% compared to 2018.

Carbon dioxide emission declines slightly by 2025, primarily due to reduced production from existing thermal power plants caused by environmental constraints and market conditions. After 2030, there will be an increase in emissions due to the commissioning of new thermal power plants. The growth of electricity production is significantly higher than the emission growth. After 2035, emissions will decline due to closure of existing thermal power plants and higher efficiency of new thermal power plants compared to existing ones. Emission in 2050 is around 40% lower compared to 2010.

Mitigation scenario (S3) - is based on the scenario from the Strategy referred to as the moderate renewable scenario with energy efficiency (MREE). MREE encourages a higher share of renewable energy sources, promoting the energy efficiency measures as an alternative to other scenarios that are traditionally based on a higher participation of thermal power plants. Although this scenario represents the most intense turn in the production mix planning philosophy, it still relies heavily on coal (especially until 2035). Emphasis is placed more strongly on the growth and promotion of RES, but the thermal energy sector is still not neglected. During consultations with representatives of line ministries, it was concluded that somewhat higher installed capacity of the new coal-fired thermal power plants should be envisaged. Therefore, the development of the electricity sector in Bosnia and Herzegovina is analysed here, which includes the construction of replacement/new coal-fired power plants with 1,050 MW capacity (350 MW more than MREE). In the case of obtaining adequate international assistance for the fair transition of mining areas, the low-carbon scenario would involve 750 MW of replacement/new coal-fired power plants. Both options include the 450 MW capacity of TE Tuzla 7 which is under construction. Considering the indications of assistance to be received for the fair transition of mining areas, the low-carbon scenario option with 750 MW of replacement/new coal-fired power plants is analysed below. By 2030, increase of the installed capacity in RES (new capacities) is expected:

- 550 MW of wind power plants, 400 MW of solar power plants, 50 MW of small hydropower plants and 60 MW of biomass power plants MW,
- 500 MW capacity of large scale hydropower plants.

In this way, the share of renewable energy sources (including large scale hydropower plants) in production will rise to approximately 55%. In addition to the above measures, it is necessary to invest in the transmission and distribution network as well, in order to reduce losses and integrate RES. Estimated costs of the preparation and implementation of all measures (in the option with 1,050 MW of replacement/new coal-fired power plants) amount to 8.625 billion KM. In the 750 MW option, a part of this amount (equivalent to the amount for the construction of a 300 MW coal-fired power plant) is directed for the transition of mining areas. That means investing over 860 million KM per year in the electricity sector until 2030.

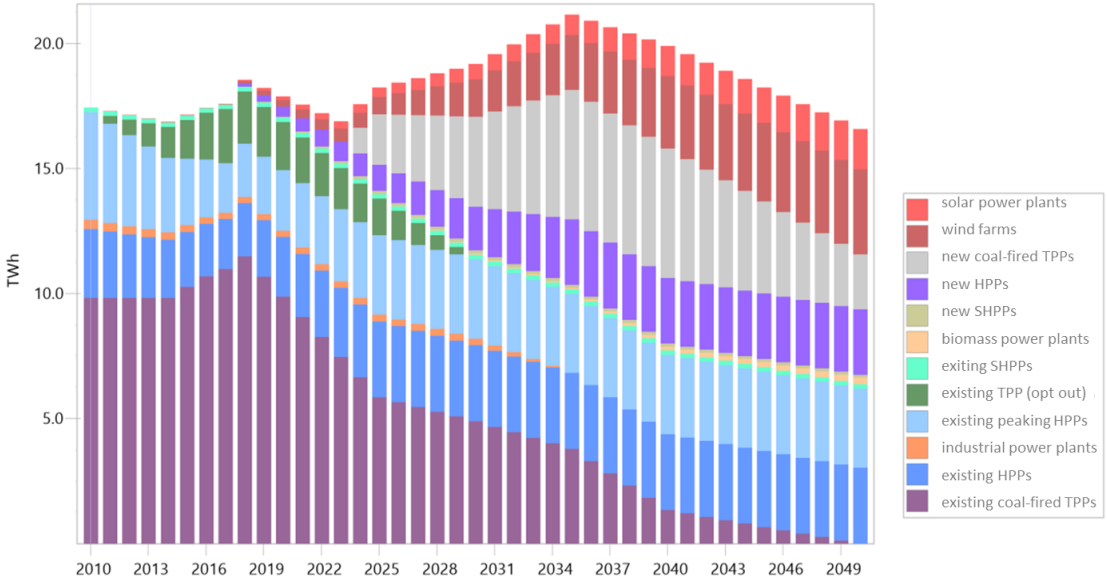


Figure 56: Electricity generation in Bosnia and Herzegovina according to the mitigation scenario

The share of production from thermal power plants should be reduced to about 45% by 2030, which still means a relatively significant role of thermal power plants. The trend of the production mix development would follow a similar pace as the expected consumption growth, and the scenario would satisfy the high security of supply of domestic consumption at similar levels as today.

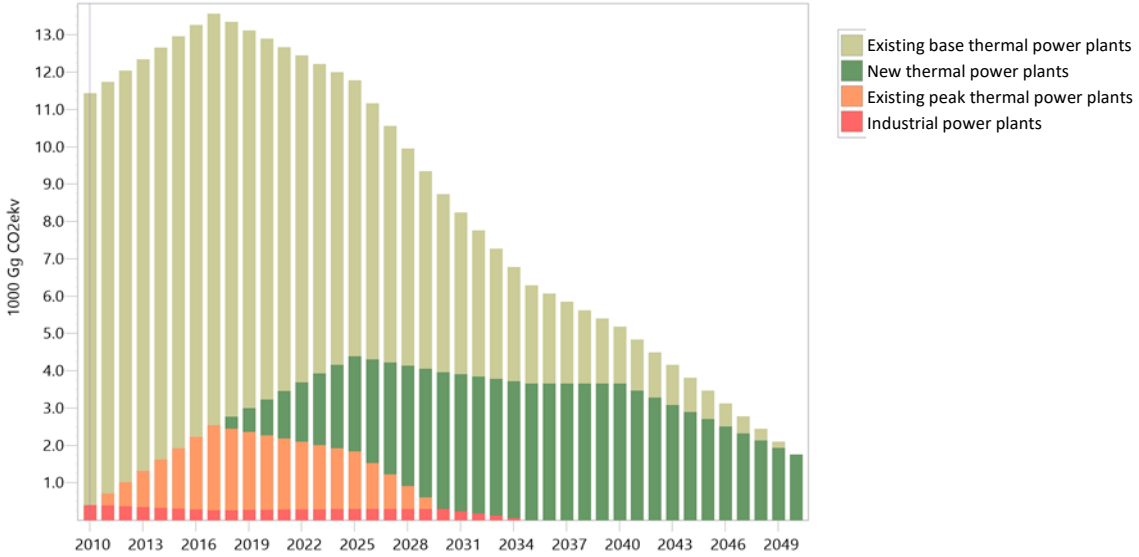


Figure 57: Greenhouse gas emission from the electricity sector in Bosnia and Herzegovina according to the mitigation scenario

After 2019, carbon dioxide emission declines intensely by 2025, primarily due to reduced production from existing thermal power plants caused by environmental constraints (in accordance with NERP) and market conditions. After than, emissions will decline slightly until 2035. During this period, most of the existing coal-fired power plants are closed. The intense decline in emissions begins in 2035 and continues until 2050, when all existing thermal power plants are closed, and replacement/new ones produce less than projected values. Emission in 2030 (about 10 million tons) is about 24% lower than in 2014, and the emission reduction in 2050 (1.76 million tonnes) compared to 2014 would be about 86.5%.

Figure 58 provides a comparative review of carbon dioxide emissions for all three analysed scenarios. S1 evidently leads to an increase in emissions in the coming period, which is why this scenario is unacceptable in the context of the imperative to reduce emissions.

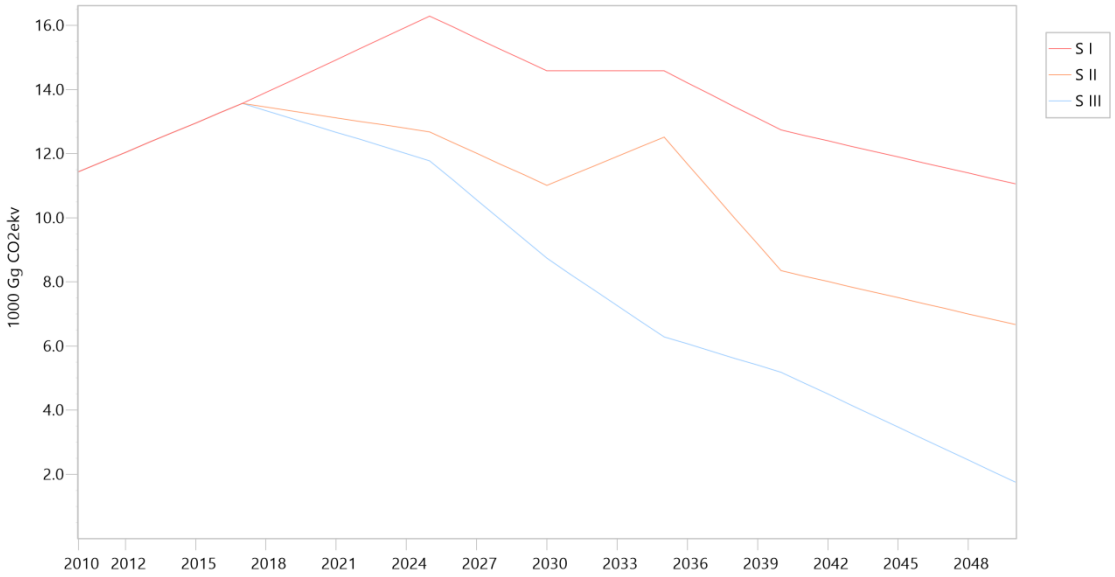


Figure 58: Trend of carbon dioxide emission from the electricity sector in Bosnia and Herzegovina according to the described scenarios

S2 results in some emission reduction, with emissions stagnating until 2035, and a significant reduction is expected only after 2035. Although S3 results in the largest emission reduction by 2050, it still does not in itself provide climate neutrality, which depends on GHG sink trends and emissions in other sectors. Still, this scenario can serve as the basis for the development of a climate neutrality scenario.

4.2 Renewable energy sources

4.2.1 Overview of situation in renewable energy sources sector

Renewable energy sources are energy sources that are completely renewable in a relatively short time, such as solar energy, water energy, wind energy, waves, tide/ebb, biomass, biogas and geothermal energy.

According to the Energy Community Treaty, the Ministerial Council adopted the Decision on implementation of Directive 2009/28/EC on the promotion of the use of energy from renewable sources, defining the mandatory target of 40% share of RES in final energy consumption and 10% share of energy from RES in transport by 2020 for Bosnia and Herzegovina. Article 16 of this Decision allows for the review of the scope of the adaptations upon request of a Contracting Party in case different baseline statistical indicators can be proven, bearing in mind that

when setting the target of 40% for Bosnia and Herzegovina at the level of the Energy Community Secretariat working group, the data for 2009 in the amount of 34% of RES share was used as the baseline element.

Action plan on the use of energy from renewable sources in Bosnia and Herzegovina was adopted in 2016. The action plan is based on previously adopted action plans of the Federation of Bosnia and Herzegovina and the Republika Srpska for the use of renewable energy sources. The action plan contains an overview of energy consumption from RES in the reference year 2009, and from 2010 to 2020, including:

- planned total final consumption of energy from RES in heating and cooling, electricity and transport, taking into account the effects of energy efficiency and energy savings, expressed in kilotons of oil equivalent (ktoe),
- planned RES share in total final consumption of energy from RES in heating and cooling, electricity and transport, expressed in percentages,
- share of renewably energy of each sector in final energy consumption,
- share of renewably energy in transport,
- an estimate of the total share (installed capacity of total electricity production) expected from each renewable energy technology,
- the maximum level of installed power of privileged producers for each technology (hereinafter: dynamic quotas),
- policies and measures for the promotion and encouragement of the use of energy from RES, in accordance with legislation governing competition and state aid,
- joint measures of ministries and institutions.

The share of RES in final energy consumption is 35.97% in 2018, which is less than necessary (38.4%) to meet the 2020 target. There has been some progress in the power industry, and a total of 45 MW of RES plants for electricity production were put into operation in 2019. The target of a 10% share of RES in transport for 2020 has not been met.

The current RES incentive schemes in the Federation of Bosnia and Herzegovina and the Republika Srpska only apply to electricity from RES, while in the Brčko District of Bosnia and Herzegovina there is no appropriate legislation. Reform of incentive schemes is underway and, in addition to feed-in tariffs, it should introduce other RES incentives, such as auctions, as well as incentives for citizen energy projects.

This chapter refers to renewable energy sources where the forms and quantities of energy generated from solar and geothermal energy potentials that are used only for thermal energy production, and of biogas used for production of both heat and electricity are analysed. The level of RES use was taken into account when analysing the scenarios by individual sectors.

4.2.2 Biomass and biogas

There is a great energy potential in residues from agriculture, forestry and the wood industry. Theoretical biomass potential in Bosnia and Herzegovina amounts to 10.2 million of dry weight per year. Technical potential is 7 million tonnes per year, of which 2 million tonnes of dry weight is unused, which is about 36 PJ or about 850,000 tons of oil equivalent.

Based on the available data on livestock for 2015 and 2016, the potential for biogas production was estimated at about 850,000 m^3/day, which is the energy equivalent of about 550 equivalent tonnes of oil. The potential of the installed electric power is about 70 MW.

Electricity production in biomass and biogas power plants in 2020 amounted to 12.56 GWh (8.84 GWh in 2019). Installed capacity of biomass and biogas plants is around 2.2 MW. The biogas plant of the Livač agricultural

cooperative has the capacity of 37 kWe. The biogas plant, with a capacity of just under 1 MWe, is located on a cattle farm in Donji Žabari in the Republika Srpska, owned by MG Gold company. In Kneževo, there is a cogeneration plant using wood biomass with the electric power of 1 MW (thermal power is 5 MW). A 250 kWe biomass cogeneration plant was installed in the Prijedor district heating.

The construction of 4 biogas power plants with the capacity of 250 kWe each is underway on the agricultural farm Spreča near Kalesija. In Livno, there is a district heating plant that uses wood chips, owned by Esco Eco Energija Company. In 2012, the Regulatory Commission for Energy of the Federation of Bosnia and Herzegovina (FERK) issued a preliminary permit to Esco Eco Energija Company from Livno for the construction of a biomass cogeneration plant. The planned capacity of the plant is 1,250 kWe. The company plans to continue building the biomass plant in the near future.

Existing biogas plants and plants that are in the planning phase can use only about 4.3% of the potential. The biggest barriers to greater use of potential are lengthy licensing procedures, provision of funding and sufficient amounts of substrates. Also, training programs about the concept of biogas plants are missing. Farmers view biogas plants almost exclusively as plants for electricity production, and neglect the production of heat and organic fertilizers without which such plants are not sustainable. Investment in agricultural production is a necessary condition for encouraging the use of biogas. The implementation of such measures through rural development policy is expected to result in energy savings in firewood and especially electricity and heat from fossil fuels.

In the last ten years or so, several district heating systems using wood biomass have been built, including projects for the transition from fossil fuels to biomass, as well as the construction of new district heating systems. This contributed to a significant increase of demand for wood chips. Production and demand for wood pellets have been growing steadily over the past decade.

In Bosnia and Herzegovina, there is currently no plan for the systematic production of fast-growing biomass for energy production. There are individual initiatives that focus on the use of areas that have been degraded due to mining works. According to available data, there is no single active commercial plant for the production of biofuels (bioethanol or biodiesel) in Bosnia and Herzegovina.[107]

4.2.3 Solar energy

The solar energy potential in Bosnia and Herzegovina is 70.5 million GWh per year, and with solar radiation of 1240 kWh/m^2/year in the north and 1600 1240 kWh/m^2/ year in the south, the conditions for the use of solar energy are quite favourable.

In 2020, 45.62 GWh was produced in solar power plants, which is almost by one-third more than in the previous year. Installed capacity of solar power plants was 34.89 MW in 2020. This means that the average number of hours of operation at full capacity of solar power plants was about 1,300 hours in 2020 in Bosnia and Herzegovina. According to the adopted NDC, an additional 400 MW of solar power plants are expected to be installed by 2030. There is great interest from investors considering that power plants with relatively large capacities are already competitive on the market.

[107] System Ecologica near Srbac, the only major biodiesel plant in Bosnia and Herzegovina, which has been in operation since 2008 and exported all its production to the EU, Serbia and Macedonia, stopped the production in 2013.

In addition to the fact that Bosnia and Herzegovina belongs to European countries with significant solar radiation, which annually ranges from 1,250 kWh/m^2 in the north to 1,600 kWh/m^2 in the south, the use of solar energy in this area cannot be considered significant.

The results of the research on the possibility of utilising solar energy for heat production using solar collectors for 15 cities in Bosnia and Herzegovina indicate that it would be justified based on the already launched initiatives. There is a noticeable trend of increase in the number of home installations for the preparation of domestic hot water. According to estimates, based on sales of several major distributors of solar collectors, there were about 15,000 m^2 of installed collectors in 2018 in Bosnia and Herzegovina. With an average solar insolation of 1,200 kWh/m^2 per year and 70% efficiency, solar collectors produce about 12.6 GWh/a of heat. Assuming that all this heat replaces electricity in domestic hot water preparation, solar collectors reduce carbon dioxide emissions by about 9,000 tonnes per year. Based on the same source, estimated annual growth (2017 - 2018) is around 15%. Great interest and increased use of solar collectors in all sectors are visible. A relatively large number of projects have been launched, and those in the public sector (e.g., solar roofs for schools, social institutions, hospitals, etc.) and those related to office buildings are particularly important. It is estimated that the construction and use of solar collectors in both households and public buildings will increase in proportion to the incentives and co-financing.

There is great potential for using solar energy to prepare hot water in buildings. 3% share of solar energy in domestic hot water production until 2030 is envisaged, involving installation of around 50,000 solar systems.

In order to increase the use of solar energy for heat production, it is necessary to encourage the development of district heating that supplies heat for domestic water heating as well. In particular, when designing and constructing new buildings, an analysis of the feasibility of using solar energy should be required. In addition, with the reduction of electricity price subsidies, solar collectors will become increasingly competitive.

4.2.4 Geothermal energy

Geothermal resource of Bosnia and Herzegovina is threefold: hydrothermal systems, geopressured zones and hot dry rocks. These areas mostly cover central and northern parts of Bosnia and Herzegovina. Of these three forms of resources, hydrothermal systems attract the most attention because their exploitation is the best developed and the cheapest in relation to the other two forms. Geothermal energy in Bosnia and Herzegovina has been explored in the past four decades, primarily in order to determine the amount of hot water. However, deep drilling for exploitation purposes was never initiated. According to existing research, around 25% of the territory of Bosnia and Herzegovina can be deemed a potential threefold geothermal resource: hydrothermal systems, geopressured zones and hot dry rocks. Mean temperature gradients for individual areas were determined as follows: Pannonian area 50 K/km, Adriatic sea bed 25 K/km, the Dinarides 15 K/km. Central and northern parts of Bosnia and Herzegovina are promising areas for geothermal energy use. These are tectonic lines Zvornik - Doboj- Bosanski Novi - Ilidža - Kiseljak – Busovača.

Research has shown that there are 44 sources of geothermal water in Bosnia and Herzegovina with fluid temperature above 20° C, of which 28 sources are in the Federation of Bosnia and Herzegovina, and 16 in the Republika Srpska. The temperature of these thermal waters ranges from 35-150° C. The total heating power that can be obtained directly (sources with water temperature over 50° C) is about 24 MW, and with the help of heat pumps, from lower temperature sources, it is possible to generate about 155 MW of heat power. This accounts for 10% of total capacity of existing district heating in Bosnia and Herzegovina. The thermal power of the source was calculated assuming that thermal energy is used for space heating until the temperature decreases to 40° C. In the second case (heat pumps), the heat output of geothermal sources was calculated with the assumed temperature decrease to 5° C, also for heating purposes.

With the use of all registered geothermal sources in Bosnia and Herzegovina with the utilization factor of 0.5, it is possible to produce 145.75 TJ of energy in one year only for space heating, or a total of 1,421.75 TJ of energy if combined with space heating and hot domestic water.

The main problem behind underutilization of geothermal potentials of higher temperature levels (50° C and higher - direct use) is the distance of heat demand from the source.

So far, there has been no significant application of geothermal energy for energy purposes in Bosnia and Herzegovina, other than for greenhouse heating in Posavina, and for several studies for the purposes of construction of central heating systems in the municipality of Gračanica based on the combined use of geothermal energy and energy from biomass. There are conceptual designs for the construction of a geothermal power plant in the area of Ilidža (Sarajevo), where the electricity generation from three new boreholes is expected, which should produce 100 kg/s of geothermal water with temperature of 120° C. It is possible to develop district heating in residential areas of Ilidža from the same source. However, there is no funding for exploration drilling. The situation is similar in the vicinity of Tuzla, where a maximum temperature of 118.3° C and the source abundance of 30 l/s have been determined at the drilling depth of 3,532 meters.

There are a relatively large number of examples of the utilization of low-enthalpy geothermal sources using heat pumps. Most of these examples are related to the area of northern Bosnia where groundwater is used in the heat pump system. Examples of the use of geothermal waters can be found in spa resorts (e.g., Fojnica), ethno-villages and the like. An example of the first relatively small district heating using geothermal energy can be found in Višegrad and Andrićgrad.

Several cities have the potential to develop district heating based on geothermal energy. The UNDP developed the NAMA project for Višegrad, and preliminary analyses also exist for Breza. An analysis for heating of the urban part of Fojnica with geothermal energy is being prepared.

The assessment of the future perspective of geothermal energy use in Bosnia and Herzegovina focuses on several areas, namely:

- in agriculture for food production (agro-culture and aquaculture),
- in the communal sphere for heating and cooling of buildings,
- in healthcare industry,
- for tourism purposes, and
- for electricity generation through mini power plants.

However, realistically considering the previous research on the potential of this resource and the currently available technology for the application of geothermal energy, the use of geothermal energy in Bosnia and Herzegovina will be limited to the sectors where it has been used so far (agriculture, health, recreation), possibly for heating and tourism purposes, while electricity generation is not envisaged, and no incentives are expected or planned in the period ahead. There are several reasons for this situation, and the main one is insufficient research of the locations and potentials of geothermal energy in general, and especially for heating and possibly production of electricity.

4.3 District heating

4.3.1 Overview of situation in district heating sector

District heating in Bosnia and Herzegovina is at the top of the priorities of all strategic documents, but the situation is quite complex in this sector. Many district heating systems are obsolete and require significant investment, and if we add to this the fact that many are subsidized, then we come to the conclusion that their long-term sustainability is at stake. Furthermore, the regulatory framework is created differently on a case-by-case basis, e.g. there are significant differences between tariff systems in different municipalities and cities. Thermal energy is still predominantly charged per square meter, and not per delivered heat, which is not sustainable in the long run.

In the early 1990s, there were about 30 district heating systems (DHS) in Bosnia and Herzegovina that were only available in urban areas, or in some cases only in parts of urban areas. The operation of these plants was mainly based on outdated technology and inefficient production of thermal energy. In addition, facilities that are connected to district heating systems are mostly energy inefficient, which generates costs that exceed revenues, which ultimately contributes to the increase in heating prices, and consequently reduce consumption, i.e., use of district heating. The purchasing power of consumers has weakened, making district heating very sensitive to sociological and political issues.

According to the available data, there were 32 companies, i.e., large district heating systems that supply consumers with thermal energy in Bosnia and Herzegovina in 2018. The total heated area by all district heating systems at the level of Bosnia and Herzegovina was about 10 million m^2 in 2018, with the largest systems located in Sarajevo (about 3,000,000 m^2 of heated space), Banja Luka (about 1,350,000 m^2 of heated space) and Tuzla (about 1,000,000 m^2 of heated space). According to the thermal energy balance for 2015, thermal energy distribution losses amounted to 6.53%.[108] In 2011-2015, Bosnia and Herzegovina recorded a downward trend in heat production, which decreased by an average of 3.0% per year.

In 2015, the produced thermal energy amounted to 88.45% of the produced thermal energy in 2011.[109] According to the International Energy Agency (IEA), the total heat consumption for heating in Bosnia and Herzegovina was 71 PJ in 2015, and the share of heat from district heating was about 8%.

The share of district heating in covering thermal needs in buildings in Bosnia and Herzegovina was about 7% in 2017. Heat production from district heating in 2017 amounted to 1.61 TWh (5,793 TJ), and losses from production to consumption amounted to 438 TJ (Agency for Statistics of Bosnia and Herzegovina). Assuming that the average efficiency of heat production is 20%, it means that the amount of energy in fuels consumed in district heating was 7,241 TJ in 2017. Figure 59 presents the share of individual fuels from district heating in 2017.

[108] Framework Energy Strategy of Bosnia and Herzegovina until 2035 (Official Gazette of BiH, No. 70/18)
[109] Framework Energy Strategy of Bosnia and Herzegovina until 2035 (Official Gazette of BiH, No. 70/18)

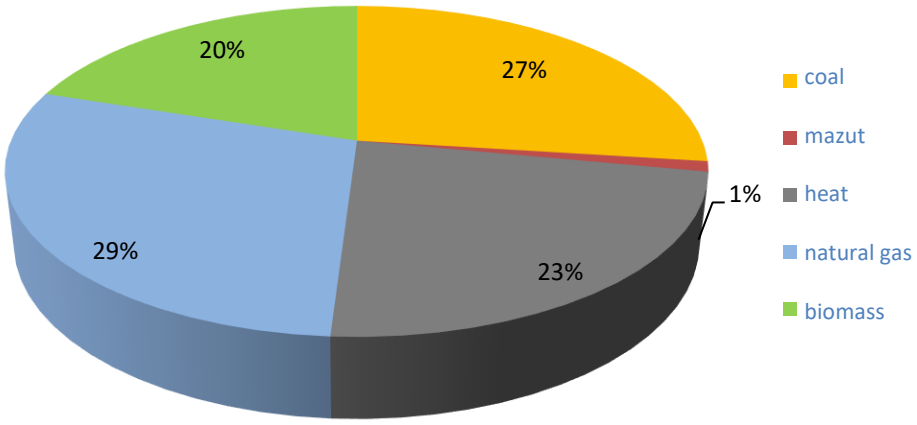


Figure 59: Share of individual fuels from district heating in 2017

Table 19 provides an overview of district heating systems with data on installed capacity, connected heating area, and the main fuel.

Table 19: Overview of district heating systems in Bosnia and Herzegovina

No.	City	Company	Installed capacity, MW	Fuel Main	Heated area, m²
1	Sarajevo	KJKP "Toplane - Sarajevo" d.o.o. Sarajevo (Public Heating Company)	522.5	Natural gas	3,265,940
2		"BAGS Energotehnika" d.d. Vogošća	23	Mazut	78,816
3		"UNIS-Energetika" d.o.o. Sarajevo	33.4	Natural gas	25,000
4	Tuzla	"Centralno grijanje" d.d. Tuzla	300	Coal	1,564,140
5	Zenica	JP "Grijanje" d.o.o. Zenica	170	Coal	1,000,000
6	Nemila	JP "Grijanje" d.o.o. Zenica	3	Biomass	7,500
7	Kakanj	JP "Grijanje" d.o.o. Kakanj	31	Coal	237,937
8	Lukavac	JP "Rad" Lukavac	36	Coal	200,000
9	Banja Luka	"Toplana" a.d. Banja Luka	297	Biomass	1,900,000
10	Doboj	"Gradska toplana" a.d. Doboj	58	Coal	491,385
11	Prijedor	"Toplana" a.d. Prijedor	80	Biomass	273,000
12	Pale	"Gradske toplane" a.d. Pale	8.5	Biomass	68,545
13	Gradiška	PJ "Toplana" Gradiška	24	Biomass	140,000
14	East Sarajevo	Toplane - INS a.d. East Sarajevo	11	Mazut	37,100
15	Bijeljina	JP "Gradska toplana" Bijeljina	7.2	Coal	64,000
16	Čelinac	JP "Gradska toplana" Čelinac	6	Coal	50,000
17	Zvornik	"Zvornik stan" a.d. Zvornik	23.8	Natural gas	90,000
18	Gračanica	"Eko toplane" d.o.o. Gračanica	17	Biomass	85,000
19	Novi Travnik	District heating plant Novi Travnik-"UNIS Energetika" d.o.o.	51.2	Coal	20,000
20	Travnik	District heating plant Travnik - "UNIS Energetika" d.o.o.	54	Coal	200,683
21	Tešanj	JP "Toplana" d.d. Tešanj	13	Coal	72,190
22	Kalesija	KP "Komunalac" d.d. Kalesija	1.3	Coal	4,400
23	Sokolac	JKP "Sokolac" Sokolac	6.5	Biomass	26,195
24	Livno	ESCO ECO ENERGIJA d.o.o. Livno	7	Biomass	-
25	Banovići	JP "Toplana" d.o.o. Banovići	11.7	Coal	93,400
26	Srebrenik	JP "9. Septembar" Srebrenik	4	Wood biomass	-
27	Zavidovići	JKP "Radnik" d.o.o., boiler room "Samačka"	3.2	Coal	10,906
		JKP "Radnik" d.o.o., boiler room "Parnjača"	9.5	Coal	6,120
28	Bugojno	Toplana OR "Bade" Bugojno	-	Coal	-
29		"Kvatro" d.o.o. Bugojno	-	Coal	-
30	Breza	JP "Komunalno" Breza	5	Coal	15,308
31	Žepče	JP "Komunalno" Žepče	6.3	Coal	6,900
32	Ugljevik	"Termo Nova" d.o.o. Ugljevik	-	Coal	-

The fuels used are natural gas, heat from thermal power plants, biomass and coal are used. District heating systems in Bosnia and Herzegovina that are located near thermal power plants and industrial facilities are specific for using thermal energy from those plants (Tuzla, Lukavac, Kakanj, Ugljevik, Zenica). Some of these plants required steam for their technological processes. Due to this connection between district heating and industrial plants, district heating systems that rely on such plants are designed to use steam to produce boiling and/or hot water for heating purposes. District heating systems also exist in small places - mostly small systems for the needs of public institutions and small settlements. The concentration of district heating systems in the areas of coal basins is evident, and a number of business entities that supply thermal energy are connected to local thermal power plants that use local fuel.

District heating systems in Bosnia and Herzegovina are very diverse in terms of different aspects. If the fuel type is taken into account, Sarajevo and Zvornik are the only ones to use natural gas. It is because these two cities are located on the gas pipeline route. There are several initiatives for cities located near the gas pipeline route to also connect to the pipeline and use natural gas as the primary energy source, but there are no concrete activities in this direction due to relatively high natural gas prices. Banja Luka and Prijedor used mazut as fuel in the heating plants, which has been among the most expensive heating fuels. In 2017 and 2015, respectively, these two district heating systems switched to wood chips as the primary fuel, while mazut plants remained as an alternative option. Ultimately, most district heating systems in Bosnia and Herzegovina use coal as the primary fuel (Travnik, Zavidovići, Doboj, Tešanj, etc.). Some of them analyse the possibilities to switch to wood biomass. In the past few years, there is a strong trend of transition to biomass (from liquid fuels) as well as the construction of several new district heating systems using biomass in Livno, Gračanica, Gradiška, then aforementioned Prijedor and Banja Luka, and other cities. This is why the consumption of wood chips increased multiple times in the last five years.

The largest district heating system is in Sarajevo, where the installed capacity of all boiler rooms within the heating system is around 522 MW, while the maximum engaged capacity is around 332 MW. In the Federation of Bosnia and Herzegovina, only Sarajevo has local boiler rooms and a system of separate heating networks. The largest investments in the modernization of the system were made within this heating system. Local measurement of delivered heat to end customers has been partially introduced. The fuel price (natural gas) is in line with the price for households, which means that this system does not have the status of privileged producer in relation to the natural gas distributor. The operation of district heating in Lukavac, which is connected to TPP Tuzla by a 20-kilometer hot water pipeline, is a good example of the functionality of district heating dislocated at a greater distance and the possibility of expanding the networks of heating systems in this way. What is specific for all heating systems in the Federation of Bosnia and Herzegovina is that heat is used almost exclusively for space heating (in very rare cases, it is used as process heat for industry), while heat energy from the heating system is used for the preparation of domestic hot water only in some collective housing facilities in Sarajevo.

District heating systems in the Republika Srpska rely on own boiler rooms, which use biomass, coal and natural gas as fuel, and mazut is used as a reserve fuel in some systems. Operations and opportunities to invest in reconstruction and development here also depend on the percentage of service charge, which is variable. Like in the Federation of Bosnia and Herzegovina, the delivered heat in the Republika Srpska is used almost exclusively for space heating, and not for the preparation of domestic hot water.

Oversize is the general problem of almost all systems built by the late 1990s. Plants were designed for a much larger number of users than they currently supply. In addition, the method of calculation of heat demand was such that the system could heat buildings adequately at extremely low outdoor temperatures. Since all systems only supply heat for space heating (not for domestic hot water), their annual utilization is about 20%. In addition to high heat losses, hot water leakage also constitutes a problem. In the case of underground pipelines, it is very difficult to detect leaks. Low energy efficiency of buildings is an additional problem. Having in mind the tariff

system, which is mostly based on payment per square meter of heated space, it has a particularly negative impact on the sustainability of district heating systems.

4.3.2 Review of scenarios for reducing greenhouse gas emissions from the district heating sector by 2050

In order to overcome the existing situation, it is necessary to take a number of measures that would lead to an increase in the overall efficiency of production and distribution of thermal energy, and thereby the competitiveness of companies for the production and distribution of thermal energy. The applicability and representation of these measures will be different for each of the district heating systems, but in general these measures would lead to a significant improvement in the functioning of the entire district heating system. In general, these measures can be divided to production and distribution measures and consumption measures.

According to GIZ[110] data, consumption of fuels based on wood residues amounted to about 220,000 tonnes in 2015. In 2020, the utilization of the natural potential of wood residues is expected to be slightly above 11%. This speaks of the growth potential of biomass share in district heating systems.

The strategic goal is to increase the share of district heating in the total heat demand by about three times compared to the existing one (in 2016), i.e., by about 25% until 2050. This means that Bosnia and Herzegovina will be closer to the EU target for 2030 (30% share of district heating in total heat demand). The specific consumption of thermal energy declines in accordance with the application of existing legislation, but a significant improvement of the legislation is planned during the forthcoming period. Renewable energy sources, primarily biomass (mainly in cogeneration plants) and geothermal energy, are being increasingly introduced to district heating systems, with a part of thermal energy being used for central preparation of domestic hot water (DHW). These measures, along with appropriate legislative solutions (e.g., ban on the use of coal in individual furnaces in some cities), would significantly contribute to the improvement of air quality in those cities, increase of housing comfort, and improvement of business conditions of district heating companies. The construction of several cogeneration plants for thermal treatment of waste is also planned, as well as discontinuation of the use of coal and mazut in district heating systems from 2035, and an increase of efficiency in the production and distribution of thermal energy. All scenarios for the development of district heating envisage the expansion of district heating systems, as well as the use of renewable energy sources, but to a different extent.

Reference scenario (S1) - Only new facilities will be connected to the district heating system, with lower energy consumption, and the share of individual fuels will remain as envisaged in the existing strategic documents). The percentage of district heating will not change in relation to the existing one, and neither will the efficiency of production and thermal energy distribution, and the scenario does not envisage the establishment of new district heating companies.

Moderate mitigation scenario (S2) - New consumers are gradually joining the district heating system on a larger scale; therefore, in terms of percentages, the number of households covered by the district heating system is about twice as high as the current one in 2050. Energy dispersion remains as envisaged by strategic documents with a higher share of renewable energy sources (biomass, geothermal energy). This scenario envisages the establishment of a district heating company in Brčko, which would use biomass as fuel, as well as heating of cities in Sarajevo and Zenica with thermal energy from the Kakanj Thermal Power Plant. All these measures should contribute to the improvement of housing comfort, higher overall efficiency of thermal power plants and

[110] Conduction of a biomass market survey in Bosnia and Herzegovina, GIZ, 2018.

improvement of air quality in cities with district heating systems. This scenario also envisages slight efficiency increase in the production and distribution of thermal energy.

Mitigation scenario (S3) - This scenario envisages intense increase of district heating system coverage, so that, in percentage terms, the number of households covered by the district heating system will be about three times higher than the existing one in 2050. The specific consumption of thermal energy declines in accordance with the application of existing legislation, but a significant improvement of the legislation is planned during the forthcoming period. Renewable energy sources, primarily biomass (mainly in cogeneration plants) and geothermal energy, are being increasingly introduced to district heating systems, with a part of thermal energy being used for central preparation of domestic hot water (DHW). These measures, along with appropriate legislative solutions (e.g., ban on the use of coal in individual furnaces in some cities), would significantly contribute to the improvement of air quality in those cities, increase of housing comfort, and improvement of business conditions of district heating companies. This scenario envisages the construction of several small heating plants using municipal waste as fuel, as well as discontinuation of the use of coal and mazut in district heating systems from 2035, and an increase of efficiency in the production and distribution of thermal energy.

In S1, the heat production increases from 1,660 GWh in 2010 to about 2,000 GWh in 2050. The shares of individual energy sources change slightly. By 2035, the use of liquid fuel will cease, and the use of coal will decline. Thermal power plants and natural gas heating plants have the largest share in heat production in 2050. The share of biomass and natural gas co-generation plants is also significant. The share of biomass grows significantly, continuing the trend that began in 2015-2018.

In S1, emissions will decrease until 2025 by about 100,000 tCO_2/year. This is the result of the transition of a part of district heating from liquid fuels and coal to biomass. This is followed by a trend of slight emission increase until 2050, when emissions amount to about 460,000 tCO_2/year. The emission reduction in this scenario is around 50,000 tCO_2/year in 2050 compared to 2010.

In S2, the heat production increases from 1,660 GWh in 2010 to about 2,200 GWh in 2050. The shares of individual energy sources change significantly. By 2030, the use of liquid fuel will cease, and the use of coal will decline significantly. Thermal power plants have the largest share in heat production in 2050, almost 50% (introduction of heating in Zenica and Sarajevo from TPP Kakanj). The share of biomass grows significantly, continuing the trend that began in 2015-2018. It is also important to note that district heating systems begin to use geothermal energy and solid waste.

In S2, emissions vary until 2030, when they amount to about 40,000 tCO_2 less than in 2010. This is the result of the transition of a part of district heating from liquid fuels and coal to biomass, and of the expansion of existing district heating systems to fossil fuels (including heat from coal-fired thermal power plants.) This is followed by a trend of slight emission increase until 2040, when emissions amount to about 540,000 tCO_2/year due to increased use of heat from thermal power plants. This period is followed by a slight emission decline. In this scenario, the emissions in 2050 are at the level of the 2010 emissions.

In S3, the maximum heat production of about 2,200 GWh is reached in 2030, which is followed by a decline in production, and therefore the production is slightly lower in 2050 than in 2010. Despite intensive increase of district heating coverage, production declines due to increased energy efficiency of users. As in S1 and S2, S3 envisages discontinuation of the use of liquid fuels in district heating systems by 2035. Coal use also ceases by 2035. The use of heat from thermal power plants and production from natural gas are reduced due to energy efficiency of users (there is no construction of new systems using these two heat sources). The heat obtained from biomass either through cogeneration plants or plants that produce only heat accounts for the largest share in 2050.

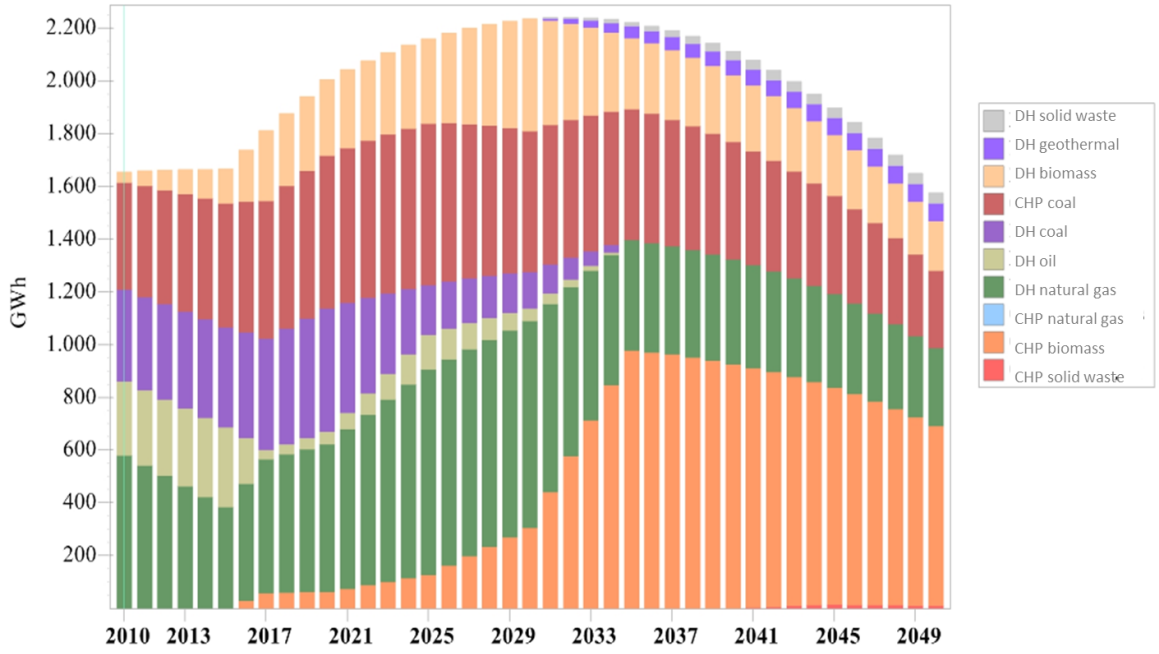


Figure 60: Trend of heat production in district heating systems by energy sources until 2050 according to mitigation scenario (S3)

GHG emissions reach maximum level in 2016. After that, emissions decrease until 2020 due to the transition of a part of district heating systems to biomass and the application of energy efficiency measures. Emissions then stagnate because of heat production increase as shown in Figure 60. After 2025, the trend of declining emissions continues until 2050, with a much more intense emission decrease until 2035. Natural gas and coal cogeneration systems are sources of GHG emissions after 2035. The slight emission reduction is caused by an increase in energy efficiency from production to use of energy. Emissions in 2050 are by about 330,000 tonnes of CO_2 or 2.7 times lower than in 2010. Emissions in 2050 stand at around 37% of 2010 emissions.

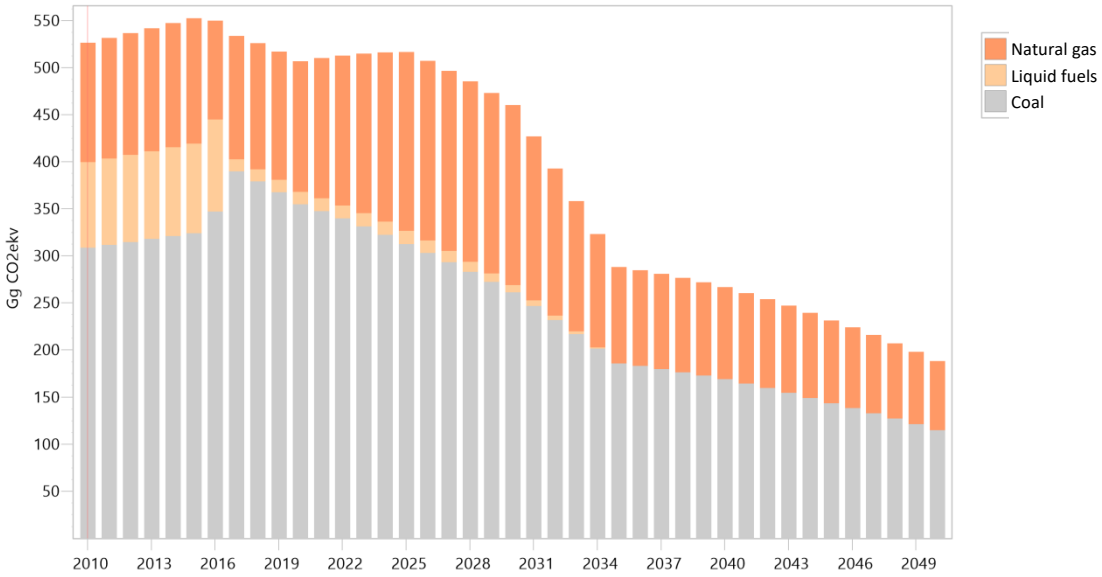


Figure 61: Carbon dioxide emission trend in district heating systems according to mitigation scenario

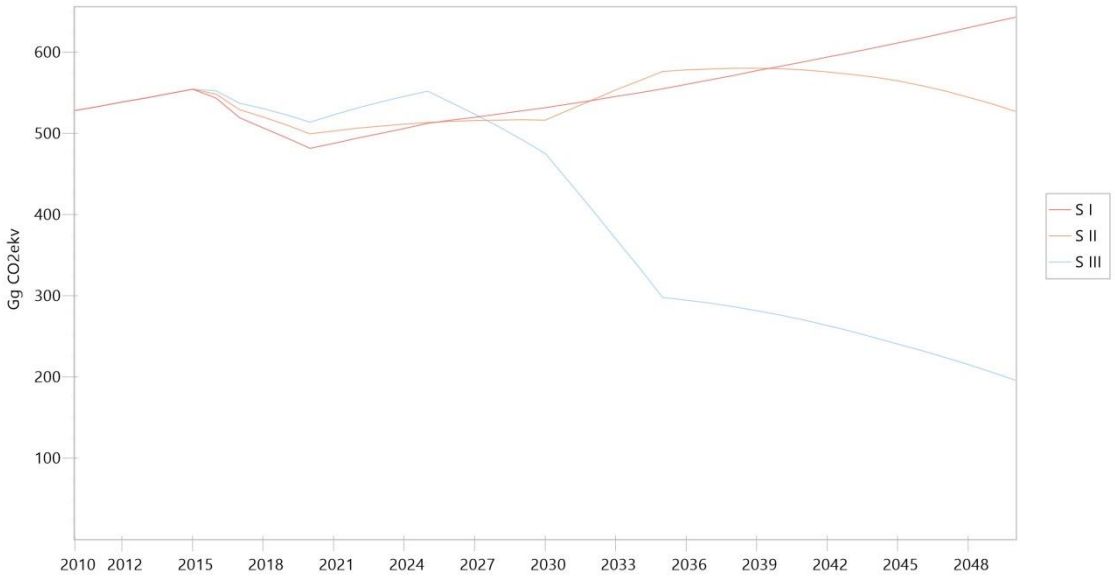


Figure 62: Carbon dioxide emission trends for three analysed scenarios of district heating development in BiH

Figure 62 presents carbon dioxide emission trends for all three analysed scenarios. It should be emphasized that S1 foresees an increase in emissions, and according to S2, emissions in 2050 are close to the emission level from 2010. Emission decrease according to S3 is described above.

To achieve the S3 development of the district heating sector in Bosnia and Herzegovina by 2050, it is necessary to implement the following measures:

(i) Installing of cumulative (at the level of a building) and individual (at an apartment level) heat meters in all buildings included in district heating system

The Law on Energy Efficiency was adopted in 2017 in the Federation of Bosnia and Herzegovina. This law, among other things, requires that energy suppliers install individual energy consumption meters for the end consumers at an appropriate pace (8% per year for the first 5 years, and then 12% per year). Users will cover the installation costs. The Law on Energy Efficiency in the Republika Srpska was adopted in 2013, and it also requires energy suppliers and distributors to install individual energy consumption meters, but it does not prescribe a time period for completion of the installation. Cumulative and individual heat meters should be installed in all buildings covered by the district heating system. This measure should be implemented in 2020-2030.

It is estimated that the implementation of this measure could reduce carbon dioxide emission by about 33,804 tCO_2 in 2030, or by about 39,400 tCO_2 in 2050 compared to the emission value if this measure were not implemented. This estimate was made based on the emission calculation in accordance with the IPCC methodology.

(ii) Reconstruction and modernization of district heating network and heating substations

Implementing this measure would improve housing comfort (all users would have the same quality of heating service), reduce distribution losses, increase the overall efficiency of the heating system, which should result in lower heat prices, reduced carbon dioxide emissions, reduced fuel consumption, and air quality would be improved due to the reduction of pollutant emissions in heating plants/industrial power plants. This is a necessary measure for further network expansion in many district heating systems. These projects should be continuously implemented until 2050.

Appropriate support will be needed for the implementation of this measure (institutional - providing guarantees for required loans, creating an appropriate legal environment, and financial support - favourable loans for the implementation of this measure, i.e., providing grants (20-30%) for the implementation of this measure, encouragement of private investors to invest).

It is estimated that the implementation of this measure could reduce emission by about 8,500 tCO_2 in 2030, and by about 40,000 tCO_2 in 2050 compared to the emission value if this measure were not implemented. This estimate was made based on the emission reduction calculation in accordance with the IPCC methodology.

The estimated costs of implementing this measure by 2030 would amount to 175,000,000 BAM, and in 2030 - 2050 the additional 525,000,000 KM (i.e., a total of 700,000,000 KM by 2050). These costs can be significantly reduced by combining network works with other infrastructure works (water supply systems, IT infrastructure, etc.).

4.4 Buildings

4.4.1 Overview of situation in the building sector

The building sector in Bosnia and Herzegovina which includes households and buildings where public and commercial services are provided consumes around 58.44% of total energy. This consumption amounts to about 40% in developed countries, but due to the relatively high energy needs (primarily heating) of the existing building stock on the one hand and underdeveloped industry on the other, the share of the building sector is significantly higher than in developed countries. Considering this, one of the priority goals should be to find ways to reduce energy consumption in both existing and new housing facilities.

Wood biomass and coal constitute the main source of heating energy in Bosnia and Herzegovina. Around 88% of the residential sector use individual boilers and furnaces for heating. A relatively low efficiency level, below 60% is the main characteristic of these energy conversion technologies both for coal and biomass. The market of boilers and furnaces is not regulated and some manufacturers on the market do not have adequate certificates of efficiency of their products.

On the other hand, imported boilers and furnaces are used that are not designed for domestic coals, which causes low efficiency of conversion of primary into useful energy and higher air pollution. According to the data from the Household Energy Consumption Survey conducted by the Agency for Statistics of Bosnia and Herzegovina in 2015[111], the dominant method of heating is with indoor furnaces with a share of 72.90%, 7.9% of households are heated by district heating, and about 19% households have their own central heating systems.

According to TNC data, the following fuels are used for indoor furnaces: firewood 77%, electricity 12%, natural gas 2% and coal 9%. These data indicate that the share of coal in individual heating systems is very small. This is because official statistics do not consider the black market of coal (private pits and coal theft).

Residential building stock in Bosnia and Herzegovina comprises 861,965 buildings that include 1,619,865 housing units – apartments, of the total gross size of 162,928,630 m^2. An extremely dominant type of residential buildings are single-family houses with 93.91% share in the total number. Their total size amounts to 120,100,130 m^2 (73.71% to total residential stock). They include the largest number of housing units (63.49%), while high-rise buildings account for the smallest number of housing units (0.79%).

[111] Preliminary results of household energy consumption survey, BiH Statistics Agency, 2015, http://www.bhas.ba/tematskibilteni/PotrosnjaEnergijeFinalSR.pdf.

Electricity production in households according to 2015 Survey is shown in Table 20.

Table 20: Overview of electricity production in households[112]

	Annual electricity consumption per household kWh	Annual electricity consumption per unit of heated area kWh/m²
Bosnia and Herzegovina	4,568.2	89.22
Federation of BiH	4,483.8	80.35
Republika Srpska	4,700.4	91.80
Brčko District	4,906.0	97.53

Total size of public and commercial buildings in Bosnia and Herzegovina is approximately 19,950,000 m^2. The territorial distribution of commercial buildings (shops, department stores, shopping malls, hotels, restaurants, etc.) and public buildings (administration, all-day stay, culture, upbringing, education, sports, health) is shown in Table 21.

Table 21: Territorial distribution of public and commercial buildings in Bosnia and Herzegovina

Area	Total size m²	Public buildings m²	Commercial buildings m²
Bosnia and Herzegovina	19,950,000	9,075,439	10,874,561
Federation of BiH	13,396,500	5,191,287	8,205,213
Republika Srpska	6,214,500	3,644,839	2,569,661
Brčko District	339,000	239,313	99,687

4.4.2 Review of scenarios for reducing greenhouse gas emissions in the building sector by 2050

Various measures that result in the reduction of energy consumption and thereby in GHG emissions in the building sector are provided for the residential and commercial sectors separately for the Federation of Bosnia and Herzegovina, the Republika Srpska and Brčko District of Bosnia and Herzegovina.

4.4.2.1 Residential buildings

According to the available data related to overall trends in society, the most important ones being those related to increased population emigration and the expected GDP growth from 2015 to 2050, the expected increase in heated residential areas is 1% per year. This percentage includes an increase in newly built residential areas, but also an increase in heated areas, especially in the sector of individual family houses (Table 22).

[112] Preliminary results of household energy consumption survey, BiH Statistics Agency, 2015,http://www.bhas.ba/tematskibilteni/PotrosnjaEnergijeFinalSR.pdf,
Preliminary results of household energy consumption survey, BiH Statistics Agency, 2015,http://www.bhas.ba/tematskibilteni/PotrosnjaEnergijeFinalSR.pdf,

Table 22: Territorial distribution of net heated areas in 2015-2050

Area	Net heated areas in m^2 per year	
	2015	2050
Federation of BiH	36,013,474	48,618,190
Republika Srpska	22,435,720	30,288,222
Brčko District	1,954,603	2,638,714
Bosnia and Herzegovina	60,403,797	81,545,126

The reference scenario (S1) predicts that there will be no major changes in current trends without any special measures to improve the energy efficiency of existing and new buildings. The only measure is the implementation of new legislation governing energy efficiency of residential buildings that has already been adopted or is being modernized, which should lead to a reduction in average consumption of energy for heating of residential buildings to a maximum of 140 kWh/m2a by 2050.

The moderate mitigation scenario (S2) envisages the implementation of energy renovation measures for existing buildings, as well as the construction of new energy efficient buildings, which should lead to an average energy of 95 kWh/m2a for heating of residential buildings by 2050. In addition to the renovation of old residential buildings in order to improve their energy efficiency and thus reduce energy consumption for their heating, increase of the percentage of centrally heated apartments through district heating system to 25% in the Federation of Bosnia and Herzegovina and to 14% in the Republika Srpska is envisaged. Also, a gradual reduction in the use of coal and fuel oil for heating is envisaged, which should lead to their complete elimination from use in 2025. Greater use of RES via solar collectors is envisaged for DHW preparation. It is predicted that the consumption of energy used for the preparation of DHW will increase by 1.2% per year, caused by the rising living standard.

The mitigation scenario (S3) has a lot of similarities with scenario S2, except that RES are applied more intensively, as well as measures to improve the energy efficiency of existing buildings by performing works on their renovation, and intensive implementation of EU directives and regulations. It is envisaged that, altogether, this will lead to energy need of 70 kWh/m^2 for heating of residential buildings in 2050. Also, the share of centrally heated apartments increases, because the degree of urbanization rises, and it will reach 35% in the Federation of Bosnia and Herzegovina, and 20% in the Republika Srpska. In accordance with the adopted strategies of the Federation of Bosnia and Herzegovina, the Republika Srpska and Brčko District of Bosnia and Herzegovina, a change of fuels can be expected, as well as the cessation of the use of coal and fuel oil by 2025. Greater use of RES is also envisaged, primarily through the use of solar collectors for DHW heating as well as heat pumps for heating of buildings. Due to the increase of the living standard of citizens, annual increase by 1.5% in energy consumption for the preparation of DHW is expected.

GHG emission trends according to the described scenarios are shown in Figure 63.

Figure 63: Trend of carbon dioxide emissions in residential buildings for analysed scenarios until 2050

2050 emissions in S3 are by around 59% lower than 2010 emissions. An approximate level of reduction is also achieved in S2, while emission in S1 is higher by about 48% in 2050 compared to 2010.

4.4.2.2 Commercial and public buildings

Based on existing pace caused by change of habits and economic trends, commercial buildings sector is expected to grow at an annual rate of 2%. Based on that, increase in size of commercial buildings is expected as shown in Table 23 by periods and territorial distribution.

Table 23: Territorial distribution of net heated areas of commercial buildings in 2015 and 2050

Area	Net heated areas in m² per year	
	2015	2050
Bosnia and Herzegovina	19,950,000	33,915,000
Federation of BiH	13,396,500	22,774,050
Republika Srpska	6,214,500	10,564,650
Brčko District	339,000	576,300

Reference scenario (S1) - No significant change is foreseen in relation to the current trends, and this sector is expected to develop faster than residential sector with an annual increase of 2%. There are no special measures that would result in improving the energy efficiency of buildings, except for the application of new regulations governing the energy performance of buildings.

Moderate mitigation scenario (S2) - Improving the energy efficiency of already constructed buildings, and construction of new, energy efficient ones with "smart" technologies will lead to reduced consumption of energy, especially the energy used for heating of buildings, but also of overall energy. The transition from high-emission fuels to lower-emission fuels used for heating is envisaged, which implies greater use of gas but also of RES, especially solar and geothermal energy. In view of the climate change, energy consumption for cooling of buildings is also expected to increase.

Mitigation scenario (S3) – Like S2, this scenario foresees the implementation of measures to improve energy efficiency of existing buildings, and thereby decrease energy consumption for heating of buildings, as well as more significant utilisation of RES, especially geothermal energy. New buildings will be constructed as energy efficient with the application of the so-called 'smart' technologies that will reduce energy consumption to a minimum, without negatively affecting the users' comfort and the performance of necessary functions. In addition to RES, natural gas will be increasingly used as fuel, and discontinuation of the use of high-emission fuels such as coal and fuel oil is also envisaged.

GHG emission trends according to the described scenarios are shown in Figure 64.

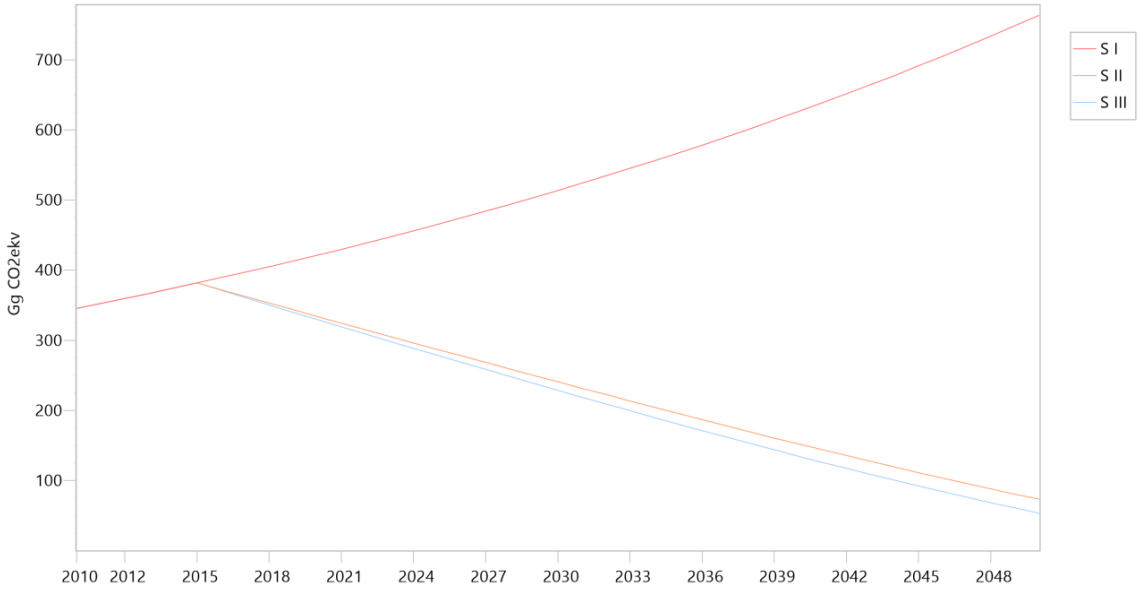


Figure 64: Trend of carbon dioxide emissions in public and commercial buildings for analysed scenarios until 2050

2050 emissions in S3 are by around 85% lower than 2010 emissions. An approximate level of reduction is also achieved in S2, while emission in S1 is by about 2,2 times higher in 2050 compared to 2010, which is caused by sector growth without a significant implementation of energy efficiency measures.

4.5 Transport

4.5.1 Overview of situation in the transport sector

Total length of road network in Bosnia and Herzegovina is 22,976 km. Observed according to the categorization, motorways account for 172 km, main roads for 3,870 km, regional roads for 4,734 km, and other/local roads for[113]14,200 km.

[113]Framework transport strategy of Bosnia and Herzegovina http://www.mkt.gov.ba/aktivnosti/default.aspx?id=5029&langTag=bs-BA

Table 24: Length of road network in Bosnia and Herzegovina

Road category	Length of roads in km			
	Federation of BiH	Republika Srpska	Brčko District	Bosnia and Herzegovina - Total
Motorway	92	80	-	172
Main road	2,068	1,765	37 *	3,870
Regional road	2,546	2,151	37 *	4,734
Local road				14,200[114]
TOTAL	**4,706**	**3,996**	**74**	**22,976**

**Data obtained based on total length of roads in Bosnia and Herzegovina*

The total of 1,080,873 motor vehicles were registered in 2018. The number of first-time registered vehicles in the same year is 89,292. Comparing the data from previous Climate Change Reports, one can conclude that the number of registered motor vehicles increases every year. Observed by structure, as much as 85.19% accounts for passenger vehicles. Percentage shares of other vehicle categories in 2018 are shown in Table 25.

Table 25: Structure of registered vehicles in Bosnia and Herzegovina in 2018

Vehicle category	Number of registered vehicles	%
Mopeds	4,787	0.44
Motorcycles	10,552	0.98
Passenger vehicles	920,841	85.19
Buses	5,212	0.48
Cargo vehicles	98,593	9.12
Trailers	33,588	3.11
Other	7,300	0.68
TOTAL	**1,080,873**	**100**

/Source: Agency for Statistics of Bosnia and Herzegovina/

According to the available data on registered motor vehicles by type of energy used (data available for the following vehicle categories: passenger vehicles, buses, cargo vehicles), 22.61% of vehicles use petrol, 72.3% of vehicles use diesel, while the remaining 5.09% use some of the alternative energy sources. Detailed overview of these data is provided in Table 26.

Table 26: Fuel for registered vehicles in Bosnia and Herzegovina in 2018

Fuel	Vehicle category			Total	%
	Passenger vehicles	Buses	Cargo vehicles		
Petrol	228,739	1	2,966	**231,706**	22.61%
Diesel	652,001	4,330	84,488	**740,819**	72.3%
Alternative energy	40,101	881	11,139	**52,121**	5.09%

/Source: Agency for Statistics of Bosnia and Herzegovina/

[114] Framework transport strategy of Bosnia and Herzegovina http://www.mkt.gov.ba/aktivnosti/default.aspx?id=5029&langTag=bs-BA

The volume of road transport in Bosnia and Herzegovina is shown through two indicators: (i) goods transport, and (ii) passenger transport. Comparing the data from previous Climate Change Reports and based on available data for 2015, 2016 and 2017, it can be concluded that the volume of transport in Bosnia and Herzegovina follows an upward trend. Observed in public road transport, 10,123,000 tons of goods were transported in 2017, and the number of tonne-kilometres amounted to 4,280,222,000. As for public passenger transport, 15,906,000 passengers were transported, number of passenger kilometres was 1,661,840,000, and vehicles passed 586,216 kilometres. If we look at the volume of passenger transport in urban and suburban transport separately, the data indicate that 130,502,000 passengers were transported, and that vehicles passed 63,572 kilometres. Table 27 provides a more detailed presentation by year with a percentage decrease or increase in transport volume indicators from one year compared to another.

Table 27: Transport volume in Bosnia and Herzegovina

Transport	Type of transport	Year		Increase/decrease in 2016 compared to 2015	Increase/decrease in 2017 compared to 2016
		2015	2016		
Public road transport	**Transport of goods**				
	Kilometres passed by vehicles	458,147	507,985	+10.88%	+15.4%
	Tons of goods transported	8,288,000	9,377,000	+13.14%	+7.96%
	Tonne-kilometres	3,405,231,000	4,015,177,000	+17.91%	+6.60%
	Passenger transport				
	Kilometres passed by vehicles	87,254,000	85,475,000	-2.04%	+9.95%
	Transported passengers	20,471,000	16,505,000	-19.37%	-3.63%
	Passenger kilometres	1,690,393,000	1,706,372,000	+0.95%	-2.61%
Urban and suburban transport	Kilometres passed by vehicles	60,592,000	62,937,000	+3.87%	+1.01%
	Transported passengers	138,705,000	131,776,000	-5.00%	-0.97%

/Source: Agency for Statistics of Bosnia and Herzegovina/

Considering the rising number of registered passenger vehicles, the growth of passenger kilometres in this segment is also estimated. Estimated number of passenger kilometres in 2017 is 9,000,909,292, which is by around 12% higher compared to 2010.

According to data from 2017, the railroad network in Bosnia and Herzegovina consists of 1,018 km of railways, of which 601 km are located in the Federation of Bosnia and Herzegovina, and 417 km in the Republika Srpska. The amount of transport of goods and passengers per railway kilometre is far below the European average. The current state of the railroad infrastructure is such that the increase in the volume of transport is impossible without major investments, and the existing amount of transport is insufficient to generate sufficient income to cover costs. Observed through goods transport and passenger transport, the volume of railroad transport in Bosnia and Herzegovina is shown in Table 28.

Table 28: Railroad transport volume in Bosnia and Herzegovina

Transport of goods	2015	2016	2017
Tons of goods transported	13,819,000	13,156,000	13,254,000
Tonne-kilometres	1,286,480,000	1,142,639,000	1,116,731,000
Passenger transport	**2015**	**2016**	**2017**
Transported passengers	518,000	409,000	472,000
Passenger kilometres	34,305,000	23,701,000	29,518,000

/Source: Agency for Statistics of Bosnia and Herzegovina

There is a noticeable decrease in both the number of passengers and the tons of goods transported in 2016 compared to 2015, and an increase in 2017. A similar decline followed by an increase is noticeable in the number of passenger kilometres, while the situation is slightly different when it comes to tonne-kilometres. The number of tonne-kilometres is on a slight decline from year to year.

Data on air transport indicate that 27 airports are officially registered in Bosnia and Herzegovina. However, only 4 airports are registered for international transport: Sarajevo, Banja Luka, Mostar and Tuzla. Data on transport volume apply to these 4 airports. Sarajevo Airport has the largest volume of transport in terms of the number of transported passengers, with 957,969 out of the total of 1,556,896 transported passengers in 2017. Other airports have a smaller number of passengers, but observing the 2012-2017 period, the total number of passengers in air transport is increasing. The number of airport operations in 2017 amounted to 19,018, which is an increase by as much as 13.79%, given that the number of airport operations in 2016 amounted to 16,713.

Bosnia and Herzegovina has a very short sea coast in Neum and does not have regulated or adequate access to international waters, nor a regulated seaport. The most important international port for the economy of Bosnia and Herzegovina is Ploče Port in Croatia, with a capacity of 5 million tons per year. The Sava River is the main navigable river in Bosnia and Herzegovina, 333 km long. Also, Brčko Port is a very important trans-shipment and transport-distribution centre, with an annual turnover of 125,461 tons in 2017.[115] Water transport along the Sava is connected to the Danube, which is considered the Trans-European Transport Corridor VII. The main features of rivet transport situation in Bosnia and Herzegovina are: neglected waterways, lack of technologically modern fleet (towing instead of thrust), technical and technological obsolescence, as well as the devastation of ports and the lack of shipyards with slipways. As a positive fact, it should be noted that river navigation has the same institutional status as other modes of transport.

4.5.2 Review of scenarios for reducing greenhouse gas emissions from the transport sector by 2050

Three scenarios of carbon dioxide emissions in the transport sector were analysed for 2010-2050. The analysis was done in the LEAP program, taking into account the actual indicators for 2010 and 2017.

Reference scenario (S1) - based on the trends of increasing number of road motor vehicles at an average annual rate of about 3% (growth rates in 2012-2017), and the average age of the fleet between 12 and 15 years, without implementing type-approval measures, with an average annual rate of increase in diesel and petrol consumption of 2%. This scenario assumes that GHG emissions produced by road motor vehicles will grow somewhat slower than the number of vehicles (due to a mild increase in vehicle energy efficiency). As for the age of the vehicle fleet in Bosnia and Herzegovina, it is estimated that the average carbon dioxide emission from road motor

[115]Data from PoWER project – Ports as driving Wheels of Entrepreneurial Realm; European Project funded under the INTERREG V B ADRION Programme; strategic partner from BiH: CETEOR: Centre for economic, technological and environmental development Sarajevo

vehicles is about 185 g CO_2/km (with an average consumption of 6.5 l/100 km for diesel and about 7.0 l /100 km for petrol vehicles). This scenario is also based on existing domestic legislation and trends from other transport sub-sectors in Bosnia and Herzegovina. S1 also envisages an increase in the volume of freight transport while maintaining the existing ratio of road and rail transport in total tonne-kilometres.

Moderate mitigation scenario (S2) - is based on the introduction of additional technical measures for road motor vehicles in terms of improving engine energy efficiency and reducing fuel consumption. According to this scenario, the growth rate of the number of road motor vehicles is identical to that in S1, but the quality of the fuel used as well as the road infrastructure are expected to improve (shorten the distances between cities). Reduction of the average age of road vehicles to 12 years by 2025 is a significant element of this scenario. The main characteristic of this scenario is the reduction of emission coefficient from 185 gCO_2/km in the base year to 150 gCO_2/km in 2025, then to 120 gCO_2/km by 2040, and to 100 gCO_2/km by 2050. This trend is, among other things, the result of the growing share of hybrid, electric and plug-in vehicles as well as compressed natural gas vehicles). In addition, the introduction, implementation and enforcement of EU directives in the field of transport is envisaged from 2025. Like S1, it also envisages an increase in the volume of freight transport with continuous growth of the share of rail transport in total number of tonne-kilometres.

Mitigation scenario (S3) - based on more significant mitigation, i.e. reduction of emissions from transport, compared to the reference scenario, through the implementation of EU directives in Bosnia and Herzegovina by 2025 (better quality fuel, more efficient motor vehicles, better tires, introduction of new regulations on imports of road motor vehicles, compliance with EU Regulation 443/2009 on limiting carbon dioxide emissions from new passenger vehicles to 95 gCO_2/km from 2021 and subsidizing purchase of electric and plug-in vehicles), building more efficient road infrastructure and flow of vehicles, introduction of measures in urban/city transport that results in reduced emissions, and a significant increase in railroad transport (50% by 2030, and 75% by 2050 participation in freight transport). The outcome of all measures is the emission factor reduction by 2030 to 100 gCO_2/km, and to 70 gCO_2/km in 2050. Like previous scenarios, this one includes the same trend of increasing number of vehicles. According to this scenario, the share of vehicle using alternative fuels in 2050 is 40%.

Figure 65 shows emission trend for the above described scenarios.

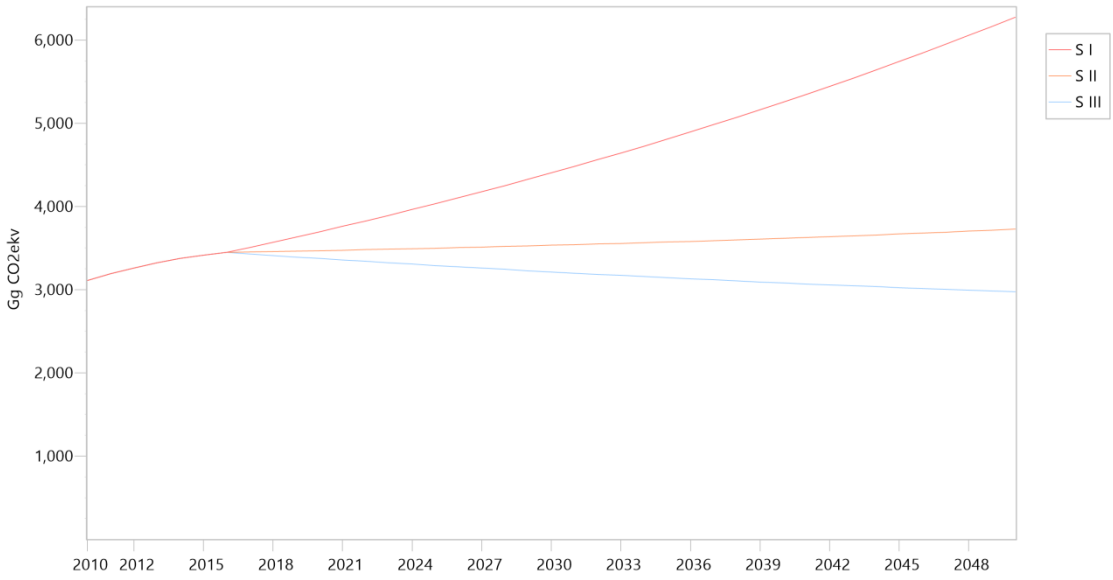


Figure 65: Trend of carbon dioxide emissions in transport for analysed scenarios until 2050

Transport development according to S1 causes continuous emission increase. This is a consequence of the constant growth in the volume of both passenger and freight transport without active policy measures aimed at reducing emissions. At the end of the analysed period, the emission is approximately twice as high as in 2010. Taking into account the share of carbon dioxide emissions from transport in total emissions in Bosnia and Herzegovina, such a scenario would mean a significant increase in total greenhouse gas emissions. Unlike S1, S2 keeps emissions at existing level with the application of win-win measures (efficiency, growth of the share of railway traffic, etc.) and relatively small incentives for alternative fuel vehicles. One can say that the emission until 2030 is practically at the 2017 level, which means that the aforementioned measures compensate for the growth of the transport volume. At the end of the period, the emission is by around 20% higher than in 2010, and only 8% higher than in 2017. Despite the slight increase, S2 is called the moderate mitigation scenario because it results in a significant emission reduction compared to the reference scenario. Unlike S1 and S2, S3 causes emission reduction. Despite the increase of transport volume, the emissions in 2030 plummet to the level of the 2010 emissions. 2050 emissions are by around 5% lower than 2017 emissions. Although the reduction in S3 seems insignificant, it should be emphasized that this reduction is achieved despite the significant growth of transport volume that can rightly be expected given that, by all indicators, transport in Bosnia and Herzegovina is underdeveloped today compared to EU Member States.

4.6 Agriculture

4.6.1 Overview of situation in the agricultural sector

According to the level of gross domestic product (GDP) generation, agriculture is a significant economic activity for Bosnia and Herzegovina. Data from the Agency for Statistics of Bosnia and Herzegovina indicate that the GDP of agriculture, forestry and fishing in 2016 amounted to 1.9 billion KM, which accounts for 6.37% in the GDP structure of Bosnia and Herzegovina. Agriculture, forestry and fishing recorded a slight increase compared to 2015, when the share of this sector in the structure of GDP was 6.24%.

According to the Labour Force Survey in 2016, the agricultural sector employed about 144,000 people (65% men and 35% women), which is 18% of the total number of employees in Bosnia and Herzegovina. Average number of employed persons was by 3,000 lower compared to 2015. Existing analyses and studies indicate a decrease in the number of inhabitants in rural areas, and an increase in the aging trend of the rural population.

Statistical data show that agricultural land in Bosnia and Herzegovina occupies about 47% of all land in 2016. In the structure of agricultural areas, the largest areas are covered by arable land and gardens (46.5%), pastures (26.8%) and meadows (19.4%).

There are no official data on irrigated areas in Bosnia and Herzegovina, but it is a very symbolic percentage of only 0.65%.

Average share of agricultural land per capita is 0.66 ha, and of arable land and gardens 0.31 ha. There is an evident trend of constant reduction of total agricultural land, and especially arable land. According to Ljuša et al (2015)[116], agricultural areas decreased by 11,323 ha in 2000–2012, with the decreasing trend clearly indicates the conversion of agricultural into artificial (built) areas (8,658.45 ha), neglect of agricultural land and transition to forest areas (2,329.47 ha), and water areas (318.70 ha). The trend of decreasing agricultural areas continued in 2012-2018, but to a much lesser extent. The data indicate that there was a decrease in agricultural land by 2,382 ha (Čustović et al., 2018). According to the presented data, in the post-war period in Bosnia and

[116] Ljuša, M., Cero, M., Čustović, H. (2015) Promjena namjene poljoprivrednog zemljišta i funkcija tla u Bosni i Hercegovini u periodu 2000–2012. godine, Radovi Poljoprivredno-prehrambenog fakulteta Univerziteta u Sarajevu, Godina LX, broj 65/1, 7–16.

Herzegovina, there is a continuous trend of arable agricultural land decrease, while the existing arable agricultural land is treated using outdated, technologically inadequate and energy inefficient machinery and other supporting technological equipment.

According to the data from the Census of Population, Households and Dwellings (2013), the total number of households engaged in agricultural activity is 363,394, of which 16% are commercial. Possessions are small and fragmented, which results in low productivity and modest overall efficiency. The production is mostly mixed. The total number of registered agricultural households in the Households Registry and the Clients Registry was 100,693 in 2016, and it is continuously increasing. These registered farms are entitled to incentives for agricultural production.

According to the estimates of the Agency for Statistics of Bosnia and Herzegovina (2016), almost half of the total area of arable land and gardens is not cultivated. 49% of arable land and gardens were sown. The structure of sown areas has not changed for many years. In the structure of total sown area, grains account for 58.9%, industrial crops 2.3%, vegetables 13.9% and fodder crops with 24.9%. Average yields are still very modest and far below the European average, which is a consequence of the lack of a clear specialization in plant production, but also very frequent adverse weather conditions.

Areas under organic farming in Bosnia and Herzegovina amount to 659 ha in 2016. Based on unofficial information, there are about 70 organic producers in the Federation of Bosnia and Herzegovina. There is no certified organic livestock farm, and two are in the conversion phase. In the Republika Srpska, 26 producers engaged in organic farming have been identified, and currently most of them are in the field of medicinal plants and berries.[117]

Livestock is one of the most important branches of Bosnia and Herzegovina's agriculture due to the high share of grassland in total agricultural land and the share of about 36% in the total value of agriculture. An extensive way of livestock breeding prevails.

A small part of the production is organized on modern, well-equipped farms. Data from the Statistics Agency of Bosnia and Herzegovina for 2016 show that, in terms of numbers, the highest number is that of the poultry (20.2 million), sheep (1.01 million), pigs (0.54 million), and cattle (0.45 million). The number of breeding stock and fattening cattle decreased, partly caused by the lack of domestic fodder, which was further reduced due to bad weather conditions. Also, the trend of inadequate disposal and application of manure is indicative.

Although agriculture is one of the most important branches in the Bosnia and Herzegovina economy, as is often stated in key documents, this sector has not been receiving sufficient attention. T The agricultural sector is marked by small farms, production for own use, and improper functioning of the local market. Poor production performance is caused by shortcomings of high mechanization level and lack of modern agricultural systems, technologies and knowledge. The farms are mostly mixed and given the still underdeveloped manner of their administration and management, they represent a potential problem due to the amount of produced and inadequately managed manure. However, this sector is already applying certain measures of farms management, which can potentially reduce emissions of harmful gases below the current level. Legislation related to the application of measures of good agricultural practice does not exist in our conditions, however, through implementation of individual projects such measures are being promoted and farmers are being trained. This issue should also be largely regulated by the EU Water Directive, which is soon to be adopted.

[117]Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina: 2017 Annual report on the agriculture, food and rural development for Bosnia and Herzegovina, May 2018

The reasons for the constant changes in the sown areas, assortment of cultures, below average yield, as well as the great stagnation of the sector in general lie in the agricultural policies applicable in the country.

Total allocated budget incentives for implementation of programmes and measures in the sector of agriculture and rural development in 2016 amounted to 155.94 million KM, which in comparison to 2015 is by 5.8 million KM more. Mechanisms and ways of implementing support remained unchanged, allocations for agriculture were insufficient, budgets were illiquid and there were many delays in the payment of incentives[118].

The area of uncultivated arable land and gardens is expected to increase, and some of these areas will be affected by succession and degradation processes, especially in marginalized areas and fragmented holdings. Without a strong policy shift, clearly defined goals for putting agricultural land under protection and in use, it is difficult to expect any significant changes in the sector.

In the observed period, at the state level, activities were focused on drafting the Rural Development Strategy of Bosnia and Herzegovina and activities related to the revision of the Strategic Plan and Operational Program for Harmonization of Agriculture, Food and Rural Development in accordance with the new Common Policy Framework in the European Union.

Still, it can be established that a progress has been made in the awareness of the entity ministries in charge of agriculture when it comes to climate change, its occurrence and effects on the agricultural sector, given that the new agricultural strategies of the Federation of Bosnia and Herzegovina and the Republika Srpska contain specific measures of mitigation/adaptation to climate change. However, it remains to be seen how the new agricultural strategies will be actually implemented and whether the annual action plans will keep up with the planned investments.

Since 2013, activities are carried out at the state level related to the development of regulations under the EU Council Regulation no. 834/2007, as well as implementation of standards governing organic production in Bosnia and Herzegovina. Apart from consultations, in 2016 there were no concrete activities in that regard. Laws on Organic Food are in force in the Federation of Bosnia and Herzegovina and the Republika Srpska are in force (in the Republika Srpska since 2013, and in the Federation of Bosnia and Herzegovina since 2016). Other adopted laws and regulations at all administrative levels make no explicit reference to climate change or mitigation/adaptation to the climate change, therefore they can be considered as regulations having an indirect impact on mitigation/adaptation measures.

When it comes to the EU accession policies, the 2016 Progress Report stated that “preparations in Agriculture and Fishing are in early stage”, and relating to Environment and Climate Change, the climate change part stated that the compliance level was limited, and it was recommended to carry out a climate change adaptation and low-emission development strategy.

4.6.2 Review of scenarios for reducing greenhouse gas emissions from the agricultural sector by 2050

Potentials for climate change mitigation in the field of agricultural production in Bosnia and Herzegovina can be observed from two perspectives: as sinks potentials and as a source of greenhouse gas emissions.

[118]Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina: 2016 Annual report on the agriculture, food and rural development for Bosnia and Herzegovina, May 2017

Potentials for the sink of greenhouse gases are defined by spatial scope and manner of use of agricultural land. The existing sink capacity of land and manners of use in Bosnia and Herzegovina for the main greenhouse gases amounts to approximately 1,305.3 Mt CO_2-eq.

Another aspect of research into the potential for climate change mitigation relates to the annual greenhouse gas emissions produced by the agricultural production sector.

For the scenario analysis we referred to two groups of factors that influence the development of the agricultural sector, external and internal factors. The external factors, in addition to climate change, primarily include: general trends on global, EU and regional levels, Bosnia and Herzegovina's entry into EU and trade liberalization. Of the internal factors, the most important ones include: vision for the development of agriculture and rural areas, legal framework in the country, policies, measures and investments that are directly linked to climate change - mitigation and adaptation, programme and incentive measures for agricultural production, use of pre-accession funds, trends and levels of production, reached level of technical and technological advancement of individual sectors, demand for domestic products.

Further below we analyse three scenarios for mitigation of climate effects in the agricultural sector, with the main starting points for each scenario as described.

Scenario S1 (baseline scenario): Starting point of the S1 scenario, from the standpoint of gas emissions in agriculture, is the least favourable. In this scenario, no major changes can be expected in terms of the development of the agricultural sector and sectoral policies. In addition, the share of agriculture in the overall economy remains at the same or similar level (up to 6.5% in GDP structure), which is significantly affected by climate change.

In the given circumstances, the industrial sector is not developing significantly, and therefore the pressure on agriculture will be increased in order to provide living conditions to the population. In such circumstances, the focus will be on increasing yield per unit area by introducing large amounts of mineral fertilizers and manure - according to estimates, up to 30% more nitrogen or 90 kg N on average. The increase in the application of mineral fertilizers, especially nitrogen, will vary depending on the region, and in areas with the expected presence of a drought effect (southern parts of Bosnia and Herzegovina) an increase in nitrogen application is expected by over 50%, 105 kg N on average. In addition to the above, an increase in irrigated areas of up to 3% is expected, which also increases the need for the use of mineral fertilizers, and thus increased greenhouse gas emissions. In some cases, natural meadows and pastures will be ploughed for the production of fodder for livestock. According to current trends, estimates show that the conversion of these areas for production purposes and for other purposes will increase by about 29% until 2040. Organic agriculture is not developing dynamically and it has a symbolic importance in the overall agricultural production. Generally, increased growth of livestock production by up to 20% is foreseen in milk production, cattle fattening and pig breeding by 2050. An increase in poultry of up to 35-40% can be expected by 2050. Such trends are expected due to the possibility of exporting meat, dairy products, eggs and poultry meat to the EU market. Along with the increase in livestock and poultry production, the need for feed production for livestock and poultry will grow. The same trend growth or higher by up to 20-30% on average can be expected, which will require an increased use of mineral fertilizers, manure and irrigation.

Similarly, increased use of land for non-agricultural purposes is expected, particularly from the point of view permanent losses in construction of infrastructure, settlements, exploitation of raw materials and similar, about 800 ha of agricultural land per year. The technologies used in agriculture and technical-technological measures will not follow world trends in this area. Measures of conservation and land development will be lacking, soil

moisture conservation measures and reduced processing will be applied at a low level. Degraded land areas will be expanded, with no significant measures for their remediation.

Agricultural practices will remain at the current level and Nitrates Directive will not be applied. Conventional agriculture standards will be partially applied. Furthermore, what should also be added is non-harmonized development of agriculture, rural area, incentive programmes and legislation in the country. Incentive measures remain at the current or lower level. The Strategic Plan for Rural Development of Bosnia and Herzegovina is not implemented according to the planned dynamics, there is no planned support to farmers to promote the introduction of new technologies that can help prevent or mitigate the effects of climate change. There is no strategy to combat drought or floods.

Scenario S2 – Starting point of S2 scenario is that there are positive changes and progress in the agricultural sector, and this is the most realistic scenario for Bosnia and Herzegovina. Starting points are that the share of agriculture in the overall economy of Bosnia and Herzegovina is increased, that the trends of use of agricultural land, as well as trends in production of agricultural products are improved, with an increase in average yields that still remain modest. Protected areas in all categories of protection are increasing and organic farming takes a significant share in the overall agricultural production. The total physical growth and productivity of agricultural and livestock production will be similar to that in scenario S1, but owing to the use of a series of mitigation measures, gas emissions will be lower in this scenario compared to S1.

Advanced technical and technological measures are used. Modest number of farmers apply Code of Good Practice. The Nitrates Directive is partially applied. Degraded land areas are becoming slightly smaller. There is a harmonized process of development of agriculture, rural area and villages in general. The concept of farm production is partially developed in accordance with the condition of the environment and available resources. Programmes of measures and incentives are partially harmonized, funds slightly increased and targeted towards officially registered farmers, especially those that apply for the introduction of new technologies that can help prevent or mitigate climate change effects. Rural development and planning take into account the principles of landscape design of rural areas in the concept of the construction of infrastructure, agricultural development and other secondary activities. LDN is implemented with the support of domestic and donor funding. Climate change is integrated into sectoral policies and strategies, and incentive programmes. Pre-accession funds are fully used. The Strategic Plan for Rural Development of Bosnia and Herzegovina is implemented at the planned pace and with the support of the Ministries of Agriculture of the Federation of Bosnia and Herzegovina, the Republika Srpska and Brčko District of Bosnia and Herzegovina that work together to implement target 6 of the Strategic Plan, as well as other strategies that directly or indirectly affect mitigation/adaptation measures. Financial resources have been provided for the implementation of the measures envisaged by the Strategy of Climate Change Adaptation and Low-Emission Development, which is becoming the backbone of activities along with the aforementioned plan. Thanks to policies and measures, awareness of climate change has increased, especially among farmers. Strategies to combat drought and floods have been developed and adopted.

Scenario S3 - Bosnia and Herzegovina as a full member of the EU is the starting point of the scenario S3. Upon joining the EU, the agricultural policy of Bosnia and Herzegovina develops in accordance with the Common agricultural policy and reaching the common European GHG emission reduction target by -20% until 2020, and by -40% until 2030 (-78,6 Mt CO_2eq per year.)[119]. The total physical growth will be similar to that in scenario S2, and productivity of agricultural and livestock production will increase additionally. Mitigation measures will be improved significantly, which should contribute to the decrease of total GHG emissions from agriculture. Efficient use of European funds and available funding for incentives and development of the sector (Pillar 1 and Pillar 2), as well as the so-called green payment for three measures: crop diversification, ecologically focused

[119] EEA (2018): Recent trends and projections in EU greenhouse gas emissions.

areas and permanent grasslands will be crucial. Climate change is fully integrated into sectoral policies and incentive programs. Strategic documents are implemented fully in accordance with action plans. Degraded land areas are successively renewed through recultivation and remediation measures. LDN is implemented with the support of domestic and donor funding. Farms have been modernised, high technical-technological measures and standards are applied, as well as Codes of good agricultural practice. The level of climate change awareness is high. Monitoring of the state of the environment and changes in space is well developed, and so is transparent reporting to both domestic and international public.

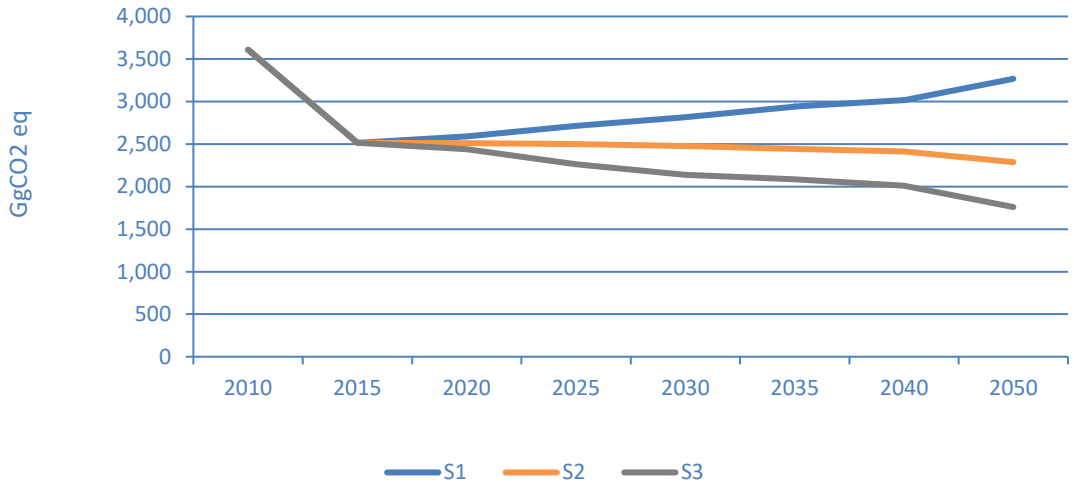


Figure 66: Total emissions of CO_2 -eq from agricultural sector in Bosnia and Herzegovina according to analysed scenarios by 2050

According to the presented indicators, the total GHG emissions in the agricultural production sector will, according to the S1 scenario, increase until 2050, when they will amount to 3,268 Gg CO_2-eq (about 30% more than the emission value in the base 2015, which is 2,514 Gg CO_2-eq). Based on scenario S2, the total annual greenhouse gas emissions will decrease, and will amount to 2,288 Gg CO_2-eq in 2050, which is a total reduction of about 10% compared to 2015. According to scenario S3, expected emissions from the agricultural sector in 2050 amount to 1,760 Gg CO_2-eq, which is a total reduction of about 30% compared to 2015, and a total reduction of about 22% compared to 2025. However, with regard to this scenario, a slight reduction can be expected after 2025, as most of the problems will be regulated immediately before and after the EU accession. The presented data point to the conclusion that with the strict application of the latest achievements in all segments of production, the potentials for preventing the causes of climate change in the agricultural sector in Bosnia and Herzegovina are very high. However, in all three scenarios, production volume will increase as productivity and mitigation measures in S2 and S3 improve and apply, which will contribute to reducing emissions as shown in Figure 66. The intensity of mitigation measures in S2 will increase slightly and selectively, while in S3 it will be integral and intensive and in line with the measures that will be implemented within the EU.

Compared to previous scenarios, the values of total CO_2-eq emissions from the agricultural sector have changed due to the latest applied methodological IPCC approach in calculations that separates dairy cows from other categories of cattle, which was not the case before. This resulted in substantial emission value decrease compared to earlier calculations.

However, in order to obtain more precise scenario indicators, this requires precise data. Currently we have no exact statistical indicators in agriculture on the actual number of farms involved in agriculture and their characteristics, the number of farmers, livestock, applied technologies and mitigation and adaptation practices, all of which significantly affects the final results of analyses and scenarios. Also, instability in incentive measures is evident from the point of view of support to various types of production. There is no evaluation or valorisation of the applied measures, or of the degree of implementation. The practice so far shows that the implementation of strategic documents is sporadic and partial, and there is a lack of analysis of implemented measures as a source of data required to make a judgment about their impact on reducing gas emissions. In the field of agriculture in Bosnia and Herzegovina, very little research has been conducted that generally deals with the topic of climate change. Scientific-professional research and estimates are not always publicly available, if any. All of this makes it impossible for agricultural scenarios to be quantified unlike some other sectors.

4.7 Forestry

4.7.1 Overview of situation in forestry

Bosnia and Herzegovina is one of the countries with the highest forest cover in Southern Europe, with richness in plant and animal life that makes it one of the most important forest regions in Europe. This unique diversity provides resilience for forest ecosystems to adapt to climate change, but there is a risk that some of the unique and more fragile ecosystems may be endangered. Although small, Bosnia and Herzegovina is a country of high bio-ecological potential located at one of the global biodiversity hotspots. At the same time, forestry is considered as one of the important sectors in terms of climate change mitigation, and one of the vulnerable sectors in terms of climate change adaptation.

The general conclusion is that there are no harmonised data on areas covered by forests in Bosnia and Herzegovina. The second forest inventory (forest survey in the entire territory of Bosnia and Herzegovina) has not been officially published. Among the first published data of this survey[120], the total area of forests and forest land is 3,231,500 ha or 63.08%, while 2,904,600 ha or 56.7% of the total area of Bosnia and Herzegovina is covered by forests. According to the Statistical Yearbooks of the Institute of Statistics of the Federation of Bosnia and Herzegovina and the Institute of Statistics of the Republika Srpska, forests in Bosnia and Herzegovina cover 2.88 million hectares in 2017, which is 56.33% of the total area of Bosnia and Herzegovina.

It was previously emphasised that there are no uniform and harmonised data on areas, timber stocks, and trends in the field of forestry in Bosnia and Herzegovina (i.e., the Federation of Bosnia and Herzegovina, the Republika Srpska and Brčko District). Nevertheless, the large share of coppice forests (forests of lower economic value) on the area of 1.25 mil. ha. or 38.75% of the total area is very certain[121]. These are forests that do not use the habitat in full capacity and that could be “converted into a higher cultivation form" in the coming period with larger investments and better management systems, and provide greater benefits. The area of 187,200 hectares of bare land (or 5.7% of the forest land area) is also an object where more work can be done in terms of afforestation, thereby increasing the direct area under forests as well as productivity.

The largest areas in Bosnia and Herzegovina today are covered by beech forests (30.92%), followed by sessile oak forests in various forms (30.89%) and finally mixed deciduous-coniferous forests (23.61%). This composition

[120] UNDP (2014). Possibilities of using biomass from forestry and wood industry in Bosnia and Hercegovina, 1-21.
FAO (2015). The Forest Sector in Bosnia and Herzegovina Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina, 1-146.

[121] UNDP (2014). Possibilities of using biomass from forestry and wood industry in Bosnia and Hercegovina, 1-21.
FAO (2015). The Forest Sector in Bosnia and Herzegovina Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina, 1-146.

of forests is the result of habitat conditions and can be assessed as partially favourable from the aspect of climate change, but with the management system "close to nature" with greater respect for climate change, the participation of "better adapted species" will certainly come to the fore in the period ahead. The total annual growth of wood stock (not including branches, stumps and underground parts) in all forests in Bosnia and Herzegovina is slightly above 14 million cubic metres, which is significantly more than the volume of felling (Mataruga et al. 2019)[122], but at the same time it indicates that habitat conditions can be used even better and achieve higher growth and yield.

4.7.2 Review of scenarios of greenhouse gas sinks in the forestry sector by 2050

The proven tendencies of increasing the volume of felling in the last 10 years do not follow the intensity of increase of the area under forests, which can be characterized as a negative effect in the direction of reducing greenhouse gas emissions. Nevertheless, today we can identify measures whose application in the field of forestry can contribute to the overall climate change mitigation potential. Based on the available literature, previously defined strategic documents in the forestry sector of Bosnia and Herzegovina, international obligations undertaken by the state of Bosnia and Herzegovina and international trends, the expectation that Bosnia and Herzegovina will become an equal EU member by 2025, and based on the sinks in forestry in 2010-2014, scenarios by 2050 have been prepared as follows:

Scenario S1 – is based on the detected trend of increased intensity of deforestation in the analysed period (175,000m^{3}more every year). It should be noted that the base taken is the sink capacity in Bosnia and Herzegovina calculated on the basis of historical data on the area under forests in Bosnia and Herzegovina, and based on the last measurements it was established that there was an increase of the forest area. This scenario has a negative trend of sequestration capacity, as a consequence of forest fund losses of an annual average rate of about 3%. After 2025, all forests are managed in accordance with the recommendations of the certifying institutions, and the logging scope is brought down to the level of 2010. There is no excessive or illegal logging, neither the decrease of forest areas. The volume of reforestation and success is the same as to date activities.

Scenario S2 – is based on the application of certain stimulus measures for preserving existing forest cover. The basic measure involves halting of the rising logging scope trend, and thereby increasing the sinks capacity through practical ways of applying certain silviculture methods to increase the carbon sequestration in tree biomass in existing forest areas. An important measure is the reforestation of bare lands, which would increase the total annual biomass increment. Another very important activity is related to the enhancement of fire protection measures aimed at preventing and reducing the number of forest fires, which in the past several decades have usually been caused by climate and are more frequent. Result of the application of these measures would affect the maintenance of the current level and would cause a slight increase in sinks capacities of forest cover in Bosnia and Herzegovina. The extent of logging in all forms is back at the level of 2010 with an immediate effect. 2,500 ha are forested per year with 100% success in planting and development of newly established forests.

Scenario S3 - is based on the assumption that Bosnia and Herzegovina will become a full member of the EU by 2025, and thereby accept all obligations and directives concerning forestry. This primarily refers to the full certification of the entire forest stock in Bosnia and Herzegovina in order to improve the sustainable management of forest complexes. One of the special measures taken into account in the scenario S3 is the

[122] Mataruga, M., Ballian, D., Terzić, R., Daničić, V., Cvjetković, B. (2019) State of Forests in Bosnia and Herzegovina: Ecological and Vegetation Distribution, Management and Genetic Variability, edited by Šijačić-Nikolić, M., Milovanović, J., Nonić, M. in "Forests of Southeast Europe Under a Changing Climate - Conservation of Genetic Resources". Springer, p: 3-19.

continuous afforestation of degraded forest cover and afforestation and rehabilitation of barren land in order to maintain and preserve existing and surface increase of forests in the coming period. According to this scenario, a very important activity for this purpose is complete landmine clearance of existing land-mined forest areas (about 10% of all forest areas), which further opens the possibility to increase the carbon storage potential of forests in Bosnia and Herzegovina. The area of 2,500 ha is afforested per year, with complete success. Additional 100 ha of energy plantations of fast-growing species are established every year. Activities and investments in fire protection are introduced from the first year of the observed period and they are constant. These activities contribute to estimated annual decrease of fire-affected area by 1,000 ha. Protected areas are isolated with intensity of 100 ha per year.

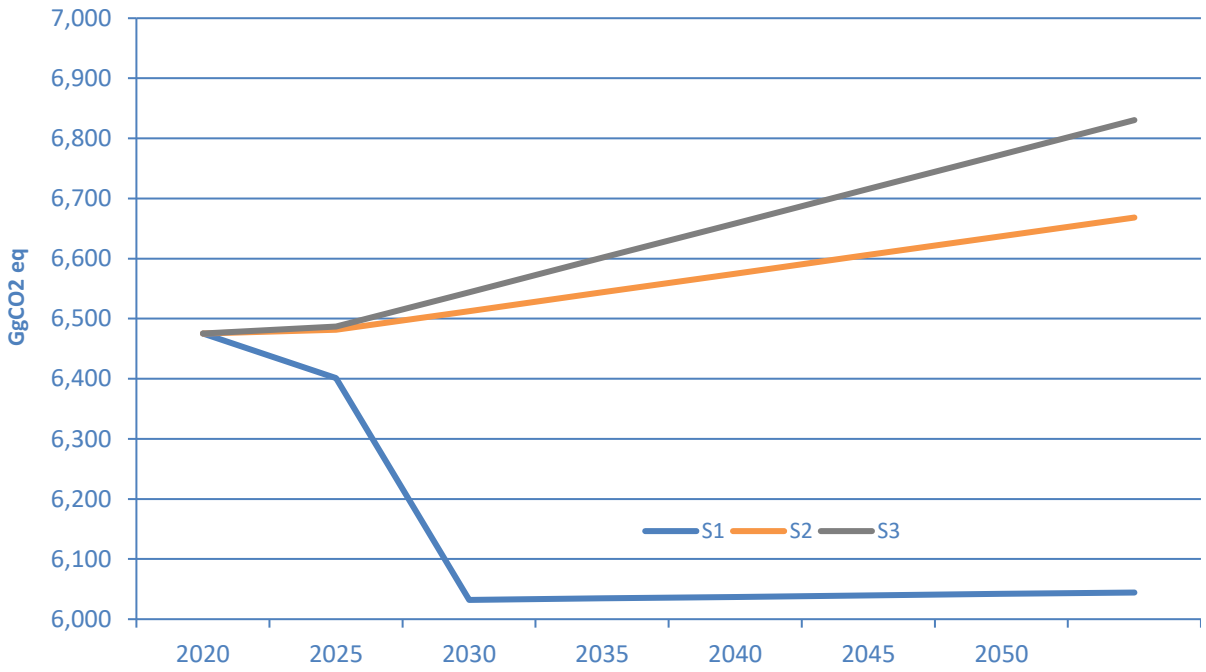


Figure 67: Projection of CO_2 (Gg) sinks in the forestry sector by scenarios

According to scenario S1, sequestration capacities will decline until 2025, and then almost stagnate, and the sinks under this scenario would be reduced to 6,045 Gg CO_2 by 2050, which is a smaller amount than predicted in the TNC. According to scenario S2, constant measures in the application of an adaptive management system, bare afforestation, and the improvement of fire protection measures, the projected value of sink in 2050 would increase by about 3% compared to 2019, reaching 6,668 Gg CO_2. If all the activities envisaged in the advanced scenario S3 were realised, the sink would be higher by 355 Gg CO_2 compared to 2019.

4.8 Waste

4.8.1 Overview of situation in waste management sector

This report deals with emissions from 2014/2015, and predicts scenarios for the period up to 2050. From 2001, which is the final year of the Second National Communication on Climate Change, until 2010, crucial things happened in waste management, which have already significantly affected the situation in waste management. These are presented below. These changes affected the process of obtaining reliable data on generated and treated waste amounts. Regarding regional sanitary landfills in the Federation of Bosnia and Herzegovina, 4 landfills were built (Smiljevići-Sarajevo, Mošćanica-Zenica, Uborak-Mostar and Korićina-Livno). In the Republika Srpska, the following landfills are operational: Brijesnica-Bijeljina, Ramići-Banja Luka and the recently

constructed sanitary landfill Crni vrh-Zvornik. Therefore, it can be said that the quantitative target - 4 regional landfills by 2021 - may be achieved in the RS soon. In addition, this document takes into account the new EC Directive[123] encouraging an increase in recycling, with the following municipal waste recycling targets: 60% by 2030; 65% by 2035; 70% by 2040, and 80% by 2050 (Scenario 3).

The amounts of generated waste in Bosnia and Herzegovina in 2015 and 2016 were 1,248,718 t and 1,243,889 t, which indicates a waste decrease by approximately 0.4%. According to updated data, the amount of waste in 2014 was slightly higher and amounted to 1,223,418 t as stated in the Third National Communication.

which can be explained by an insight in collected new data and new estimates. The daily generated amount of waste per capita is slightly lower compared to the Third National Communication and amounts to 0.78 and 0.77 kg/inhabitant/day.

Coverage of collection and disposal services was about 72% and 75% (2010 and 2011), and 74% and 70% (2014 and 2015), which points to variations, without exclusively arithmetic progression of increase or decrease. For the given amounts of generated waste, calculated methane emissions are 44.70 Gg CH_4 and 40.84 Gg CH_4 (2014 and 2015).

As early as in 2001 and until 2010/2011, significant progress was made in legislation. An amendment to the Law on Waste Management was adopted in the Federation of Bosnia and Herzegovina. More precisely, the “Law on Amendments to the Law on Waste Management” was adopted in November 2017, while 2 amendments to the Law on Waste Management were adopted in 2015 and 2018 in the Republika Srpska.

The Rulebook on packaging and packaging waste management was adopted in the Federation of Bosnia and Herzegovina in December 2011, as well as the Rulebook on management of waste from electrical and electronic products in October 2012. In the Republika Srpska, the Decree on packaging and packaging waste management was adopted in 2015, and the first operator was registered in 2018.

As for secondary legislation, it is important to emphasise that changes were made several times in the field of packaging and packaging waste management as well as electrical and electronic waste management from 2012 to 2018.

During that time, operators of the packaging waste and electrical and electronic waste management system were registered (a total of 4 operators from 2012 to 2018). The operators aim at collecting as much packaging waste and electrical and electronic waste as possible, and disposing them in the prescribed manner.

Implementation of this legislation and the implementation level contributed to the change of situation in waste management sphere. Unfortunately, the legislation is still not harmonized in the entities of Bosnia and Herzegovina (the level of transposition of directives is not the same), nor have the same legal acts been adopted (e.g. rulebooks on specific waste streams), which makes it difficult to predict scenarios for the whole of Bosnia and Herzegovina. In the period between the preparation of the Third and Fourth National Climate Change Communications, the 2017-2026 Waste Management Strategy was adopted in November 2017 in the Republika Srpska, the preparation of the Waste Management Plan for the Republika Srpska began in April 2018. The Waste Management Strategy of the Federation of Bosnia and Herzegovina was valid until 2018, and Cantonal waste management plans have been developed in most cantons (e.g. Sarajevo Canton, Zenica-Doboj Canton; Una-Sana Canton, etc.).

[123]Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste

Table 29 shows amounts of generated waste, methane emissions and disposed waste amounts.

Table 29. Data on waste amounts and methane emissions in Bosnia and Herzegovina (2014, 2015)[124]

Year	Total amount of generated waste BiH (t)	Total amount of disposed waste BiH (t)	Total population number	Waste amount per capita kg/capita/day	Annual net emissions of CH_4 $GgCH_4$
2014	1,332.42	986	3,827.343	0.78	44.70
2015	1,2487.18	900.95	3,518.298	0.77	40.84

In the period after 2002 and 2003, in addition to the adoption of legal acts regulating waste management, the Environmental Action Plan of Bosnia and Herzegovina (NEAP) was adopted. In addition to official acts of the institutions in Bosnia and Herzegovina, the World Bank, the Czech Development Agency and SIDA implemented a series of significant projects aimed at establishing an integrated waste management system, mainly related to the development of waste management programs. Also, the implementation of the *EU Project for Strengthening Environmental Institutions in Bosnia and Herzegovina* and preparations for pre-accession funds have been finalised, which contributes to the progress of the environmental protection sector in the EU accession process. The project ended in December 2014. The Directive Specific Implementation Plan (DSIP)[125] and Action Plans for the implementation of the EU Landfill Directive in the Federation of Bosnia and Herzegovina, the Republika Srpska and Brčko District of Bosnia and Herzegovina were developed within the project. The project recommendations for this area are that the Directive Specific Implementation Plans (DSIPs) for each of these horizontal directives should be prepared under coordination of the Ministry of Foreign Trade and Economic Relations, in cooperation with the Directorate for European Integration.

4.8.2 Review of scenarios for reducing greenhouse gas emissions from the waste sector by 2050

Reference scenario (S1) - – This scenario assumes waste disposal in landfills that are not regulated (except for sanitary landfills Smiljevići–Sarajevo, Mošćanica–Zenica, Uborak-Mostar and Korićina-Livno, Brijesnica-Bijeljina, Ramići-Banja Luka and Crni vrh-Zvornik), i.e., it is mostly disposed in non-regulated municipal landfills, while the rest ends up in so-called illegal dumping sites.

Scenario 1 from the Third National Communication provides that around 70% of generated waste is collected and disposed in partially regulated landfills. It is still assumed that waste disposal at illegal landfills will continue until 2030. Considering that the illegal dumping sites are unregulated, the calculation was made on the basis of the total waste generated that ends on illegal dumping sites (regardless of whether it is collected and disposed of in unregulated municipal dumps or whether it is dumped at illegal landfills).

In accordance with the Third National Communication, it was predicted that the total percentage of recycling in 2018 would be 10%, which was not met, and it amounts to about 4.0%. Recycling is not envisaged in 2010 and 2011. From 2012, recycling is envisaged to increase by 0.5% per year (currently it is around 0.5% in Bosnia and Herzegovina).

From 2015, recycling is envisaged to increase by 0.5% per year. The total increase in the percentage of recycling from 2015 to 2050, increased by 0.5% per year, indicates that it will increase from the percentage of 3.5% of

[124] Data source: Agency for Statistics of Bosnia and Herzegovina, available at:
http://www.bhas.ba/saopstenja/2016/KOM_2015_001_01_BA.pdf,
http://www.bhas.ba/saopstenja/2017/ENV_01_2016_Y1_0_BS.pdf

[125] Directive on the landfill of waste (1999/31/EC)

recycling in Bosnia and Herzegovina (2017) to 20% by 2050. Waste collection coverage is increasing by 2.5% per year from 2016 to 2022, and from 2022 to 2030 the increase is 3% per year.

When it comes to the population number, the data were taken from the Agency for Statistics of Bosnia and Herzegovina for 2015, 2016 and 2017.

Projection of population number for 2020, 2025, 2030, 2035, 2040, 2045 and 2050 is taken from the document *Probabilistic Population Projections based on the World Population Prospects*[126]. This indicates the following population decrease percentages:

- from 2018 to 2020 - 0.05% per year
- from 2020 to 2025 - 0.25% per year
- from 2025 to 2030 - 0.3% per year
- from 2030 to 2035 - 0.4% per year
- from 2035 to 2040 - 0.5% per year
- from 2040 to 2050 - 0.6% per year.

Moderate mitigation scenario (S2) - In the Third National Communication, Scenario 2 took into account the targets set by the Waste Management Strategy and Waste Management Plan of the Federation of Bosnia and Herzegovina, however neither a new Waste Management Strategy nor a Waste Management Plan has been developed for the Federation of Bosnia and Herzegovina. For the preparation of the Fourth National Communication, the set targets from the Waste Management Strategy of the Republika Srpska (2017-2026) were used, as well as certain data from the Cantonal Waste Management Plans of the Federation of Bosnia and Herzegovina (CS; ZDC; USC).

In accordance with the analysis of the above-mentioned strategic documents (Waste Management Strategy of the Republika Srpska, cantonal waste management plans), it is predicted that the annual recycling rate will decrease from 3% (2013) to 1% per year (2016); it amounts to 1.5% in 2017-2021, and grows by 4% per year until 2025, 1% per year from 2026-2032, and by 0.5% per year in 2033 -2050. According to these calculations in Scenario 2, the total recycling percentage in 2050 would be only 46%. Waste collection coverage was 74% in 2014, and 70% in 2015 and 2016. From 2017 to 2023, coverage is projected to increase from 70% to 95%, and from 2024 it should be 100%.

Scenario 2 takes into account recycling increases like in the baseline scenario, but also predicts a recycling increase continuity (46% by 2050). As for treatment by other methods, such as biological treatment or incineration, a percentage of 16% is projected by 2050.

Scenario 2 even expects a slight reduction in methane and predicts that it will be around 41 $GgCH_4$ in 2050, which may be caused by increased separation and recycling of generated waste as well as the existence of regulated landfills.

Waste treated with a biological or other method started with only 0.5% (2018), and should reach 16% by 2050, which fully corresponds to the Scenario 2 from the Third National Communication.

The strategies and plans that exist in the Republika Srpska and the Federation of Bosnia and Herzegovina do not indicate that it will be possible to achieve the targets set by the EU Directives.

[126]Median (50 percent) prediction interval, 2015 – 2100 (The 2017 Revision June 2017 - Copyright © 2017 by United Nations.

Mitigation scenario (S3) - The prediction from the Third National Communication will be kept in this scenario, and an increased level of recycling will be introduced at the waste generation site and at the landfills themselves. New rulebooks on the disposal of batteries and accumulators; tires, glass and other waste from specific streams that will be adopted in 2019 will greatly contribute to this. Currently, such waste mostly ends up in landfills. The rulebooks will also affect the change of the way of charging for services based on generated waste amount. This scenario did not take into account the construction of incinerators for incineration of mixed municipal waste (i.e. treatment after recycling), RDF production, etc. Based on the collected data, a graph was made which shows a disproportion in scenarios 2 and 3, but this is in line with change of several factors that affect waste generation, such as: population reduction while increasing waste production per capita, increasing services coverage, increasing the percentage of recycling, reducing methane emissions.

The disproportion may also be affected by the fact that Scenario 2 did not take into account strategic documents at the level of the Republika Srpska and the Federation of Bosnia and Herzegovina, and the formulation of Scenario 3 took into account all changes to EU directives in the field of waste management that were adopted in 2018.[127].

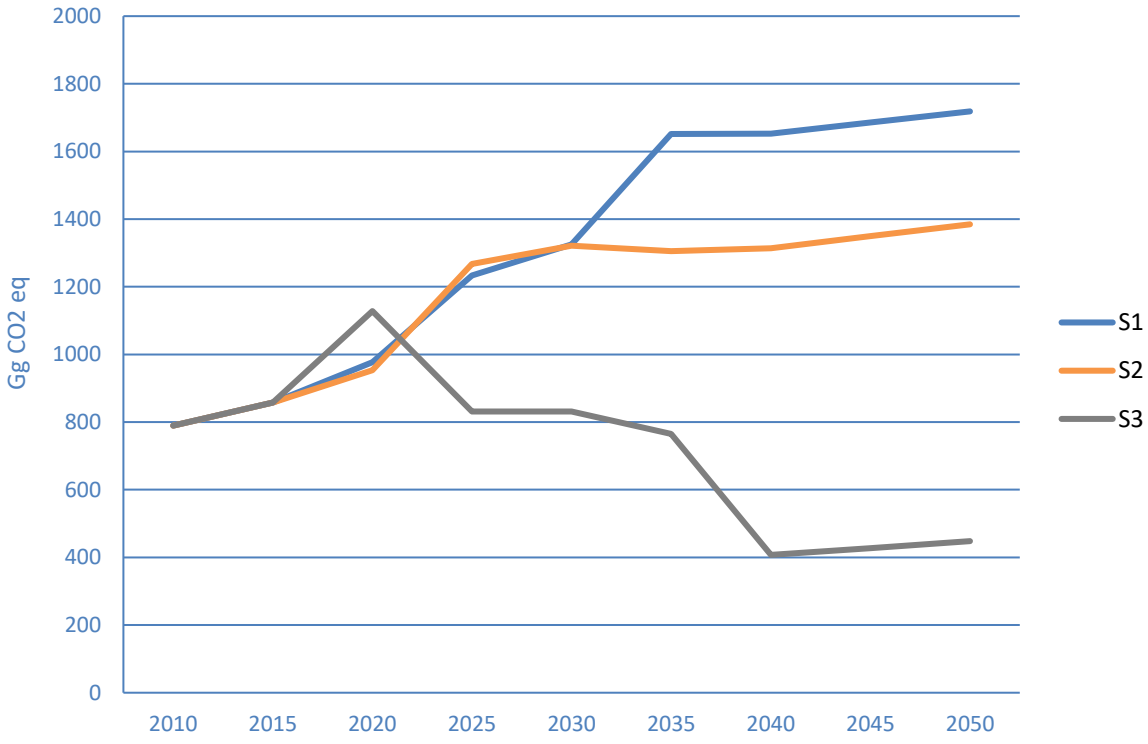


Figure 68: Total CO_2-eq emissions from waste sector in Bosnia and Herzegovina according by scenarios

[127]DIRECTIVE (EU) 2018/851 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2008/98/EC on waste

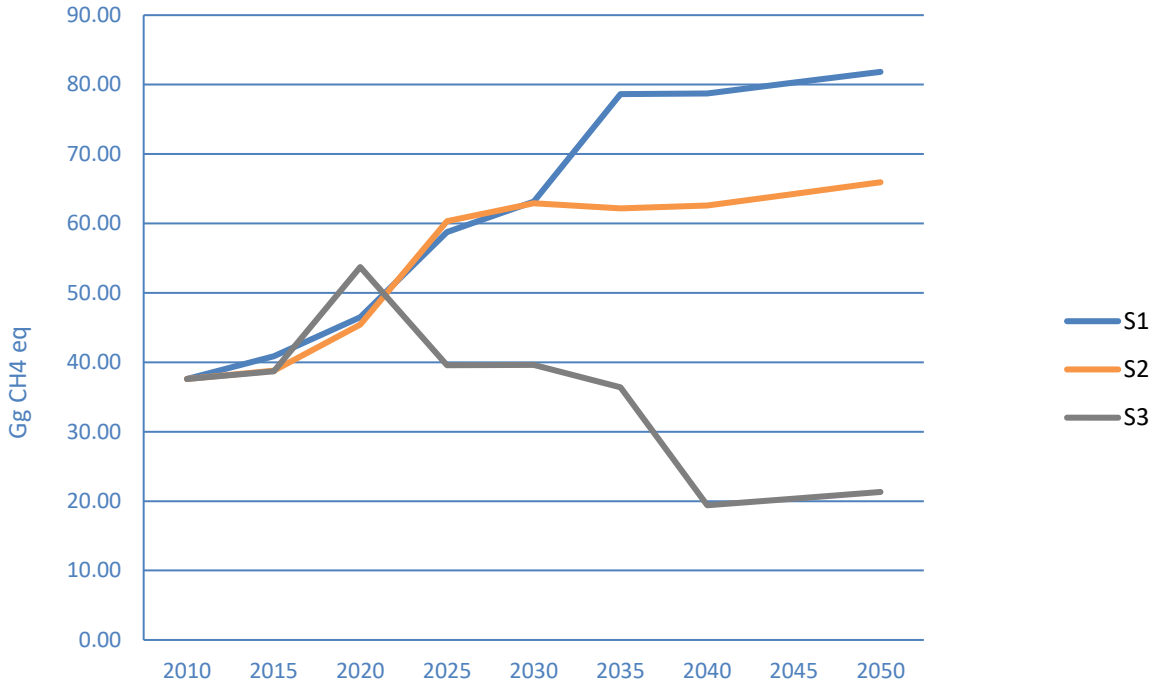


Figure 69: Total CH4 eq emissions from waste sector in Bosnia and Herzegovina by scenarios

This indicates that substantial methane emission decrease is expected as of 2039. The introduction of a higher degree of recycling and recovery in scenarios 2 and 3 leads to a reduction in emissions, because the amounts of disposed waste are reduced. Scenario 3 envisages a rather high percentage of recycling (around 80% by 2050) and a reduction in mechanical-biological treatment due to the separation of organic waste at the place of generation and significantly higher public awareness level (12% by 2050) Thus, according to Scenario 3, the amount of methane is only 2.9 Gg CH_4 in 2050.

It is important to note that DOC of Bosnia and Herzegovina was calculated for emission calculation purposes. According to available data, the share of DOC in waste is 0.25, which is much higher than in other developing countries. This value will decrease with time, with the reduction of organic waste share.

4.9 Total potential of reducing greenhouse gas emissions (aggregate review of scenarios)

Based on the obtained results of developing scenarios of individual sectors, a consolidated/ summary result was made, which unifies all effects for each scenario. Summary review foresees the total mitigation potentials for each of the scenarios, not including the effects of sinks in forestry. It should be emphasised that the analysis of climate change mitigation potential does not include emissions from industry, fugitive emissions from fuels or emissions from wastewater treatment.

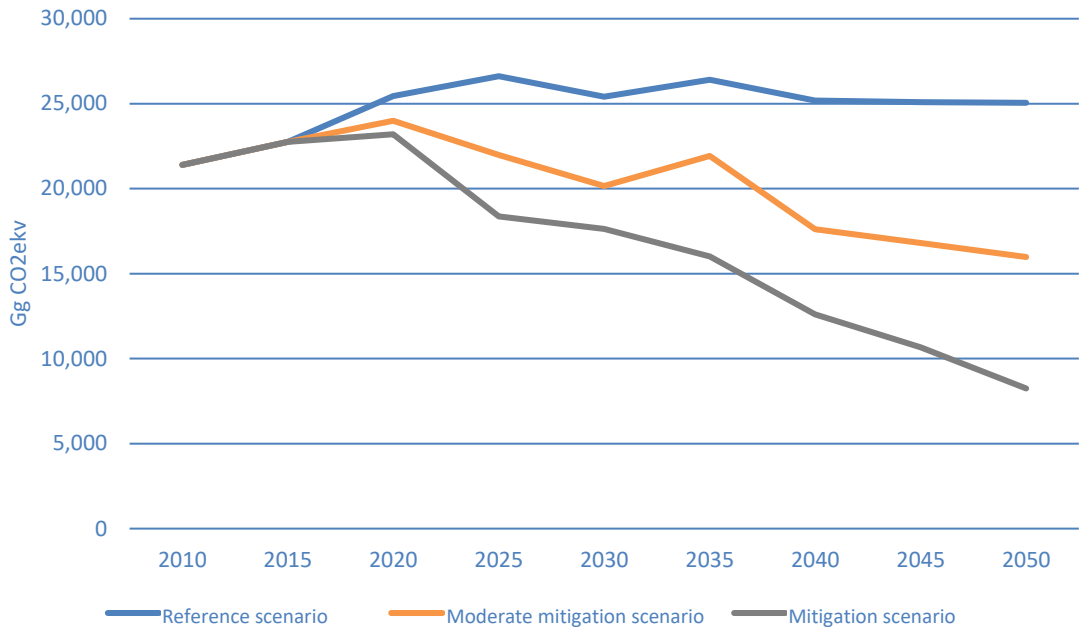


Figure 70: Total (sink in the forestry sector is not included) emissions by scenarios for the period 2010 – 2050

The most influential sector in the emission projections, but also in the reduction potential, is the power sector. Its share in emissions (in the sectors covered by this analysis, which represent about 87% of total emissions in 2014) at the beginning of the observed period is about 57%, and at the end of the observed period in S1, it falls to about 45%, in S2 to about 42%, and in S3 to only 21%. In contrast, shares in other sectors are mainly growing, so in the housing sector, the share is growing from the initial 3.4% to 4.4% in S3. The largest increase is recorded in the transport sector from the initial 16% to 40% in 2050 in the mitigation scenario. This shows that there are additional potentials to reduce GHG emissions in the transport sector, which should be taken into account in future analyses, based on monitoring of the development of new technologies and infrastructure in that sector. It should be emphasized that a scenario analysis of emissions from industry was not conducted.

According to the projected emissions, S1, which corresponds to the "business as usual" is headed towards emission growth 2035, and then it stagnates. In 2025, emissions are higher by about 23% compared to 2010, and will remain at approximately that level until 2050. S2 is characterized by a moderate constant emission decline until 2030, followed by some increase and later decline until 2050, when emissions are lower by about 26% compared to 2014 emissions. The mitigation scenario (S3) records a more intensive decline in emissions by the end of the observed period, and in 2050 they are by 55% lower than the total emissions in 2014.

Taking into account the size of the GHG sink in 2014 and emissions according to the mitigation scenario in 2050, total net emissions in 2050 would amount to around 5,330 Gg CO_{2ekv} (also taking into account emissions from sectors that are not considered here), which is by about 80% less than net emissions in 1990.

5 OTHER RELEVANT ACTIVITIES

5.1 Technology needs assessment for mitigation and adaptation

5.1.1 Access to the UN Framework Convention on Climate Change

Climate change issue on the global level is treated by the United Nations Framework Convention on Climate Change (UNFCCC). So far, the First, Second and Third National Communications of Bosnia and Herzegovina have been adopted in accordance with the United Nations Framework Convention on Climate Change. Second Biennial Update Report of Bosnia and Herzegovina on Greenhouse Gas Emissions has been prepared and adopted. On 23 May 2017, the Council of Ministers of Bosnia and Herzegovina adopted the Third National Communication of Bosnia and Herzegovina and the Second Biennial Report on Greenhouse Gas Emissions of Bosnia and Herzegovina in accordance with the UNFCCC, which were submitted to the UNFCCC Secretariat in Bonn. These reports serve as important strategic documents for sustainable development, and link environmental protection and the fight against climate change with key issues of socio-economic development of the country.

5.1.2 Clean development mechanisms and NAMA

NAMA is a significant mechanism to support climate change mitigation through international funding, technology transfer and capacity building. NAMAs can help governments mobilize support for decarbonisation and switch to low-carbon development. NAMAs do not only focus on reducing GHG emissions, the benefits may include improved access to energy at stable and affordable prices, increased efficiency in energy and industry, improved competitiveness and benefits in terms of health, education and gender equality.

Although there is no internationally unified definition of NAMA, it can be said that NAMA is a voluntary intervention by the government of a developing country that leads to a reduction in greenhouse gas emissions. Since it includes long-term policies tailored to state/local frameworks, NAMA provides more opportunities for large reductions and support to development priorities than other project/activity-based instruments, such as CDM.

In principle, Bosnia and Herzegovina participated in the CDM with the Ministry of Spatial Planning, Civil Engineering and Ecology in the Government of the Republika Srpska, which was assigned as the Designated National Authority (DNA) under the Kyoto Protocol of the UNFCCC. In 2015, Bosnia and Herzegovina also established a mechanism for NAMA (appropriate measures for climate change mitigation in Bosnia and Herzegovina) approval and submission to the NAMA Register at the UNFCCC Secretariat, which was added to the existing activities of the Designated National Authority (DNA) under the Kyoto Protocol of the UNFCCC by the decision of the Council of Ministers of Bosnia and Herzegovina. DNA for CDMs and NAMAs should play a key role in participating in new market mechanisms. Its activities should be as follows:

- Active participation (based on consultations with relevant ministries at the levels of the Federation of Bosnia and Herzegovina, the Republika Srpska and Bosnia and Herzegovina) in negotiations within the UNFCCC in order to protect the country's interests and engage in the development of a new market mechanism;
- Establishment of necessary structures for participation in NAMA (depending on adopted international rules),
- Initiation and coordination of preparation of Bosnia and Herzegovina’s strategy for NAMA;

- Initiation and coordination of preparation of a strategy for joining the EU ETS;
- Promoting these mechanisms to stakeholders (such as chambers of commerce, ministries - policy makers in sectors such as energy, industry, forestry, agriculture, tourism, etc., local authorities, FIPA, etc.) through the preparation and updating of guidelines relevant to specific stakeholders and the implementation of training for stakeholders;
- Management of a database containing relevant NAMA data (such as the sector to which the project belongs, reduction of greenhouse gas emissions based on monitoring, reporting and verification, type of mechanism applied, additionality, etc.) so that NAMAs can be considered in terms of inventory and NDC.
- Networking with institutions that have the same role in the countries of the region (among other forms of networking, an annual conference has been proposed).

In order for all the above-described activities to be successfully implemented, it is necessary to establish a Council of DNA for NAMA implementation. The task of the Council is to assess the fulfilment of criteria of individual NAMAs, and give an opinion thereon to the Designated Body. In the case of specific NAMAs, the Council can be expanded to include experts in specific areas. Furthermore, it is important to consider the fact that before the completion of the EU accession process, Bosnia and Herzegovina will be part of the EU emission trading system (ETS). This means that the electricity generation sector will be obliged to obtain emission quotas at auctions, while other sectors will receive a certain amount of emission quotas based on acquired rights or according to the sector's criteria. The implementation of the country's Emission Reduction Plan will have a significant impact on greenhouse gas emission trends in Bosnia and Herzegovina. The NAMA Designated Authority may take on the roles that will result from the EE ETS accession.

Domestic capacity building is a prerequisite for successful inclusion in the NAMA mechanism within the UNFCCC. It is particularly important to promote this international cooperation mechanism. A reliable and transparent domestic MRV system is a prerequisite for attracting the interest of potential international partners. Against this background, the following recommendations are provided:

1. Work on strengthening of the Designated Authority for NAMA projects through the establishment of the DNA Council;
2. Adopt a procedure that will define the steps from initiating to nomination of NAMA projects for support, and reporting on the implementation of NAMA projects;
3. Define clear criteria for NAMA approval (to be adopted by the Designated Authority);
4. Promote the NAMA mechanism through trainings of entrepreneurs, all levels of government and non-governmental organizations;
5. Promote approved NAMAs internationally;
6. Establish a system of monitoring, reporting and verification for NAMA projects based on established MRV structures for state communications, biennial reports on GHG emissions and CDM projects;
7. Plan a budget for functioning of the Designated Authority for NAMA.

5.1.3 Adaptation and Low-Emission Development Strategy

The negative consequences of climate change are already visible in Bosnia and Herzegovina even though the country contributes little to the causes of climate change on the global level. In response, Bosnia and Herzegovina adopted the first *Adaptation and Low-Emission Development Strategy* in 2013, with the strategic aim of gradually decreasing greenhouse gas emissions and increasing the resilience of Bosnia and Herzegovina to climate variability and climate change, and preventing environmental degradation.

Based on climate scenarios and climate change mitigation scenarios within the preparation of the Fourth National Communication of Bosnia and Herzegovina in accordance with the UNFCCC, the *Strategy for Adaptation to Climate Change and Low Emission Development of Bosnia and Herzegovina* for 2020-2030 was developed. The strategy represents a significant and important step towards the development of a sustainable 'green economy' in Bosnia and Herzegovina. The Strategy vision is that by 2030 Bosnia and Herzegovina will be a sustainable and prosperous 'green economy'. Bosnia and Herzegovina is committed to accessing the EU as a member state with low emissions, high quality of life for everyone, preserved natural ecosystems, sustainable natural resources management and a high level of climate change resilience. Increasing levels of energy efficiency, greater renewable energy use, and improved energy and transport infrastructure and services will lead to international investment, job creation and business enterprise in a resource-efficient economy. Negative impacts of climate change will be minimised by reducing vulnerability and taking advantage of opportunities brought about by climate change. The transition to a 'Green economy' will particularly benefit the vulnerable and disadvantaged by being socially inclusive and contributing positively to gender equity.

This will be achieved through the implementation of the *2020-2030 Climate Change Adaptation and Low-Emission Development Strategy of Bosnia and Herzegovina,* which has two main objectives.

- With regard to adaptation, the Strategy aims at increasing Bosnia and Herzegovina's resilience to climate variability and climate change, and in doing so, to secure development gains.
- The goal of the Strategy in the field of low-emission development is to stop the trend of increasing greenhouse gas emissions, significantly reduce emissions by 2030 with the simultaneous economy growth through measures and programmes that will result in reducing greenhouse gas emissions by 50% until 2050 compared to 2014, and reducing net greenhouse gas emissions by 80% until 2050 compared to 1990. The strategy serves as a comprehensive policy framework to deal with the climate change challenge in Bosnia and Herzegovina, and will facilitate access to international support for implementation.

The Strategy includes two closely related components: climate change adaptation and low-emission development. While mitigation is essential to minimise impacts and ensure that they remain manageable, adaptation is also required to ensure that Bosnia and Herzegovina reduces the risk and vulnerability of society and the economy to, and maximises opportunities arising from climate change.

5.1.4 Nationally determined contribution of Bosnia and Herzegovina

The Paris Climate Change Agreement[128] entered into force on 4 November 2016, after the 21st Conference of parties (held in 2015). Ratifying the Paris Agreement, countries confirmed their climate change mitigation activities. In October 2015, Bosnia and Herzegovina submitted the first Intended Nationally Determined Contribution (INDC) of Bosnia and Herzegovina and ratified the Paris Agreement by the Decision on the ratification of the Paris Agreement in accordance with the UNFCCC (Official Gazette of BiH - International Agreements, No. 01/17). According to the provisions of the Paris Agreement, the states are obligated to submit updated and more ambitious documents on climate change mitigation activities every five years in the forthcoming period.

With this in mind, in March 2021, Bosnia and Herzegovina adopted, and in April 2021 submitted to the United Nations Framework Convention on Climate Change (UNFCCC) updated Nationally Determined Contribution (NDC) reaffirming its commitment to the fulfilment of the Paris Climate Agreement with which the world leaders

[128]The main objective of the agreement is to strengthen the global response to the climate change threat by maintaining the increase in global average temperature to 2° C above pre-industrial levels, and to take measures to limit global average temperature growth to 1.5 ° C above pre-industrial levels.

have jointly agreed to advance climate action in order to limit temperature rise to 1.5 Celsius degrees. Bosnia and Herzegovina is one of the first countries in the Western Balkans to adopt an updated NDC with a plan to reduce greenhouse gas emissions.

Bosnia and Herzegovina is committed to reducing greenhouse gas emissions by 2030 in the sectors of electricity, district heating, buildings, transport, industry, agriculture and waste by a total of 12.8% compared to 2014 (unconditional target), or 17.5% in relation to 2014 (conditional target - with more intense international assistance). According to the unconditional target, emissions in 2050 are by 50.0% lower compared to 2014, and according to conditional target, by 55.0% lower compared to 2014. Also, it is important to emphasize that the presented targets mean the reduction in GHG emission by slightly above one third until 2030, and almost by two thirds (about 66%) until 2050, compared to 1990. Taking into account the size of the GHG sink in 2014 and emissions according to the conditional target in 2050, net emissions in 2050 would be by about 80% lower than net emissions in 1990.

To achieve the targets in both options (unconditional and conditional targets), Bosnia and Herzegovina will need intense international assistance for capacity building, education, technology transfer, establishment of financial mechanisms to encourage decarbonisation, development of required study and project documentation, and project financing itself. In the option that defines the conditional target for faster decarbonisation of the electricity sector (which requires higher level of effort on decarbonisation of mining areas), international assistance should be more intense.

5.1.5 Technology needs assessment for agricultural and water resources sectors

Agriculture

In the climate change context, agriculture is becoming increasingly vulnerable. The application of technologies and adaptation measures, as well as improved agricultural practices, can reduce the impact of climate change. Adaptation in agriculture is crucial to limit potential harms and, moreover, turn negative consequences into benefits. Given the numerous agricultural practices and activities that can be applied, it is necessary to approach the selection of technologies and adaptation measures, which can be implemented in a planned manner (political and strategic decisions), but also independently by agricultural producers. The most important challenges in the agricultural sector that need to be addressed by adaptation measures and technologies in agriculture are:

- Water deficit;
- Water surplus and landscaping;
- Increase of resilience and productivity of plants;
- Risk reduction in livestock;
- Disaster preparedness - response options for improved disaster preparedness and appropriate adaptation technologies.

Water deficit in the agricultural sector is increasingly becoming a challenge. Irrigation is imposed as a mandatory measure in intensive agricultural production in almost all parts of Bosnia and Herzegovina, except for the mountains. The calculation of the total water balance at the level of Bosnia and Herzegovina shows significant water surplus on an annual basis, with the distribution of surpluses being unfavourable and occurring outside the season of the most intensive plant development. On the other hand, the same period witnesses unevenly distributed deficits. Both surpluses and deficits grow from north to south and from east to west. In general, based on the results of the soil water balance survey at the level of Bosnia and Herzegovina, one can say that most of the revenue rainfall (51.2%) is spent on evapotranspiration, i.e., for production of food, raw materials

and maintaining ecosystem stability. We refer to this part as useful plant water or green water that has been marginalized in all previous budgets of planners, managers and politicians.

The second, slightly smaller part (48.8%) is called surplus, potential runoff or blue water. It is a part that restores underground aquifers, springs, lakes and watercourses, and serves the water supply of the population, industrial, recreational, hydropower and irrigation needs. Water planners, managers and politicians are focused on blue water only, while green water is neglected. Therefore, one can say that the crisis of deficit of water required for irrigation does not exist in the distant future either if new perceptions are adopted in the water and soil management strategy, as well as moisture conservation measures (technologies) listed here. On the other hand, excess water on a plot causes great damage during the year because it constitutes a problem in the soil preparation phase, the development of sown plants in the spring and harvesting of crops in the fall. Therefore, flood protection, drainage and other agro-ameliorative measures (technologies) listed here are of great importance for safe and stable production.

However, it is safe to say that a water and soil management crisis is upon us if new perceptions are not adopted in water and soil management strategies and technologies.[129].

Increasing the resilience and productivity of plants implies the application of a whole set of measures and technologies that should increase the resilience, but also the productivity of production. Greenhouses and hothouses are particularly sensitive production ecosystems. Also, these can be significant areas for biomass and food production and carbon sequestration. In this type of production, the maintenance of the water-air regime is of crucial importance.

In order to ensure safe and stable plant production, the introduction of new species and varieties of crops and orchard seedlings is very important. Diversification of crops and new varieties in the conditions of climate change is becoming increasingly important as a measure of adaptation, and the world works on it intensively. Adaptations follow the direction of selecting species and varieties in view of changed and increased average temperatures, prolongation of the vegetation period and reduced amounts of snow.

In order to improve the safety of plant production, preserve biodiversity, protect the environment and ecosystem resilience in general, more and more work is being done on the introduction of classic and innovative technologies such as raising windbreaks, integrated fertilization system and plant nutrition management with organic and mineral fertilizers. The mixed farm system and agroforestry are becoming increasingly relevant technologies in an effort to resist the effects of climate change on agricultural production. For Bosnia and Herzegovina, this is a very acceptable measure considering the specifically developed mixed farm that should be combined with agroforestry. In addition to these, there is a range of other measures and technologies, among which crop rotation is considered one of the most important from the point of view of productivity of agricultural production and development of plant diseases and pests specific for monoculture.

Technologies and approaches in livestock, which is very sensitive to climate change, are developed in a similar way. In order to reduce the risk, adaptation in livestock aims at introduction of new species and selection and crossing of certain species and strains, which is a great scientific and professional challenge in the development and adaptation of livestock production in climate change context.

Disaster preparedness means, above all, good organization and the necessary knowledge. To this end, a system of extension services for agriculture and rural development should be developed, without whose support

[129]Vlahinić M., Čustović H., Alagić E., 2006: *Prijeti li kriza vode potrebne za navodnjavanje u poljoprivredi Bosne i Hercegovine, Godišnji skup agronoma u Neumu, Radovi Poljoprivredno-prehrambenog fakulteta Univerziteta u Sarajevu*, LII, no.58/2, p.25-36.

farmers and others engaged in agriculture could hardly ensure the application of modern agro-technical measures and procedures in line with environmental requirements at the local and global levels.

Risks of disasters in plant production can best be avoided by establishing a system of monitoring and control of diseases and pests in plants. A similar organizational system is being established in livestock, which should monitor and control the occurrence of diseases in domestic animals. The system of monitoring the health of plants and animals at the farm level is of great importance and a condition for a safe and stable agricultural production. However, the emergence of new diseases and pests can only be realistically monitored at the regional, national and international levels. Insurance of agricultural production against natural disasters through insurance agencies is a very developed measure in developed countries. It is the best way to ensure the safety and continuity of stable agricultural production in conditions of unpredictability of climate phenomena.

To identify the technologies used in the agricultural sector, as an input, the overview provided by the CTCN (*Climate Technology Centre & Network*)[130]. The review includes a total of 25 adaptation technologies in the agriculture and forestry sectors. These technologies were analysed, and those relevant for our context were selected. The technologies have been descriptively modified to make them easier to understand, and based on expert opinion and experience, the list has been supplemented with adaptation technologies relevant to Bosnia and Herzegovina. Adaptation technologies in the agricultural sector are grouped according to challenges, and in each of these groups and challenges, several measures or technologies are envisaged, a total of 22, with possible options and responses depending on local or regional conditions.

The total of 22 adaptation technologies were selected, taking into account the natural characteristics of Bosnia and Herzegovina and the impacts of climate change, as well as the existing practice and targets from strategic and planning documents. After the selection, the prioritization of these technologies in the agricultural sector of Bosnia and Herzegovina was done through the Multi-Criteria Analysis (MCA). The end result in shown in Table 30.

Table 30: Adaptation technologies selected as possible adaptation technologies in the agricultural sector in Bosnia and Herzegovina (results of the implemented MCA prioritization)

Rank	Technology	Description
1	Mixed farms and agroforestry	Adaptation technology to **increase of resilience and productivity of plants.** Adaptation response: production safety and resilience of farmed plants and animals to extreme climate events.
2	Crop rotation	Adaptation technology to **increase of resilience and productivity of plants.** Adaptation response: reducing the risk of disease and pest attacks, plant resilience to extremes in the ecosystem and environmental protection.
3	Irrigation and system selection, water collection (harvesting)	Adaptation technology for **water deficit.** Adaptation response: efficient water consumption management.
4	Selective livestock breeding	Adaptation technology for **risk reduction in livestock.** Adaptation response: resilience to climate change and maintaining productivity in livestock.
5	Soil moisture conservation measures	Adaptation technology for **water deficit.** Adaptation response: efficient water consumption management.
6	Construction of a drainage system for evacuation of excess water from a plot	Adaptation technology for **water surplus and landscaping.** Adaptation response: floods-water surplus.
7	Contouring	Adaptation technology to **reduce surface soil erosion and moisture conservation — landscaping measure.** Adaptation response: reducing or preventing soil erosion and degradation.

[130]https://www.ctc-n.org/technology-sectors/agriculture-and-forestry?f%5B0%5D=type%3Atechnologies&f%5B1%5D=field_sectors%3A14957&f%5B2%5D=field_objective%3A14912

Rank	Technology	Description
8	Fodder-feed production	Adaptation technology for **risk reduction in livestock.** Adaptation response: safety in feed production and domestic animal welfare.
9	Terracing	Technology of adaptation of agriculture on sloping terrains, erosion control and drainage of excess water - **landscaping of a land plot on a slope.** Adaptation response: reducing or preventing soil erosion and degradation by water or tillage.
10	Extension services for agriculture and rural development	Adaptation technology for **perceiving climate risks.** Adaptation response: hazard and risk assessment, production sustainability support.
11	Agricultural production insurance (insurance companies)	Adaptation technology for **perceiving climate risks.** Adaptation response: hazard and risk assessment.
12	Micro-accumulations in the hilly and mountainous part that are used for irrigation of small plots, as watering places for domestic and wild animals, construction of reservoirs, wells and catchments for water collection	Adaptation technology for **water deficit.** Adaptation response: water storage.
13	Disease and pest control in plants	Adaptation technology for **perceiving climate risks.** Adaptation response: hazard and risk assessment in agricultural production.
14	Disease control in domestic animals	Adaptation technology for **perceiving climate risks.** Adaptation response: hazard and risk assessment.
15	Production management in greenhouses and hothouses	Adaptation technology to **increase of resilience and productivity of plants.** Adaptation response: safety in food production and reduction of gas emissions into the atmosphere.
16	Windbreaks	Adaptation technology to **increase of resilience and productivity of plants.** Adaptation response: reducing the impact on plant stress, improving production productivity and the microclimate of cultivation sites.
17	Establishing forest belts and afforestation on steep terrains	Adaptation technology to **protect against soil erosion and reduce the risk of landslides.** Adaptation response: reducing or preventing soil erosion and landslides.
18	Selection of different cultures, new species and varieties	Adaptation technology to **increase of resilience and productivity of plants.** Adaptation response: adaptation to changes in order to be resilient to biodiversity conservation and safety in food production.
19	Projecting the need for irrigation (spatially and by crops)	Adaptation technology for **water deficit.** Adaptation response: efficient water consumption management.
20	Establishment of coastal buffer zones	Adaptation technology for **water surplus and landscaping.** Adaptation response: preventing watercourse pollution and reducing erosion.
21	Sustainable pasture management	Adaptation technology for **risk reduction in livestock.** Adaptation response: seasonal nomad livestock farming in mountainous areas and rotation pastures in the Dinarides karst area for sustainable livestock production and food production.
22	Integral fertilization system with organic and mineral fertilizers	Adaptation technology to **increase of resilience and productivity of plants.** Adaptation response: fertilization system serving production and environmental protection.

Some of these measures require significant financial investment, while others require information and awareness raising, as well as capacity building to address new practices.

Water resources

Water is a strategic resource, and various ways have been devised and applied in an attempt to control it. In the light of climate change, awareness of the need for security when it comes to water is rising. Water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of water with

acceptable quality necessary for sustaining livelihoods, human well-being, socio-economic development, for ensuring protection against water borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.[131] Traditional technologies are still in use, but now mostly supported by new approaches and technologies - GIS, LIDAR, REMOTE SENSING, SATELLITE, etc.

Although research on the regulation and use of water and the organization of water resources management in Bosnia and Herzegovina is not complete, it can be said with certainty that the oldest crafts were related to water supply, flood protection, construction of dwellings outside flood levels, etc.[132] According to A. Trumić and S. Mikulec, if the criterion for determining the time stages of development is the connection between technical practice and scientific research, then the historical development of water management can be divided into three stages: (i) construction based on experience and tradition (approximately until the beginning of the 19th century), (ii) application of modern technology based on scientific achievements, especially achievements of technical sciences (beginning of the 19th century until the beginning of the Second World War), (iii) multidisciplinary approach to technical problems and direct cooperation among experts in various disciplines (after the Second World War).

Given the strong water management tradition, many different technologies are more or less known in the water sector in Bosnia and Herzegovina, which were, or are still, in use, or are being developed. The application of a wide range of technologies is specific, but the application success varies over time and from case to case, because in addition to the technical aspect, technology application also has a socio-economic context.

In the context of climate change challenges, adequate application of technologies is becoming increasingly important and demanding in Bosnia and Herzegovina. The application of known and already applied technologies is potentially more successful, because new technologies are available that are not exclusively hydrotechnical, but enable the acquisition of more data and information, their transfer and faster possibilities of providing information and communication, and thereby better planning and operational water management.

Of 102 identified technologies[133], 14 adaptation technologies were selected taking into account the natural characteristics of Bosnia and Herzegovina and the impacts of climate change, as well as the existing practice and targets from strategic and planning documents. After the selection, the prioritization of 14 climate change adaptation technologies in the water resources sector of Bosnia and Herzegovina was done through the Multi-Criteria Analysis (MCA). The end result in shown in Table 31.

Table 31: Results of the implemented MCA prioritization for adaptation technologies in the water resources sector

Rank	Technology	Description
1	Urban green areas	Adaptation technology for the challenges of **too much water, not enough water, water pollution**. Adaptation response: urban stormwater management, increasing water resources.
2	Collection of rainwater for storage	Adaptation technology when there is **not enough water.** Adaptation response: Water storage.
3	Improving the efficiency of treatment devices	Adaptation technology for the challenge of **water pollution**. Adaptation response: Improvement of water treatment capacity
4	Optimization of urban drainage systems	Adaptation technology for the challenges of **too much water, water pollution.** Adaptation response: urban stormwater management and improvement.

[131]UN WATER: Water Security and the Global Water Agenda. A UN Water analytical brief. United Nations University, 2013.

[132]JVP Vodoprivreda Bosne i Hercegovine: Okvirna vodoprivredna osnova Bosne i Hercegovine/ Water Resources Management Framework of BiH, 1994

[133]Development of the Fourth National Communication of Bosnia and Herzegovina in accordance with the United Nations Framework Convention on Climate Change: Communication 4 - Study on technological needs assessment for the water resources and agricultural sectors in Bosnia and Herzegovina, Enova, Ceteor and Jozef Stefan Institute, 2019

Rank	Technology	Description
5	Assessment and mapping of flood risk	Adaptation technology for **perceiving climate risks.** Adaptation response: Hazard and risk assessment.
6	Reduction of losses and leaks in the system	Adaptation technologies when there is **not enough water.** Adaptation response: Efficiency and water consumption management.
7	Multipurpose accumulations	Adaptation technologies when there is **not enough water, too much water, water pollution.** Adaptation response: Water storage.
8	Assessment and mapping of drought risk	Adaptation technology for **perceiving climate risks.** Adaptation response: Hazard and risk assessment.
9	Progressive pricing of water services	Adaptation technologies when there is **not enough water.** Adaptation response: Efficiency and water consumption management.
10	Source protection	Adaptation technology when there is **not enough water, water pollution.** Adaptation response: Water increase.
11	Retentions	Adaptation technology when there is **too much water.** Adaptation response: River flood protection.
12	Flood forecasting systems	Adaptation technology for the challenge of **disaster preparedness**. Adaptation response: Early warning.
13	Torrent information systems	Adaptation technology for the challenge of **disaster preparedness**. Adaptation response: Early warning.
14	Limiting salt water penetration	Adaptation technology for the challenge of **rising sea level, water pollution**. Adaptation response: Limiting salt water penetration.

MCA results for both sectors could be improved through the work of a group consisting of several stakeholders and experts.

5.2 Overview of plans and programmes for systemic surveillance

5.3 Education, training and awareness raising

Achieving inclusive and good education of the young population confirms the belief that school education is the most powerful and proven instrument of sustainable development. According to this goal, all girls and boys will complete primary and secondary school free of charge. Also, the goal is to provide the same opportunities in terms of affordable vocational education, as well as to eliminate the differences in terms of gender and wealth, in order to achieve universal access to good education.

In accordance with Article 6 of the Convention, each state within the UNFCCC is responsible for building a system for the promotion and development of education, awareness raising and training on climate change. It is not only an obligation created within the UNFCCC, but also the development of a system that will enable each country to participate more professionally and actively in its own planned activities. Strategies of municipalities in Bosnia and Herzegovina envisage that education should be carried out systematically, and it should in various ways contribute to raising of the level of environmental awareness in order to improve the quality of life and preserve the environment.

It is beyond doubt that education and awareness raising of environmental issues, with the aim of adopting ecologically sustainable patterns of action, is the main goal and measure of environmental protection in the long run. Most problems in the environment are caused by human action, and treating the cause of the problem basically means focusing on people, that is, on their behaviour.

At the Summit on Sustainable Development, held on 25 September 2015, United Nations Member States adopted the 2030 Agenda for Sustainable Development, which contains 17 Sustainable Development Goals to

eradicate poverty, combat inequality and injustice, and address climate change by 2030. [134] *Goal 13 (Climate action)* is to take urgent action to combat climate change and its impacts. One of the defined results (13.3) for achieving this goal is to improve education, awareness raising and human and institutional capacities for climate change mitigation, adaptation, impact reduction and early warning.

Within the preparation of the Third National Communication, it was concluded that it is necessary to enhance training of experts working inside and outside the public sector in climate change and adaptation to climate change. A lack of knowledge was identified among experts within non-governmental organizations and civil society in order for them to work on further education of wider groups of citizens. Furthermore, it is recommended to establish a clear link between the QA/QC programme, the QA/QC plan (yet to be developed), as well as capacity building and the need to train the GHG inventory development team to focus on those parts of the GHG emissions inventory, IT applications and databases, and methodological issues that are crucial. It has also been identified/recognized that inventory workers, statistical office staff and other relevant stakeholders (industry/operators, registries, reference centres for verification and validation of emissions data, etc.) have to undergo a series of trainings to build capacity, so that they can compile and verify inventory data.

This is also indicated by the decisions of the Paris Agreement (2015) and the objectives of the EU Strategy (stimulating research, ClimateADAPT platform), which is to strengthen society's ability to cope with the effects of climate change and identify and fill knowledge "gaps".

Although climate change is a global problem, specific sectors of society such as universities should be more engaged and active in the search for regional and local solutions, which would also be a response to the global problem. Despite the fact that many universities around the world undertake extraordinary efforts to address the climate change challenges, there is still an extremely small number of published papers addressing this issue.

Currently, even in more developed countries than Bosnia and Herzegovina, knowledge related to climate change is not taught effectively: an analysis of existing curricula in 78 countries shows that only 58% use the term ecology and 47% mention environmental education[135].

Legislation in the Federation of Bosnia and Herzegovina stipulates that environmental education programs are to be included in curricula and extracurricular programmes. In addition to important environmental issues, educational programmes will include data on how to ensure access to information, how to participate in decision-making and how to obtain protection of environmental rights. Also, in the Republika Srpska, in cooperation with the Ministry responsible for education and culture and the Ministry responsible for science and technology, the Ministry develops and acts in accordance with the annual educational plans in the field of environmental protection that improve education and public awareness of environmental protection in teaching and an extracurricular programme. As in both entities, law requires that the competent department of the Brčko District is to provide support to educational institutions, scientific institutions, professional organizations and associations in order to be able to conduct their educational activities more effectively when it comes to environmental protection.

In the current education system, school curricula still do not include environmental issues to the extent that they should, which is why it is necessary to develop programmes that will integrate the environment in the curricula of primary, grammar and vocational high schools and universities, and especially in curricula of biotechnical and technical faculties, faculties of natural sciences as well as economics and law faculties.

[134] UNDP Bosnia and Herzegovina: Sustainable development goals, available at: https://www.ba.undp.org/content/bosnia_and_herzegovina/bs/home/post-2015/sdg-overview.html

[135] UNESCO (2016): Global Education Monitoring (GEM) Report - Education for people & planet: Creating sustainable futures for all

The subject "My Environment" was introduced in primary schools, and it integrates aspects of studying nature and society, where students observe, research and ask questions about school, family and environment as important places of their life and development, and about living things, which are needed to introduce students to the world around them. The situation is somewhat better in higher education, where the increasing introduction of subjects in the field of environment and climate change is evident at an increasing number of universities. The reason behind this lies in the fact that changing curricula is much easier in higher education than in primary and secondary education. It is of great importance to strengthen the appropriate professional capacities and educate teachers about the importance of climate change, so that information and knowledge can be passed on to new generations.

Activities conducted so far in the field of education and awareness raising of climate change were quite modest. Therefore, a better education in the sphere of environmental protection and raising awareness are of particular importance because it can help the implementation of long-term strategies and policies related to climate change. It is very important to organize coordinated joint implementation between the different stakeholders, particularly government institutions and civil society.

Since the submission of the Third National Communication, a number of projects have contributed to the increase of inter-institutional capacity for climate change. Some of the projects are:

- **The Green Economic Development Project** (GED) (2013-2021), funded by the Government of Sweden, the Environmental Protection Fund of the Federation of Bosnia and Herzegovina and the Environmental Protection and Energy Efficiency Fund of the Republika Srpska, is implemented by the UNDP. The project also includes the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, as well as the ministries of spatial planning of the Federation of Bosnia and Herzegovina and the Republika Srpska, cantonal ministries and other institutions;
- **Transfer of climate change-resistant technologies for flood management, in the Vrbas River Basin** (2015-2020), funded by the Global Environment Facility and implemented by the UNDP in close cooperation with Bosnia and Herzegovina, Federation of Bosnia and Herzegovina and Republika Srpska and local governments;
- **Financing of environmental protection for projects of accelerated low-carbon development** (URBAN LED) (2017-2022), implemented by UNDP and aimed at increasing the capacity of the Environmental Protection Fund of the Federation of Bosnia and Herzegovina and the Environmental Protection and Energy Efficiency Fund of the Republika Srpska;
- **Improve the Bosnia and Herzegovina's Adaptation Plan (NAP) process for mid-term investment planning in climate-sensitive sectors in Bosnia and Herzegovina** (2018-2021), implemented by UNDP in cooperation with the Ministry of Spatial Planning, Civil Engineering and Ecology of the Republika Srpska and the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina;
- **The Joint Swiss-UN Programme: Disaster Risk Reduction for Sustainable Development in Bosnia and Herzegovina** (2018-2022), funded by the Government of Switzerland and implemented by UNDP in cooperation with the Ministry of Security of Bosnia and Herzegovina, Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, Ministry of Civil Affairs of Bosnia and Herzegovina, Ministry of Labour and Social Policy of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska, Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Education and Science of the Federation of Bosnia and Herzegovina, Ministry of Education and Culture of the Republika Srpska, Ministry of Spatial Planning of the Federation of Bosnia and Herzegovina, Ministry of Spatial Planning, Civil Engineering and Ecology of the Republika Srpska, Civil Protection Administration of the Federation of Bosnia and Herzegovina, Civil Protection Administration of the Republika Srpska, representatives of local authorities, cantonal ministries of education;

- **Biomass energy for employment and energy security in Bosnia and Herzegovina** (2009-2019), funded by the Czech Development Agency and implemented by UNDP in cooperation with the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, the Embassy of the Czech Republic in Bosnia and Herzegovina, the Ministry of Agriculture, Water Management and Forestry of the Federation of Bosnia and Herzegovina, Ministry of Agriculture, Forestry and Water Management of the Republika Srpska, Government of Brčko District of Bosnia and Herzegovina;
- **Integrated Disaster Risk Management (IDRM)** (2018), funded by the Italian Agency for Development Cooperation and implemented by UNDP in cooperation with the Ministry of Security of Bosnia and Herzegovina, the Civil Protection Administration of the Federation of Bosnia and Herzegovina, the Civil Protection Administration of the Republika Srpska, the Public Security Department of the Brčko District Government, the City of Doboj, the City of Tuzla, cantonal and municipal authorities and other relevant agencies.
- **Regulatory framework for setting tariffs in water and sewerage services in Bosnia and Herzegovina** (2013-2017), funded by the Government of Sweden, the International Stockholm Water Institute and the Water Management Instrument, and implemented by UNDP in cooperation with the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, Ministry of Agriculture, Water Management and Forestry of the Federation of Bosnia and Herzegovina, Ministry of Agriculture, Forestry and Water Management of the Republika Srpska, Association of Municipalities and Cities of the Federation of Bosnia and Herzegovina and Federation of Municipalities and Cities of the Republika Srpska, Association of Employers in Communal Economy in the Federation of Bosnia and Herzegovina and "Vodovodi RS" Association;
- **Increased resilience to risks and disasters of Livno, Mrkonjić Grad and Maglaj** (IRLMM) (2018-2019), funded by the Government of the Czech Republic and implemented by UNDP in cooperation with the Ministry of Security of Bosnia and Herzegovina, the Civil Protection Administration of the Federation of Bosnia and Herzegovina, the Civil Protection Administration of the Republika Srpska, municipal authorities and others relevant agencies;
- **Disaster Risk Reduction Initiative in Bosnia and Herzegovina** (2013-2018), funded by the Ministry of Spatial Planning of the Federation of Bosnia and Herzegovina, municipalities of the Federation of Bosnia and Herzegovina, the Republic of Turkey and UNDP, and implemented by UNDP in cooperation with the Ministry of Security of Bosnia and Herzegovina, Civil Administration Protection of the Federation of Bosnia and Herzegovina, the Civil Protection Administration of the Republika Srpska, the Public Security Department of the Brčko District Government, cantonal and municipal authorities and relevant agencies (including economic and planning departments and civil protection departments), civil protection organizations, spatial planning bodies, water management agencies, hydrometeorological institutes , geological institutes, etc.

5.3.1 Needs in education and capacity strengthening

In the education system of Bosnia and Herzegovina, sufficient attention is not paid to climate change issues, even though the Constitution clearly emphasizes it. The climate change education program should aim to incorporate climate change education into the international response to climate-related changes. The programme should help people understand the impact of global warming and increase awareness of climate change among youth.

Environmental education strategies, which will integrate environmental elements, including climate change, into the curricula of primary, secondary and vocational schools, as well as universities, especially technical, biotechnical, economic, legal and natural sciences faculties, have not been enacted yet. The administrative capacity of Bosnia and Herzegovina in the field of climate change is limited, and with no strategic approach to capacity building. At the country level, the UNFCCC Focal Point, the RS Ministry for Spatial Planning, Civil

Engineering and Ecology is practically the only institution in the administration fully dedicated to the issue. Capacity building would initially target relevant ministries at the levels of Bosnia and Herzegovina, the Federation of Bosnia and Herzegovina and the Republika Srpska, and other public agencies. Institutional strengthening is needed at all administrative levels: state level, level of the Federation of Bosnia and Herzegovina and the Republika Srpska, regional and local levels, together with the business sector and civil society.

Therefore, it is proposed to establish certain forms of scientific cooperation in the development and implementation of sustainable development. These measures are crucial for the formation of a nucleus of future professionals in administration and economy, and they contribute to the creation of a civil society aware of environmental issues. There is a need to increase knowledge of existing staff in the environmental protection sector at all administrative levels, which requires development of long-term strategies with steps and time intervals defined based on the needs assessment.

Training should be organized that will meet the strategy objectives, in cooperation with organizations/ institutions capable of providing such trainings.

On the other hand, environmental officials should organize training for industries, such as training programs with a focus on pollution prevention, Environmental Management System (EMS), and the introduction of standards to establish adequate and efficient cooperation in the economy.

By introducing educational programmes, existing staff could increase their skills and new staff would access training.

Capacity building and training of officials, mainly at the local level, has been done by international organizations (UNDP, GIZ) primarily through the development and monitoring of local environmental action plans and action plans for sustainable energy.

Generally, there is limited awareness of climate change issues and the need for adaptive measures among the public and interested parties. There is also a need for greater involvement of civil society and enhanced advocacy.

Despite the activities already undertaken and taking place in Bosnia and Herzegovina to support capacity building related to climate change, there are still a number of needs and gaps that should be addressed. Based on the identified needs for capacity building for adaptation, mitigation and inventory of greenhouse gases, a number of comprehensive activities have been identified, which include:

- Increase of technical and institutional capacity
- Further inter-sectoral cooperation and coordination
- Inclusion of climate change in institutional and sector-specific planning and budgeting in Bosnia and Herzegovina
- Addressing technical needs related to: GHG calculation, systematic and continuous measures, data collection, risk modelling, vulnerability assessment, regional and global climate impact models
- Capacity building at local/cantonal level, involvement of civil society as well as the most vulnerable/risk-exposed
- Support further research into the specific impacts of climate change for Bosnia and Herzegovina, as well as effective mitigation measures.

Climate change education aims to understand the process of climate change as a prerequisite for developing an effective response to climate change.

General training

General (basic) training applies to all sectors in the field of climate change adaptation and mitigation and includes:

- Training in effective and continuous sector monitoring and data collection to determine climate impacts and vulnerabilities
- Training in risk identification and priority measures for adaptation activities
- Training in financial and societal needs
- Training in interdependencies between sectors and the resulting needs for coordinated policy making
- Training in technical and scientific research required to conduct vulnerability assessments
- Risk management planning training that includes climate change for strategic planning
- Training in early warning systems for extreme weather/hydrological events
- Training in inclusion of disaster risk reduction (DRR) issues[136] in planning and development
- Training in how to incorporate emergency planning results into strategic adaptation planning
- Training in how to participate in public dialogue and ensure participation in adaptation planning and decision-making, especially for vulnerable groups
- Training in inclusion of disaster risk reduction (DRR) and climate change adaptation (CCA) considerations[137] in education systems
- Training in the development of greenhouse gas emission trajectories
- Training in how to develop/include GHG reduction measures in relevant sectoral policies and plans
- Training of relevant institutions in how to harmonize legislation of Bosnia and Herzegovina with the EU legislation and eventually implement it
- Training in best available techniques for mitigation measures.

Climate change education

In the climate change education fields, the following objectives set in the Third National Communication remain a priority:

- Raise education on the effects and causes of climate change, as well as mitigation and adaptation measures to a higher level
- Hold expert meetings on the need to introduce climate change learning in the curricula of all levels of formal education (with best practices from the neighbouring countries), and it is necessary to choose the best model for Bosnia and Herzegovina
- Educational institutions need to adopt an education strategy on climate change in formal education at all levels
- Conduct training of civil servants, including representatives of ministries of education, on the causes and effects of climate change and their integration into curricula and standards
- Conduct training of professors and teachers on the need to introduce the topic of climate change in education, as well as on teaching methods;
- In formal education and the business sector, appoint a team of experts on climate change education;
- Hold expert meetings on linking non-formal education and private and public enterprises with the aim of adapting to climate change and mitigating its consequences.

[136] Disaster Risk Reduction

[137] Climate Change Adaptation

Development of greenhouse gas inventory

Capacity building in the area of GHG inventory should be ensured through close cooperation with the hydrometeorological institutes of the Federation of Bosnia and Herzegovina and the Republika Srpska working on data collection and calculation of emissions, agencies/statistical institutes, environmental protection funds and line ministries. The following trainings are needed to strengthen the capacity in the field of greenhouse gas inventory development:

- Requirements under the Regulation on a mechanism for monitoring and reporting greenhouse gas emissions MMR/525/2013 (Monitoring Mechanism Regulation), Legislation in accordance with the constitutional setup, obligations under the UNFCCC
- Inventory development system in Bosnia and Herzegovina (structure required for efficient, reliable, transparent, timely and comparable inventory)
- Preparation of inventory of emissions from the energy sector (specific methodologies and software tools, CRF tables, emission calculation, preparation of emission factors of Bosnia and Herzegovina, estimates in case of lack of data)
- Emission calculation from the Traffic subsector (IPCC and COPERT V model).
- Calculation of emissions/sinks from the LULUCF sector (Development of a land use change matrix, use of Corine Land Cover data)
- Calculation of emissions from the Waste sector (due to the lack of data in this sector, expert estimates are needed, which leads to budget unreliability)
- QA/QC procedures (Defining the steps necessary to ensure and improve the quality of the budget)
- Data insecurity assessment.

Agricultural sector

When it comes to climate change adaptation and mitigation, and sustainable land management, it is necessary to continuously train and strengthen the capacity of all stakeholders: extension services, agricultural producers, farms, cooperatives, agricultural enterprises, agricultural goods, all levels of institutional management in agriculture, non-governmental sector dealing with environmental protection, spatial planners and development planners at all levels, as well as all others interested in the management of natural resources and the consequences of climate change.

Among other things, extension services should be crucial for strengthening the capacity of farmers to understand and implement measures of climate change adaptation and mitigation, safe food production and environmental protection. Professional services should have the knowledge and skills to adapt, and effectively contribute to their dissemination among farmers. Experts working in these services should be highly educated and specialized in the fields they deal with in order to be able to educate farmers in the field and contribute to safer high-quality food production and environmental protection in changed climate conditions. The services should function at regional and local levels considering that natural phenomena do not follow any strict state boundaries. In that regard, the capacity of extension services should be increased.

In addition, it is necessary to strengthen systematic research in the field of climate change and agriculture, and to strengthen capacity in terms of early warning of extreme events, in particular: drought, floods and hail. For efficient adaptation to the changed climate conditions, it is necessary to apply modern solutions that correspond to special, local conditions. Farmers will have to adopt new knowledge and follow new scientific and technological solutions, in order to adapt their production to the changed environmental conditions. Universities, institutes, professional services and, education system in general play a significant role in this.

Insuring crops, plantations, livestock, but also agricultural infrastructure is becoming an imperative. However, very few farmers use this option, which is a common practice in other developed countries. Insurance of agricultural production is the best guarantee that it will continue next year and that the farmer is not exposed to the risk and capriciousness of the weather. However, it is necessary to raise awareness among farmers, but also to disseminate information about the possibilities and benefits of insurance in agriculture.

Water resources management

In the case of water resources management, it is necessary to understand changes in the hydrological regime and impacts on humans and the environment, on the use and protection of water resources, and on protection against water. It is necessary to understand the causes and consequences of climate change and prepare for life with the climate change effects: for example, educating residents of areas at high risk of floods about opportunities to reduce the risk of losses and damage caused by floods will help take appropriate action to adopt a more sustainable lifestyle.

The strategy related to priority technologies (TNA) can be implemented (i.e., priority technologies can be applied at the desired level) only with systematic support measures. Awareness-raising and education campaigns (change of attitudes) are needed, as well as training in order to transfer and disseminate the necessary specialist knowledge and skills.

Water is the primary medium for climate change effects on us. Water resources management can play a key role in how Bosnia and Herzegovina can adapt to climate change and reduce its negative effects. For example, trainings presenting technologies available in water management will be very useful to the sectors of agriculture, environment, hydro energy, spatial planning.

Forestry sector

It is very important to work on the development of human resources and strengthening of research organizations focusing on assessing the impact / vulnerability, climate change impact on the forestry sector, which could lead to the inclusion of these aspects in policy development. The environmental, social and economic impacts of climate change should be assessed in more detail. This could indirectly contribute to progress on issues such as the establishment of mixed forests, use of indigenous species, selection of more tolerant genotypes, support to the natural forest regeneration dynamics and the encouragement and promotion of biodiversity conservation. It could also lead to awareness raising, information sharing, cross-sectoral cooperation and greater involvement of the forestry sector in adaptation and climate change mitigation aspects. Negative consequences of extreme climate change in forests and forest ecosystems are more difficult to identify. It requires long-term research and monitoring. This is the only way to determine and identify the cumulative effects of temperature and precipitation. The locations of forests, i.e., geographical and climatic zones are equally important.

In addition to the above, a very important activity is training of forestry employees who need to change their habits, primarily through gradual changes in the management system and the choice of species in the establishment of new forests. In addition to changes in habits among forestry employees, it is even more important to comprehensively raise public awareness of the importance of forests, its contribution to climate change mitigation and the need to preserve and improve the general useful forest functions.

Biodiversity

In the curricula in primary and secondary schools, topics related to biodiversity are represented with a minimum number of hours. It is necessary to increase the number of hours needed for the implementation of teaching

units in this area, and especially to enable students to visit protected and highly valuable natural areas as part of regular classes and excursions, in order to increase knowledge about natural values and understand the need for their preservation.

In Bosnia and Herzegovina, a very small number of municipalities have developed a fire risk assessment and fire protection plan. Therefore, in order to develop the most efficient protection of species and habitats from fire, it is necessary to work on capacity building of institutions responsible for this field, primarily civil protection administrations of the Federation of Bosnia and Herzegovina and the Republika Srpska, and operational civil protection centres.

Tourism sector

The link between climate change and the tourism sector is best explored in western countries. Many shortcomings are evident in this area in Bosnia and Herzegovina. There are not enough scientific studies even at the regional level, and the problem is the data, the quality and availability of which are the main precondition for research and studies. The lack of research directly reflects on the possibility of adopting adequate adaptation measures for the tourism sector in Bosnia and Herzegovina. Also, awareness of climate change among tourism entities in Bosnia and Herzegovina is very low.

Climate change education is insufficiently represented in the curricula of primary and secondary schools in Bosnia and Herzegovina, and it is necessary to work on the introduction of new curricula modelled on the education systems of European countries. In the process of successful climate change management, the institutions that, in addition to providing a basis for the implementation of strategies and policies should also ensure their mutual interaction constitute one of the most important elements.

In the future, competent institutions and line ministries should take a key role in developing the capacity of the tourism sector in the process of awareness raising and adapting to climate change. It is necessary to encourage investments in the so-called green technologies in tourism, work on the adoption and implementation of legislation, and be more active in awareness raising and education through concrete initiatives and connecting of public and private sectors.

Educational and informative measures for the tourism sector should be aimed primarily at tourism workers, members of the non-governmental sector, and all stakeholders interested in more effective adaptation to climate change. These measures are primarily aimed at raising awareness of the consequences of climate change and changes in the way of doing business in the tourism sector. They are intended for the general public, local authorities, agencies, institutions and other organizations.

Health sector

Due to the prominent role of the health sector in supporting adaptation to climate change and mitigating its harmful impact on health, it is necessary to strengthen the capacity of public health institutes and emergency services in terms of implementing staff training programmes in current climate change. Continuous training and capacity building is needed to improve health monitoring and information systems as well as to prevent diseases sensitive to climate change impact. The aim of the training programme is to consider the impact of climate change on health as a global and regional problem, to understand the importance of assessing sensitivity to climate change and to consider the possibilities of protection against climate extremes. Training for health professionals is also important due to the need to include climate change in health sector strategies (development of strategies and plans for adaptation to climate change in the health sector, i.e., revision of

existing strategic documents in terms of introducing climate change). Training for health professionals would include the following thematic units:

- Prioritizing protection of health from the effects of climate change
- Describing how to implement public health measures to protect health from climate change in different environments
- Selection of methods and indicators for evaluating the implementation of measures.

The integration of the climate change topic into the curricula of pre-school institutions, primary and secondary schools and universities is also of great importance.

Waste management

It is necessary to strengthen the professional capacities in municipalities and public utility companies that collect and dispose waste in order to improve reporting, as well as the capacity to implement waste management practices that have benefits in the climate change mitigation system.

5.3.2 Awareness raising

Education, training and awareness-raising are needed at different levels of society: they help policy makers understand the urgency and importance of establishing mechanisms to combat climate change at national and global levels, and communities learn how climate change will affect them, what they can do to protect themselves from adverse effects, and how they can reduce their own impact on the climate. It is necessary to better inform the public about adverse effects of climate change, and about the possibilities of adequate adaptation.

Aarhus centres in Bosnia and Herzegovina facilitate access to environmental information for citizens and institutions, provide assistance in exercising the right to participation in environmental decision-making, and provide support in the legal protection of human rights in the field of environment. Environmental protection laws in the Federation of Bosnia and Herzegovina, the Republika Srpska and Brčko District lay down that every individual and organization has the right to participate in all procedures for the adoption of such plans from the early stages of such procedures. Civil society organizations often carry out activities and projects in the field of environmental education and public awareness raising of environmental issues.

Furthermore, existing activities of public health institutes include the production and distribution of educational and promotional materials intended for vulnerable population groups and the general population during extremely high or low temperatures, episodes of air pollution, floods etc. (brochures, leaflets, posters). In case of extreme weather conditions and other emergencies, in cooperation with the media, public health institutes also issue announcements that contain guidelines for the protection of public health.

However, the first step in all phases of adaptation to climate change is to strengthen the level of awareness and knowledge of the general population and vulnerable population groups about the impact of climate change on health. This includes additional education of the population on how to live and behave in extreme weather/climate situations (extremely high or low temperatures, air pollution episodes, contamination of drinking water and food, mosquito and tick bites, floods, droughts, etc.), and defining of measures and recommendations on how to behave in these situations.

In general, the role of the general public should be to contribute to the implementation of measures that will result in reduced impact in general, and should not be underestimated. Such education must be improved and intensified, enabling both children and adults to learn about climate change and how they can contribute in that regard. The topic should be incorporated to a greater extent into the primary, secondary and higher education curricula.

In order to engage communities in the climate change discussion, a broad public-focused, awareness-raising campaign should be conducted, including printed and multimedia materials suitably adapted for different target groups, which was not done before in Bosnia and Herzegovina. A series of media events, television programmes, workshops and other relevant awareness-raising events should also be organized. In relation to communication activities, community members, including vulnerable groups, must also have the opportunity to contribute and participate in their implementation.

Table 32: Trainings for capacity building and public awareness raising, by sectors

Training title / Topic	Lead entity	Training effects or benefits	Target group	Training implementation period/Training duration
Agricultural sector				
Climate-smart agriculture*: • adaptations in agricultural sector • mitigations in agricultural sector • sustainable land management	Faculties of agriculture, agricultural institutes in Bosnia and Herzegovina	The specific objectives of climate (smart) oriented agriculture are as follows: • integrated management of land, agricultural, forest and water resources at the local and regional levels, as well as at the level of water areas in order to ensure synergy between elements of the ecosystem, • promotion of activities that increase carbon storage (sequestration), • reduction of various greenhouse gas emissions in agriculture, • analysis of carbon emission for the purpose of sustainable agricultural practices, • genetic selection and development of resistant varieties and breeds for the purpose of income diversification on the farm, • development of risk insurance and risk management strategies, as well as	Extension services, agricultural producers, farms, cooperatives, agricultural enterprises, agricultural goods, all levels of institutional management in agriculture, non-governmental sector dealing with environmental protection, spatial planners and development planners at all levels, as well as all others interested in the management of natural resources and climate change effects.	Annual training lasting 2 days by region

Training title / Topic	Lead entity	Training effects or benefits	Target group	Training implementation period/Training duration
		development of strategy for building resilience of certain ecosystems and timely distribution of information on the state of the climate.		
Water management				
Climate change adaptation and water resources management	Water resources management experts	Water is the primary medium for climate change effects on us. Water resources management can play a key role in how the world/Bosnia and Herzegovina can adapt to climate change and reduce its negative effects.	Water sector Agricultural sector Environmental sector Hydro energy sector Spatial planning sector	1 business day with selected presentations
How to prepare for flood	Protection and rescue experts	Reducing the risk of losses and damage caused by a flood event	Inhabitants of areas at high risk of floods	One business day with selected presentations
Forest resources and forestry sector				
Importance of forest ecosystems in light of climate change	Experts in meteorology and climate change modelling and other related fields together with forestry experts	Obtaining wider knowledge about existing climate change and scenarios, as well as all the "benefits" that forest ecosystems bring in the segment of adaptation and mitigation	Representatives of relevant ministries, public enterprises, faculties, NGOs, media, general public	1 day
Cultivation practices in forestry in response to climate change	Teachers of growing, establishing and planning (arranging) of forests	Presentation of new adaptive forest management systems and their application in our country, taking into account climate change aspects	Spatial planners, executors of management plans and those who implement them in practice (forestry engineers)	1-2 days
Forest protection and climate change	Forest protection teachers	Introduction to new pests and pathogens, fire damage and control measures	Forestry engineers, fire protection services…	1-2 days
Biodiversity, forest ecosystems and climate change	Teachers of ecology, genetic resources…	Examining the current state of diversity in our forests, potential threats and opportunities to preserve them	Forest engineers and ecologists	1-2 days
Establishment of new forests and plantations	Professors of seed production, nursery and afforestation	Knowledge of the necessary transfer of genetic resources, forest seeds and planting material in the establishment of new forests, bioenergy and other plantations	Forest engineers and ecologists	1-2 days

Training title / Topic	Lead entity	Training effects or benefits	Target group	Training implementation period/Training duration
Monitoring climate change effects on forest ecosystems	International experts	Construction of towers, installation of equipment, monitoring and recording of measurable climate change effects on forest ecosystems	Local experts	7 days
Biodiversity				
Development of effective protection of species and habitats from fire	International experts	Obtaining wider knowledge about existing climate change and scenarios, as well as all the "benefits" that forest ecosystems bring in the segment of adaptation and mitigation	Primarily the Civil Protection Administration of the Federation of Bosnia and Herzegovina, but also representatives of relevant ministries, public enterprises, faculties, NGOs, media, general public	1-2 days
Tourism sector				
Education on "low-carbon tourism" and climate change adaptation in the tourism sector	Ministry of Trade and Tourism of the Republika Srpska and Ministry of Environment and Tourism of the Federation of BiH, relevant educational institutions	Education and training of staff in the field of climate change in the tourism sector	Tourism workers, members of the non-governmental sector, and all interested stakeholders	1 year (education duration period) / 1-2 days
Education of employees in tourism on more efficient and environmentally responsible operations of hotels and other tourist capacities	Ministry of Trade and Tourism of the Republika Srpska and Ministry of Environment and Tourism of the Federation of BiH, relevant educational institutions	Staff education and training; Raising awareness of the importance of "green business"	Tourism workers	1 year (education duration period) / 1-2 days
Health sector				
Training on improving the system of statistical monitoring and information on health protection measures	Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska Government, Public Health Institute of the Federation of Bosnia and Herzegovina, Public Health Institute of the Republika Srpska	Consider the impact of climate change on health as a global and regional problem, understand the importance of assessing sensitivity to climate change and to consider the possibilities of protection against climate extremes.	Health professionals	3 days
Increasing awareness and knowledge on the prevention of diseases sensitive to climate change effects (extremely high or low temperatures, air pollution episodes, contamination of drinking water and	Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska Government, Public Health Institute of the Federation of Bosnia		General population and vulnerable population groups	Time required for the production and distribution of educational promotional materials

Training title / Topic	Lead entity	Training effects or benefits	Target group	Training implementation period/Training duration
food, mosquito and tick bites, floods, droughts, etc.), and defining of measures and recommendations for general population and vulnerable groups on how to behave in extreme weather/climate situations.	and Herzegovina, Public Health Institute of the Republika Srpska			
Climate change and health: global and regional political development	Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska Government, Public Health Institute of the Federation of Bosnia and Herzegovina, Public Health Institute of the Republika Srpska		Health professionals	3 days
Climate change impacts on health	Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska Government, Public Health Institute of the Federation of Bosnia and Herzegovina, Public Health Institute of the Republika Srpska		Health professionals	3 days
Climate change vulnerability assessment, impact and adaptation	Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska Government, Public Health Institute of the Federation of Bosnia and Herzegovina, Public Health Institute of the Republika Srpska		Health professionals Policy makers	3 days
Capacity building for the development of the health component of the Adaptation and Action Plan of Bosnia and Herzegovina	Ministry of Health of the Federation of Bosnia and Herzegovina, Ministry of Health and Social Welfare of the Republika Srpska Government, Public Health Institute of the Federation of Bosnia and Herzegovina, Public		Health professionals	3 days

Training title / Topic	Lead entity	Training effects or benefits	Target group	Training implementation period/Training duration
	Health Institute of the Republika Srpska			
Waste management				
Separate collection of organic waste and planning of biogas plants	Local and international experts	Obtaining wider knowledge about climate change in the field of waste management and gaining knowledge about waste management practices that benefit the climate change mitigation system	Educational institutions on all levels Representatives of local communities	1 day
Reduction of waste at the place of generation in order to reduce the amount of landfilled waste	Landfill management experts		Public communal enterprises that collect and dispose waste Representatives of municipalities-departments for waste management	1 day
Impact of landfills on greenhouse gas generation	Local and international experts		Public communal enterprises Private partners - landfill owners	1 day
The importance of separating waste, especially organic and municipal, which accounts for a significant amount of total waste disposed in landfills	Local and international experts		Educational institutions Representatives of local communities (for the purpose of strengthening and transferring knowledge at gatherings in local communities)	1 day

5.4 Preparation of operational public information programmes

Knowledge and awareness of climate change in Bosnia and Herzegovina is still insufficient, although progress is evident compared to the previous period. Citizens, businesspeople and politicians are not fully aware of how vulnerable Bosnia and Herzegovina is to climate change and how much it will be felt in the quality of life and business. Therefore, the priority is that relevant information reach all stakeholders.

The following main information must be conveyed:

1. Bosnia and Herzegovina is vulnerable to climate change,
2. There are methods of adaptation, namely adaptation to changed conditions (coping, partial or complete adaptation) and adaptation with the application of measures to reduce global emissions (mitigation),
3. Developed countries are ready and have committed through international agreements to help developing countries adapt to climate change.

In order for adaptation and mitigation programmes to be implemented, information should reach all levels, forms and profiles of education, all citizens, business organizations and all government employees.

The basics of the concept for complete information system remain unchanged in relation to the Second and Third National Communications, and additional efforts should be made to bring the proposed concept to life.

5.4.1 Climate web portal update

In the period between the two Communications, the website www.unfccc.ba continued functioning and informing the public about the state of climate change in the world and in Bosnia and Herzegovina. As part of the preparation of this report, the Interactive Climate Atlas of Bosnia and Herzegovina was updated and improved (available at http://www.unfccc.ba/klimatski_atlas/index.html). Data were collected and processed, climate trends were analysed, climate model was made and model maps and difference maps were made, which included:

- Collection and processing of data for the implementation of climate models
- Development of the climate model according to the RCP 8.5 scenario for three periods: 2011-2040, 2041-2071, 2071-2100,
- Based on model values, generating raster maps by seasons, for the vegetation period and annually
- Generating maps of temperature and precipitation differences between those measured in the reference period 1961-1990 and model ones
- Formatting, styling, placement in database and adding maps to the web platform.

The total of 72 maps were prepared, as follows: 6 maps (annual, vegetation period, seasons) for all three model periods for temperatures and precipitation (36 maps in total), and differences between measured (1961-1990) and model values for all observed periods (36 maps).

5.5 Cooperation under global environmental agreements

5.5.1 International cooperation

With the signing and ratification of the UN Convention on Climate Change in 2000, Bosnia and Herzegovina officially became part of international cooperation in the field of climate change. From the very beginning, Bosnia and Herzegovina regularly attended all conferences of the parties, as well as meetings of expert bodies within the UNFCCC Secretariat, including meetings of the IPCC and CTCN. Ratifying the Paris Agreement[138], Bosnia and Herzegovina confirmed its climate change mitigation activities.

Bosnia and Herzegovina has ratified and acceded to the amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer (from London, Copenhagen, Montreal and Beijing)[139] and thus gained the right to international technical and financial assistance in the implementation of the Vienna Convention for the Protection of the Ozone Layer and Montreal Protocol. The Kigali Amendment is the fifth amendment to the Montreal Protocol, which entered into force on 1 January 1 2019. It defines emission reduction measures, as well as the production and consumption of hydrofluorocarbons (HFCs), in order to reduce the market of products and equipment that contain or depend on these substances, and increase the use of alternative technologies that do not deplete the ozone layer. Bosnia and Herzegovina is in the final process of ratifying the Kigali Amendment. However, further steps should be taken on harmonization with EU legislation on ozone-depleting substances and fluorinated gases.

Bosnia and Herzegovina is a signatory to several conventions and protocols in the field of water resources: Convention on the Protection and Sustainable Use of the Danube River, UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Barcelona Convention, World Meteorological

[138] Decision on the ratification of the Paris Agreement in accordance with the UNFCCC (Official Gazette of BiH - International Agreements, No. 01/17)
[139] Official Gazette of BiH - International Agreements, 8/03

Organization (WMO) Convention[140], Framework Agreement on the Sava River Basin, with a number of related protocols. The implementation of these agreements is aimed at sustainable management of water resources in accordance with EU and domestic legislation, the provisions of international agreements and conventions, through various activities including the implementation of projects in the country and at the regional level. Through the implementation of these activities, water sector institutions actively cooperate with the EU Delegation to Bosnia and Herzegovina, the World Bank, UN agencies and other international and financial organizations and institutions. Most projects are at the regional level, so the aspect of interstate and inter-institutional cooperation and data exchange is very important as a prerequisite for project success.

Complementary activities between the three UN conventions - climate change, biodiversity and desertification - are certainly necessary to harmonize activities in Bosnia and Herzegovina, but also constitute a great opportunity for international cooperation, which would help Bosnia and Herzegovina achieve sustainable development.

Bosnia and Herzegovina is a signatory to the Convention on Biological Diversity (UNCBD) and the Protocol on Biosafety, which deal with the problem of invasive species and under which Bosnia and Herzegovina has undertaken to combat them in its plans and goals (strategic goals of the National Biodiversity Strategy and Action Plan of Bosnia and Herzegovina - NBSAP 2015-2020). Bosnia and Herzegovina submitted the 6th National Report on Biodiversity in Bosnia and Herzegovina, which was prepared by domestic experts, competent institutions (Federation of Bosnia and Herzegovina, Republika Srpska and state level), implementing agencies (UNDP in Bosnia and Herzegovina), as well as other decision makers. Bosnia and Herzegovina has not yet ratified the Nagoya Protocol on Access to Genetic Resources and Fair and Equitable Sharing of Benefits Arising from their Utilisation, in addition to the Convention on Biological Diversity. This agreement should enable more efficient prevention of climate change effects and biodiversity preservation.

As a potential member of the EU, Bosnia and Herzegovina should meet the requirements related to environmental legislation, where it is emphasized as a priority that strategies and programmes of Bosnia and Herzegovina for protection against genetically modified organisms (GMOs) and invasive species must be developed. Given that the European Union strategies and laws (2020 Biodiversity Strategy for the EU and directives) prescribe plans and actions using various mechanisms to combat the spread of invasive species, it is clear that Bosnia and Herzegovina should harmonize its legal frameworks and needs with the needs of the European Union. Controlling invasive species and reducing their impact on indigenous species and entire ecosystems is today one of the greatest nature protection challenges, and therefore early detection of the presence of a potentially invasive alien species in the ecosystem is important.

Within the UN Sustainable Development Goals (SDGs) from the point of view of agriculture, and when it comes to land, the most important is Goal 15: Life on land: *Sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss,* and its target 15.3. Target 15.3 reads that "by 2030, it is necessary to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world." During 2015, as a member of the United Nations Convention to Combat Desertification (UNCCD), the EU agreed to participate in achieving the land degradation neutrality (LDN) goals by 2030 on a volunteer basis. However, the assessment of land degradation in individual countries and in the EU has not been completed yet, and a uniform methodology in that regard has not been adopted either. Unlike the EU member states, Bosnia and Herzegovina has developed

[140]In June 2019, the WMO and the Global Water Partnership (GWP) signed a Framework Memorandum of Understanding on Strategic Cooperation to achieve the integrated water resources management goals.

the "LDN Target Setting Plan" for the Federation of Bosnia and Herzegovina and the Republika Srpska, which should be adopted by the Council of Ministers of Bosnia and Herzegovina as a single document at the state level.

In the international activities that are currently implemented related to forestry and climate change and the relationship between the scientific community and decision makers, the "Assessment of the state of nature and management of natural resources of Bosnia and Herzegovina" project which uses IPBES (https://ipbes.net/) methodology should be emphasized. Funds for the implementation of this international project are provided by IKI (Climate Initiative of the German Federal Ministry for the Environment, Nature Protection and Nuclear Safety).

Tourism department of the Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, through the Working Group for Coordination of Activities in Tourism, implements projects with various international organizations (World Tourism Organization (UNWTO), Japan International Cooperation Agency (JICA), United Nations Development Programme (UNDP), OXFAM ITALIA, the Society for International Cooperation (GIZ), the United States Agency for International Development (USAID), the Swedish International Development Cooperation Agency (SIDA), the European Commission and the International Sava River Basin Commission).

International policies aim at minimizing the negative effects of climate change on the environment and human health. Many decisions that affect climate change also have direct consequences for human health. The role of the health sector, especially public health, is to support adaptation to climate change and mitigation of its harmful effects on health. Protecting health from climate change requires a broad partnership focused on the health community, but also on connections with other actors. WHO regional and national offices (WHO) enable the cooperation of health sectors within member states, which constitute the primary defence against the health impacts of climate change and variability. The WHO is currently developing a global strategy outlining the general framework of the international response to health protection against climate change. The WHO is developing this strategy with partners in the health sector, and will align with the activities of the UN and other partner agencies.

The World Health Organization is working to highlight win-win situations in which sustainable development choices can simultaneously reduce the impact on the global climate and improve public health, for example by reducing outdoor and indoor air pollution. Since 2000, the WHO has brought together cross-sectoral government partners in 9 workshops to raise awareness of climate change impacts and to share experiences in assessing and addressing health climate risks. This series of workshops was focused on particularly vulnerable countries in the European region and the world. Each workshop was an important forum not only to raise awareness, but also to persuade Member States to jointly address the additional health risks posed by climate change. In this way, Member States were given the task to determine their capabilities and needs for capacity building, information and resources, which provides a solid basis for future activities to protect the population from climate change. Since 1990, the WHO has published reports describing and assessing evidence of health risks posed by climate change. The WHO programme is now increasingly focused on making this information available to the most vulnerable countries, on conducting vulnerability assessments in the health sector, and on supporting public health. Once Member States start taking action to protect health from climate change, it will become increasingly important to monitor and evaluate their programmes to ensure that they are also effective and timely. The WHO is committed to developing a monitoring and evaluation framework that includes both process measures - success in awareness raising or in coverage of interventions to protect against climate-sensitive diseases, as well as outcomes in terms of success in improving population health. These measures should be integrated into basic health monitoring systems and be coordinated with the systems used to measure success in tackling climate change and achieving sustainable development goals in other sectors.

At the same time, ECDC (European Centre for Disease Prevention and Control) is exploring the development of a "European Environment and Epidemiology Network" that could link data on climate/environmental factors and communicable diseases. Combining, integrating and analysing such data will improve understanding of the relationship between climate change and communicable diseases in Europe, and inform public health. The European Environment and Epidemiology Network would link communicable disease surveillance data (currently available in the ECDC) to meteorological variables, entomological data, water quality data, air quality data, geology, population density and many other sources of information. By integrating and synthesizing these datasets, disease surveillance systems could incorporate and analyse environmental precursors for a disease pandemic, thus preparing public health to respond to the challenges of our time.

5.5.2 Regional cooperation

Regional cooperation is considered to be cooperation that takes place within Southeast Europe or the Western Balkans. Regionalism is a strategic way to adapt to global change, as an increasing number of countries do not have the capacity and resources to cope with the challenges posed by these changes on their own. The creation of regional networks and structures increases the chances of achieving economic stability and establishing a more open and stimulating business environment. The creation of a regional economic space contributes to the removal of unfavourable investment barriers and enables easier resolution of conflicting interests in the business domain.

Regional cooperation and good neighbourly relations are an essential part of the process of Bosnia and Herzegovina's accession to the European Union. Bosnia and Herzegovina still actively participates in regional initiatives.

The most important regional cooperation processes in the previous period were: The South-East Europe energy market agreement, the Regional Cooperation Council, the Belgrade Climate Change Initiative and the Igman Initiative. In addition to these, it is necessary to mention the participation of Bosnia and Herzegovina in the ECRAN (Environment and Climate Regional Accession Network) programme from the very beginning.

By signing the Energy Community Treaty, Bosnia and Herzegovina, among other things, undertook to transpose the EU acquis (EU Acquis Communautaire), i.e., to transpose and implement the relevant EU directives and regulations in the field of climate change and energy. The most important aspects, whose transposition process began almost a decade ago, encourage the use of RES, increasing energy efficiency and establishing a system for collecting, reporting and verifying of GHG emissions.

A very successful network that is constantly evolving is the Covenant of Mayors. The Covenant of Mayors agreement was launched by the European Commission in 2008, and its main task is to support local authorities in implementing sustainable energy policies. Local authorities play an important role in CO_2 emission reduction. 25 cities and municipalities in Bosnia and Herzegovina signed the Covenant of Mayors.

By signing the Declaration on the Green Agenda for the Western Balkans on 10 November 2020 in Sofia, Bosnia and Herzegovina expressed its commitment to implementing measures in the field of climate change mitigation, energy transition, sustainable mobility and circular economy, as well as biodiversity protection, sustainable agriculture and food production. Bosnia and Herzegovina has opted for a number of concrete actions, including the introduction of a carbon tax and market models to encourage renewable energy sources, as well as the phasing out of coal subsidies with the aim of achieving climate neutrality by 2030. In the coming period, the mechanisms of cooperation between the EU and the Western Balkan countries on the implementation of the Green Agenda will be defined.

The 2014 floods showed how serious the consequences of climate change can be, and that Bosnia and Herzegovina is no exception. This contributed to intensification of activities/projects related to flood protection, through the implementation of structural and non-structural measures, with the aim of reducing flood damage and flood risk. After the 2014 floods, the Sava embankments in Bosnia and Herzegovina and overhangs on sections that had not met the criteria for superelevation above large waters for protection against waters with ranking 1/100 years (100-year event) were reconstructed. It is very important that the reconstruction was done in Croatia as well.

In previous years, significant projects have been implemented: development of flood hazard and risk maps in Bosnia and Herzegovina, project for improvement of strategies and legal framework for disaster risk reduction. Several projects were implemented, with the aim of developing hydrological models and establishing flood forecasting systems, mainly for the Sava River Basin, in Bosnia and Herzegovina and regionally. Although most projects are still ongoing, certain products have already been implemented and are in use, such as the common flood alert platform in the Sava River Basin (Sava Commission is the project coordinator), the forecasting model for the Vrbas and Una river basins, and equipment for capacity building of institutions in charge of hydrological and meteorological monitoring was procured. Upon completion of the projects, Bosnia and Herzegovina will have domestic models for flood forecasting in the Sava River Basin, and in addition to access to a common platform for accessing meteorological and hydrological forecasting models in the Sava River Basin region, Bosnia and Herzegovina has had access to products of the European Flood Awareness System (EFAS) since 2017. The project of establishing a central platform is underway, within which all measured meteorological, hydrological and oceanographic data would be collected, as well as the results of numerical models for the entire area of Southeast Europe (SEE-MHEWS).

The implementation of the GIZ project of the Open Regional Fund for Southeast Europe - Biodiversity (ORFBD) is underway, which should continue until December 2020. This project is a continuation of the former GIZ ORF - BD project (2015-2018), and its goal is to create a BIMR policy and capacity building [141]document for the BIMR regional platform, as well as to update the current List of Endemic Species of the Southeast Region and publish it in the GBIF network. Activities on the "Supporting Decision-Making and Capacity Building to Support IPBES through National Ecosystem Assessment" project have also been launched. The project aims to build capacity at the state level to support ecosystem assessment and their integration into decision-making mechanisms. The projected project duration is five years (01.10.2018-31.03.2023).

Forestry and climate change are in the focus of a number of different cross-border cooperation projects between Croatia, Serbia, Montenegro and Bosnia and Herzegovina.

Bosnia and Herzegovina has signed several agreements on cooperation in the field of tourism with neighbouring Croatia, Serbia, Montenegro, Slovenia, Albania, Turkey, Jordan, China, Kuwait, etc.[142] IPA cooperation programmes were particularly important in the tourism sector in recent years. Under IPA 2008, Bosnia and Herzegovina implemented the project "Technical Assistance to the Tourism Sector in Bosnia and Herzegovina", which aimed at implementing sustainable development policy, strengthening institutions and legislation in the field of sustainable tourism, and developing human resources. Also, the IPA II CBC programme between Bosnia and Herzegovina and Montenegro, which was implemented in 2014-2020, was especially important in the field of adaptation and climate change mitigation.

[141]Biodiversity Information Management and Reporting (BIMR)

[142]http://www.mvteo.gov.ba/Content/Read/vodni-resursi-turizam-zastita-potrosaca

5.6 Gender equality in climate change related decision and policy making processes

Bosnia and Herzegovina, as a signatory to the United Nations Framework Convention on Climate Change, is obliged to fulfill its obligations, including inter alia the inclusion of women and men in the activities under this Convention, as well as in the development and implementation of gender-sensitive national climate policies. Women's participation in climate change decision-making is a crucial prerequisite for gender-sensitive and more effective climate change policies. In most countries, including Bosnia and Herzegovina, women remain underrepresented in decision-making positions and processes.

Within the framework of the project "Preparation of the Fourth National Report on Climate Change and the Third Biennial Report on Greenhouse Gas Emissions in Bosnia and Herzegovina", a Gender Study was prepared, as the first step towards raising awareness of the mandatory inclusion of women and men in the processes of making policies and decisions related to climate change in Bosnia and Herzegovina. The publication seeks to encourage consideration of different perspectives of women and men, their roles, needs, priorities, vulnerabilities and interests in future planning and adoption of measures. While the Fourth National Report of Bosnia and Herzegovina in accordance with the UNFCCC and the Third Report on Greenhouse Gas Emissions include the identification of priority measures for adaptation and greenhouse gases reduction in numerous sectors, the Gender Study is focused on five sectors: energy, transport, agriculture, health and waste. The study explores the connection between these sectors and climate change and gender, providing recommendations for a more effective gender mainstreaming in all sectors.

Some of the recommendations made in the study are summarized below.

Energy and transport are two sectors with great potential for reducing GHG emissions, however different needs and demands of men and women and their different access and representation within the sector require a gender-sensitive approach to ensure effective, but also feasible recommendations:

- At the household level: conduct studies to collect gender disaggregated data on energy consumption activities and allocate appropriate energy costs.
- Design more gender-sensitive proposals to encourage a change in attitudes and behaviors within the transport sector with the aim of reducing greenhouse gases.

Given that women are responsible for a large share of work in the **agricultural sector**, there is a strong need for gender disaggregated data. It is necessary to better understand the following:

1. share of households headed by women, which perform in agricultural activities,
2. gender disaggregated structure of arable land and
3. percentage share of women/men cultivating different categories of land.

This data should be linked with information on how climate change affects different categories of land use as well as their crops/fruits/vines. This would help to better understand the different impact of climate change on women and men within the agricultural sector.

The **waste management system** could be more efficient if both women and men could be informed about the advantages of waste sorting, and the woman as the head of the household could influence the change in the previous waste management practices of other family members.

- At the household level, conduct pilot studies to determine information about waste structure, treatment methods, awareness of the link between waste and climate change, and knowledge about recyclable and reusable materials.
- Incorporate gender-sensitive lens in the waste management system that would facilitate the process of waste collection.
- Use the role of women as agents of change in households and raise awareness about waste and the link to climate change.

Climate change will create additional **health** problems, which will likely put an additional burden on women. Mostly women take care of the health of family members, which includes caring for sick and elderly people. In order to identify vulnerability, exposure and capacity to adapt to climate change the following is required:

- Based on the data collected, identify where women and men are most vulnerable and exposed during floods and heat waves;
- Data on health issues (respiratory diseases, infections, etc.) should be linked to the effects of climate change and must be gender disaggregated.

6 CONSTRAINTS AND GAPS

This chapter provides an overview of limitations and obstacles related to institutional, legal, financial, technical, and human resource capacities in Bosnia and Herzegovina that affect the implementation of obligations under the United Nations Framework Convention on Climate Change (UNFCCC).

Information about these obstacles and limitations is based on the findings of previous studies and projects in Bosnia and Herzegovina, as well as the results of the sector analysis in the previous chapters.

6.1 Institutional constraints

Climate change should not be addressed by governments in isolation. The success of climate change response will depend on organizations, local communities and businesses preparing for a changing climate, and implementing appropriate responses. Authorities in Bosnia and Herzegovina should provide leadership, support and an enabling environment, and must collaboratively with a range of local community, national and international partners.

International experience has shown that developing and implementing different actions in response to climate change is often constrained by a range of institutional complexities and horizontal issues.

In accordance with the Dayton Agreement, the implementation of environmental policy in Bosnia and Herzegovina is the responsibility of the Federation of Bosnia and Herzegovina, the Republika Srpska and the Brčko District of Bosnia and Herzegovina. The inter-entity environmental body was established in 2006 by decisions of the Government of the Federation of Bosnia and Herzegovina, the Government of the Republika Srpska and the Government of the Brčko District, in order to establish coordination and harmonization of environmental policy at the level of Bosnia and Herzegovina. The Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina is responsible for defining policies, main principles, coordinating activities and harmonizing the plans of entity-level authorities and institutions at the international level in the field of environmental protection, while responsibility for UNFCCC obligations and preparation of national communications lies with contact institution of Bosnia and Herzegovina according to the UNFCCC, i.e., the Ministry of Spatial Planning, Civil Engineering and Ecology of the Republika Srpska.

In Bosnia and Herzegovina, there are no clearly defined roles of certain ministries or bodies in terms of responsibility for drafting, implementing and monitoring of policies, legal acts and measures for climate change. There is no clear effort to focus climate issues on other relevant policy areas.

The competence of the state administration in environmental matters is limited to functions that are mainly related to international cooperation and necessary coordination. In Bosnia and Herzegovina, there is a lack of both vertical and horizontal cooperation and coordination between competent institutions, and these mechanisms are of particular importance for international activities as well as activities in Bosnia and Herzegovina.

Bosnia and Herzegovina does not have standardized systems or methods for data collection and transfer and reporting on environmental data. Statistical institutions in Bosnia and Herzegovina (Statistics Agency of Bosnia and Herzegovina, Statistics Institute of the Federation of Bosnia and Herzegovina, Republika Srpska Statistics Institute) collect certain environmental data as defined by the Statistical Survey Programme. In addition to statistical institutions, environmental data in Bosnia and Herzegovina are collected by different institutions

without sufficiently developed coordination or a single database. The process of data exchange and communication between different institutions, as well as the process of data exchange between the Federation of Bosnia and Herzegovina and the Republika Srpska is insufficiently developed. This makes it difficult to create a complete picture of the state of the environment in Bosnia and Herzegovina and of the link between development activities and the state of the environment, i.e., indicators that support the decision-making process.

Climate change is a multi-sectoral issue. Adequate monitoring systems should be established to properly ensure accurate and up-to-date climate risk data. In addition, incomplete availability of monitoring results for all contaminants in the environment (water, soil, air, etc.), lack of references to the health indicator database, and overlapping competencies of individual institutions constitute barriers to managing risks related to climate change. In Bosnia and Herzegovina, there are no reliable health statistics on the impact of climate change on population health, because the mandatory health records do not contain the data needed for such a complex assessment. The lack of an inter-ministerial body for environment and health also represents a vulnerability in the risk management sector, which significantly affects risk assessment and the adoption of protection measures.

In addition, at different government levels in Bosnia and Herzegovina, there are no institutions that would implement operational measures in the field of climate change in the tourism sector. The current tourism development management model involves a large number of stakeholders, but without clear competencies and responsibilities. In this regard, it is necessary to work on the systemic strengthening of institutions in Bosnia and Herzegovina, which could then have a stimulating effect on strengthening of non-governmental and private sectors. Insufficient cooperation at all levels of government is also an obstacle, which prevents better and more efficient access to funds of international financial institutions. Strengthening of capacities and human resources is especially important in the field of project activities, in order to make the most of the funds from the pre-accession funds of the European Union, and to overcome financial constraints.

6.2 Financial constraints

Generally, Funds required for effective implementation of mitigation and adaptation measures exceed those currently available within Bosnia and Herzegovina. Bosnia and Herzegovina will need assistance in the form of technology transfer and capacity building in order to cover the costs of adaptation and climate change mitigation.

When it comes to sources of funding, the Law on Budgets (Official Gazette of FBiH No. 102/13; 9/14; 13/14; 8/15; 91/15; 102/15; 104/16) in the Federation of Bosnia and Herzegovina, the Law on the Budget System of the Republika Srpska (Official Gazette of the RS, No. 121/12, 52/14, 103/15 and 15/16) and the Law on the Budget of the Brčko District of Bosnia and Herzegovina (Official Gazette of the BD, No. 34/19) define the drafting of the Framework Budget Document of the Federation of Bosnia and Herzegovina, the Framework Budget Document of the Republika Srpska and the Framework Budget Document of the Brčko District of Bosnia and Herzegovina as the basis for budget preparation and drafting. The key objective of the Framework Budget Documents is to ensure a better link between the priority policies of the Government of the Federation of Bosnia and Herzegovina, the Government of the Republika Srpska and the Government of the Brčko District and the ways in which they allocate public resources. The process of budget preparation takes place according to defined budget calendars, with the development of budget requirements based on strategic planning documents, legal obligations and the current situation, as well as an estimate of costs and sources of funding by main items.

The Republika Srpska Fund for Environmental Protection and Energy Efficiency and the Environmental Protection Fund of the Federation of Bosnia and Herzegovina are active as financial institutions for the collection and distribution of funds for environmental protection in Bosnia and Herzegovina, but the financial resources available to them are not sufficient. Brčko District of Bosnia and Herzegovina does not have a separate environmental protection fund yet. The laws on funds in the Federation of Bosnia and Herzegovina and the Republika Srpska stipulate that the resources of the funds should be used to finance environmental protection, with the emphasis on financing of climate change mitigation and adaptation.

At the entity level, Bosnia and Herzegovina has introduced certain financial support mechanisms for climate change mitigation, such as the feed-in tariff (guaranteed price) with mandatory purchase of electricity produced from renewable energy sources. Funds for these support schemes are collected through special fees on the price of electricity for end consumers. The support scheme system for electricity from RES is currently underway. According to the draft reforms for both entities, in addition to the existing mechanisms, the introduction of auctions, net billing and incentives for citizen energy projects is expected, which will have a favourable impact on decentralization of the electricity system and a series of positive effects.[143]*In addition, the Environmental Protection Fund of the Federation of Bosnia and Herzegovina and the Republika Srpska Fund for Environmental Protection and Energy Efficiency support energy efficiently projects, mostly in public buildings through grants and loans with favourable interest rates.*

Over the past decade, Bosnia and Herzegovina has received international financial support for climate change mitigation and adaptation from global funds and bilateral programmes. One can say that so far, financial support has been focused on reducing GHG emissions, while support for adaptation has been on a much lower level (partly due to the lack of action plans in this area).

The EU policy on climate change, for developing countries, dates back to 2003. The policy has been updated since to include and focus on specific areas, namely adaptation, disaster risk reduction and support for capacity development and technology transfer in sustainable agricultural and energy sectors, including adaptation and effects mitigation strategies.

Given that emission reduction targets are set on a voluntary basis, according to the Paris Agreement, it is to be expected that the level of international assistance for reduction of GHG emissions will be commensurate with the ambitiousness of the targets in Bosnia and Herzegovina. Emphasis was placed on giving priority to adaptation measures at the 16th Conference of the Parties in Cancun, according to the Copenhagen Agreement. Thus, there are funds that specifically support adaptation measures, and special funds that support climate change mitigation.[144]. There are also funds that are specifically budgeted to help miners and mines that will be forced to suspend production. It is important to monitor international sources for potential funding opportunities, such as: Green Climate Fund; Cohesion funds; Global Environment Fund; Adaptation Fund; Horizon 2020; LIFE programme; Global Energy Efficiency and Renewable Energy Fund; The Global Climate Partnership Fund (GCPF); Structural Funds; European Social Fund (ESF); European Union Solidarity Fund (EUSF); European Territorial Cooperation (ETC); European Maritime and Fisheries Fund (EMFF); European Globalisation and Adjustment Fund (EGF); The Common Agricultural Policy CAP; The European Regional Development Fund (ERDF); European Solidarity Fund.[145]

[143] One should also keep in mind that the Economic Reform Programmes of Bosnia and Herzegovina, the Federation of Bosnia and Herzegovina, and the Republika Srpska are prepared annually for a three-year period, presenting economic policy measures adopted by governments and establishing complex and comprehensive multi-year reform processes.

[144]https://climatefundsupdate.org/the-funds/

[145]Roadmap and Action Plan for the implementation of nationally determined contributions of Bosnia and Herzegovina for 2020-2030

6.3 Constraints in human resources

Administrative capacities in environmental sector are still poor. Environmental authorities do not have the capacity to implement and enforce legislation at the entity, cantonal and local levels. There has been no improvement in administrative capacity to address climate change, as there is no staff or allocated funds for this purpose.

Bosnia and Herzegovina should significantly strengthen its administrative capacity across the country and improve cross-sectoral cooperation to (i) tackle climate change in a systemic way that goes beyond the current project-by-project approach and (ii) further ensure alignment with the EU climate acquis and enable its effective implementation. Bosnia and Herzegovina should accelerate the process of implementing the adopted Strategy for harmonization of legislation with the Acquis Communautaire in the field of environmental protection of Bosnia and Herzegovina, and accordingly, improve the legal framework, strengthen administrative capacities and monitoring systems and improve inter-institutional coordination between all authorities in the field of environmental protection.

In order to better prepare for the forecasted climate change in the agricultural sector, it is necessary to continuously strengthen the capacity of all stakeholders, especially farmers. The lack of a sufficient number of extension services and poor or no education of farmers, as well as limited financial resources are the main limitations that must be overcome in this sector. A very important role in the process of adaptation, but also in the mitigation of climate change, is played by extension services, whose knowledge, as well as human capacities, should be separately and continuously developed.

The administrative setup of Bosnia and Herzegovina largely impedes the efficient management of data related to biodiversity and forest resources. Although data management strategies have been adopted at the state and entity levels, the level of implementation is very low. The lack of good professional staff is evident in all institutions responsible for nature protection and biodiversity conservation.

The problem in the development of sustainable tourism is also related to scarce human resources, and the system of secondary and higher education in this field should be improved in the future. The system of formal education in tourism is not fully adapted to modern processes on the tourism market. It is necessary to work on raising awareness of the role of climate change in the tourism sector, and creating a positive attitude of the population about tourism as a strategically important industry.

Capacities for assessment of climate change impacts on population health are insufficient. There is a lack of funds for research programmes focusing on vulnerability and adaptation, as well as for supporting the work of expert and/or advisory bodies in this field. Existing network capacities of the Public Health Institute of the Federation of Bosnia and Herzegovina, the Public Health Institute of the Republika Srpska and PHI "Zdravstveni centar Brčko" as well as the Emergency Medical Institute/services in the Federation of Bosnia and Herzegovina, Emergency Medical Service within Health Centres in the Republika Srpska and the Emergency Medical Service of the PHI "Zdravstveni centar Brčko" are part of the health system that should be constantly improved. More funds should be directed to informing and educating the population, as well as to scientific research. Insufficient implementation of health impact studies and human health risk assessments, as well as insufficiently integrated role of the public health sector currently affect the level of response to the crisis and its impact on human health.

The lack of connection between global and national policies, methodologies, tools and practices with the strategy of climate change adaptation and disaster risk reduction is a challenge in the future sustainable development of the existing system at national and international levels.

Effective responses require adequate level of coordination and cooperation between institutions, new ways of institutions working together, sharing knowledge and information, and integrating planning, monitoring and evaluation. In other words, stronger inter-sectoral cooperation is needed. Therefore, it would be most appropriate to organize events once or twice a year that would provide easier access to all relevant data and information and encourage stakeholder networking. The inclusion of climate change in health sector strategies is also crucial. The process should start with the development of adaptation strategies and plans and revision of existing strategic documents. With regard to legislation, one of the most important adaptation measures that should be taken in order to protect workers' health and lives from climate change effects in Bosnia and Herzegovina is the revision of the Law on Occupational Safety (Official Gazette of FBiH, No. 79/20) in the Federation of Bosnia and Herzegovina, the Law on Occupational Safety (Official Gazette of RS, No. 01/08 and 13/10) in the Republika Srpska, the Law on Occupational Safety and Health (Official Gazette of BD BiH, no. 34/19, 2/2021 and 6/21) in the Brčko District of Bosnia and Herzegovina in terms of introducing items related to work in extreme weather conditions.[146]

6.4 Overcoming the constraints and gaps

Insufficiently developed capacity of Bosnia and Herzegovina to implement measures aimed at adapting to climate change is caused by the lack of knowledge and awareness of climate change risks for Bosnia and Herzegovina. Bosnia and Herzegovina's previous three communications to the UNFCCC have determined the strong climate change impact in the most sensitive sectors, but have also defined adaptation options.

In the implementation of the adaptation framework, it is necessary to develop a system of indicators compatible with European Union standards, which will also fit the specificities and needs of Bosnia and Herzegovina. Capacity building for monitoring of climate change effects is a priority, which requires undertaking of capacity building measures to manage development in the climate change environment. These measures were proposed in the Third National Communication, and they are still valid as recommendations:

1. It is necessary to choose a stable system of statistical data on climate change, the results of adaptation to these changes and indicators that ensure the application of internationally recognized analysis methodologies, as well as monitoring of phenomena that support sustainable development, even in an environment of adverse climate change. These components are to some extent included, and can be further expanded and integrated into existing meteorological information systems, or into the systems of regular statistical reports of institutions of the Federation of Bosnia and Herzegovina and the Republika Srpska and the Agency for Statistics of Bosnia and Herzegovina.
2. The existing system of meteorological observations should be improved - observation of climate change and adaptation results, including an early warning system. Development of professional capacities should be integrated in the international observation system
3. Professional and political bodies responsible for managing the development in an unstable climate environment should be appointed. Expert bodies at the state and entity levels (in addition to traditional planning and proposing of economic measures in parliamentary structures) should be trained to also involve measures to prevent the effects of adverse climate change (Bosnia and Herzegovina Council of Ministers, entity governments, institutions responsible for economic and spatial planning, water area agencies, economic operators, civil protection, etc.). It is necessary to establish the obligation of

[146]In the Federation of Bosnia and Herzegovina, Article 9(5) of the Law on Occupational Safety (Official Gazette of FBiH, No. 79/20) stipulates the following: Due to weather conditions such as high or low temperatures, etc., as well as in other states of need, the ministry may issue recommendations to employers on the implementation of special protection measures, which will prevent the occurrence of harmful effects on workers' health. If the weather conditions or other states of need for which the recommendations were issued last longer than five days, the ministry shall consult the representative associations of employers and workers for the territory of the Federation.

political bodies in Bosnia and Herzegovina to assume political responsibility for sustainable development in the changing climate conditions.

4. Create general public belief about the need for society to take climate change more seriously, and that it is necessary to invest material and human resources in implementation of sustainable development measures, so that climate change becomes tolerable, and development stable. Still, crucial initiatives and adaptation measures are at the level of Bosnia and Herzegovina, i.e., within the international cooperation framework.

From 2018 to 2021, the United Nations Development Program (UNDP) in partnership with government institutions at all levels of government in Bosnia and Herzegovina is implementing a project to "Advance the National Adaptation Plan (NAP) process for medium-term investment planning in climate sensitive sectors in Bosnia and Herzegovina (BiH)." The project will support Bosnia and Herzegovina improve the process of development of the National Adaptation Plan, and the achievement of the targets defined in the Paris Agreement and Sustainable Development agenda until 2030. Green Climate Fund (GCF) resources will be used to enable the government to integrate climate change risks, coping strategies and opportunities into ongoing development planning and budgeting processes.

The project will improve climate change adaptation planning in Bosnia and Herzegovina with a focus on sectoral approaches, upgrading the knowledge base on adaptation, prioritizing medium-term adaptation interventions, building institutional capacity to integrate climate change adaptation, and demonstrating innovative ways to finance climate change adaptation on entity, cantonal and local levels. The proposed activities will result in the development of a Climate Change Adaptation Plan and an implementation strategy that will focus on increase of adaptation rates in key sectors, in the medium term.

Expected project outcomes are:

- An effective coordination system of Bosnia and Herzegovina has been established to lead the process of the Bosnia and Herzegovina Climate Change Adaptation Plan
- Priorities identified in terms of capacity to assess climate change sensitivity, development of socio-economic scenarios and adaptation options for two key sectors
- An innovative strategy for financing of investments in climate change adaptation in four to five selected municipalities developed and tested.

In parallel, preferred mitigation measures should be based on reducing the existing trend of increasing greenhouse gas emissions and preserving existing sink zones (sequestration).

Primary mitigation measures are based on reducing the current growth trend of GHG emissions, which include: increasing energy efficiency in all production sectors; application of modern technologies in all areas of production; electricity supply from renewable energy sources; stimulating employment in production sectors in which mitigation measures are implemented, etc. Additional mitigation measures are based on the preservation of the main sink capacities.

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Abbreviations

Brčko District	The Brčko District of Bosnia and Herzegovina
BiH	Bosnia and Herzegovina
CDM	Clean Development Mechanism
DNA	Designated National Authority
EEA	European Environment Agency
EE	Energy efficiency
EU	European Union
EU ETS	EU Emission Trading System
Federation of BiH	The Federation of Bosnia and Herzegovina
GHG	*Greenhouse gasses*
INC	Initial National Communication Report
INDC	Intended Nationally Determined Contribution
IPCC	The Intergovernmental Panel on Climate Change
NAMA	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contribution
RES	Renewable energy sources
Republika Srpska	The Republika Srpska
WHO	World Health Organisation
TNC	Third National Communication Report
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	The World Bank

Literature

Abegg, B., Agrawala, S., Crick, F., Montfalcon, A. 2007. Climate change impacts and adaptation in winter tourism. Climate Change in the European Alps. Adapting Winter Tourism and Natural Hazards Management, pp. 25-60.

Abramović V., Jacimović D., Jocović M., (2016): Klimatske promjene i njihov uticaj na zemlje regiona

Agencija za statistiku Bosne i Hercegovine (2017): Poljoprivreda, okoliš i regionalne statistike, Požnjevena površina, ukupna proizvodnja i prinos najvažnijih usjeva 2016.

Agnew, M. D., Viner, D. 2001. Potential impacts of climate change on international tourism. *International Journal of Tourism and Hospitality Research* 3(1), pp. 37-60.

Akcioni plan za zaštitu od poplava i upravljanje rijekama u BiH 2014-2021

Amelung, B., Nicholls, S., Viner, D. 2007. Implications of global climate change for tourism flows and seasonality. *Journal of Travel Research* 45 (3), pp. 285-296

Bach, W., Gossling, S. 1996. Klima ¨ okologische Auswirkungen des Flugverkehrs. ¨ *Geographische Rundschau,* 48, pp. 54–59.

Berrittella, M., Bigano, A., Roson, R., Tol, R. S.J. 2006. A general equilibrium analysis of climate change impacts on tourism. *Tourism Management*, 27(5), pp. 913– 924.

Bilten -Statistički podaci Brčko Distrikta BiH. Agencija za statistiku BiH Podružnica/Ekspozitura Brčko (2018).

Bosnia and Herzegovina authorities, European Union, United Nations and the World Bank (2014): Bosnia and Herzegovina Floods 2014: Recovery Needs Assessment

Čustović H., Ljuša M., Bishal K. Sitaula (urednici): Adaptacija na klimatske promjene u sektoru poljoprivrede (Vrijeme je da djelujemo odmah), Poljoprivredno-prehrambeni fakultet Univerziteta u Sarajevu, novembar 2015.

Drought Conditions and Management Strategies in Bosnia and Herzegovina - Concise Country Report, 2013, https://www.researchgate.net/publication/270816670_Drought_Conditions_and_Management_Strategies_in_Bosnia_and_Herzegovina_-_Concise_Country_Report.

Drugi izvještaj R Srbije prema Okvirnoj konvenciji UN o promjeni klime, 2015.

Drugi nacionalni izvještaj Bosne i Hercegovine u skladu s Okvirnom konvencijom Ujedinjenih nacija o klimatskim promjenama, 2013.

EEA (2018): Recent trends and projections in EU greenhouse gas emissions

EEA Report (2016): Climate change, impacts and vulnerability in Europe 2016, An indicator-based report

Elsasser, H., Bürki, R. 2002. Climate change as a threat to tourism in the Alps. *Climate Research*, (20) pp. 253-257.

EU 2018 saopštenje za javnost, https://europa.eu/rapid/press-release_IP-18-4202_hr.htm

European Commission: Commission Opinion on Bosnia and Herzegovina's application for membership of The European Union, 2019.

FAO (2015). The Forest Sector in Bosnia and Herzegovina Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina, 1-146.

FAO (2015). The Forest Sector in Bosnia and Herzegovina Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina, 1-146.

FAO (2018): Climate smart agriculture, case studies 2018

FAO, 2015. The Forest Sector in Bosnia and Herzegovina Preparation of IPARD Forest and Fisheries Sector Reviews in Bosnia and Herzegovina, 1-146.

Gajšak M., Šubić M., (2018): Utjecaj klimatskih promjena na poljoprivredu, Časopis „Gospodarski list", Hrvatska

Germanwatch publications, 2015,2016,2017,2018,2019

http://www.mvteo.gov.ba/Content/Read/vodni-resursi-turizam-zastita-potrosaca(pristupljeno 17.06.2020.)

https://uwaterloo.ca/news/news/climate-change-will-limit-where-winter-olympics-can-be-held (pristupljeno 25.02.2019.)

https://www.fhmzbih.gov.ba/latinica/KLIMA/3.KlimatskePromjene.pdf (pristupljeno 18.03.2019.)

Institut za javno zdravstvo (2015), zarazne i parazitarne bolesti na teritoriji Republike Srpske

Institut za zaštitu zdravlja Republike Srpske, Izvještaji o zdravstvenom stanju stanovništva Republike Srpske, 2013-2017.

IPCC (2017): Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (SR2)

IPCC, Climate change 2013: The Physical Science Basis

Izrada Četvrtog nacionalnog izvještaja Bosne i Hercegovine u skladu sa Okvirnom konvencijom UN o klimatskim promjenama: Izvještaj br. 4 - Studija o procjeni tehnoloških potreba za sektor vodnih resursa i poljoprivrede u Bosni i Hercegovini, Enova, Ceteor i Jozef Stefan Institute, 2019

Izrada Četvrtog nacionalnog izvještaja Bosne i Hercegovine u skladu sa Okvirnom konvencijom UN o klimatskim promjenama: Izvještaj br. 4 - Pilot studija o utjecaju klimatskih promjena na zdravlje ljudi, Enova, Ceteor i Jozef Stefan Institute, 2019.

Izvještaj „Jačanje zdravstvenih sistema BiH za integraciju u EU", EuropeAid/120971/C/SV/

Izvještaj „Jačanje zdravstvenih sistema BiH za integraciju u EU", EuropeAid/120971/C/SV/

JVP Vodoprivreda Bosne i Hercegovine: Okvirna vodoprivredna osnova Bosne i Hercegovine, 1994.

Kovats SR, Ebi KL. Hetawaves and public health in Europe. Eur J of Pub Health. 2006;6:592-599.

Lipper L., McCarthy N., Zilberman D., Asfaw S., Branca G., Editors (2018): Climate Smart Agriculture Building Resilience to Climate Change, FAO, Springer.

Ljuša, M., Cero, M., Čustović, H. (2015) Promjena namjene poljoprivrednog zemljišta i funkcija tla u Bosni i Hercegovini u periodu 2000−2012. godine, Radovi Poljoprivredno-prehrambenog fakulteta Univerziteta u Sarajevu, Godina LX, broj 65/1, 7−16.

Majstorović Željko, 2017: Unapređenje poljoprivrede, šumarstva i vodoprivrede u skladu sa klimatskim promjenama u Bosni i Hercegovini, Posebna izdanja ANUBiH, OPMN 26, str. 115-124

Mataruga, M., Ballian, D., Terzić, R., Daničić, V., Cvjetković, B. (2019) State of Forests in Bosnia and Herzegovina: Ecological and Vegetation Distribution, Management and Genetic Variability, edited by Šijačić-Nikolić, M., Milovanović, J., Nonić, M. in “Forests of Southeast Europe Under a Changing Climate - Conservation of Genetic Resources”. Springer, p: 3-19.

Mataruga, M., Ballian, D., Terzić, R., Daničić, V., Cvjetković, B. (2019) State of Forests in Bosnia and Herzegovina: Ecological and Vegetation Distribution, Management and Genetic Variability, edited by Šijačić-Nikolić, M., Milovanović, J., Nonić, M. in “Forests of Southeast Europe Under a Changing Climate - Conservation of Genetic Resources”. Springer, p: 3-19.

Mataruga, M., Ballian, D., Terzić, R., Daničić, V., Cvjetković, B. (2019) State of Forests in Bosnia and Herzegovina: Ecological and Vegetation Distribution, Management and Genetic Variability, edited by Šijačić-Nikolić, M., Milovanović, J., Nonić, M. in “Forests of Southeast Europe Under a Changing Climate - Conservation of Genetic Resources”. Springer, p: 3-19.

Meteorološki godišnjaci (2007. – 2017. godine), Federalni hidrometeorološki zavod.

Ministarstvo vanjske trgovine i ekonomskih odnosa BiH: Godišnji izvještaj iz oblasti poljoprivrede, ishrane i ruralnog razvoja za BiH 2017, maj 2018. godine

Ministarstvo vanjske trgovine i ekonomskih odnosa BiH: Godišnji izvještaj iz oblasti poljoprivrede, ishrane i ruralnog razvoja za BiH 2016, maj 2017. godine

Ministarstvo vanjske trgovine i ekonomskih odnosa Bosne i Hercegovine (2017): Izvještaj iz oblasti poljoprivrede, ishrane i ruralnog razvoja za Bosnu i Hercegovinu

Mjesečni statistički pregled Federacije BiH, godina XXII, br. 2 (2019).

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G. & Kent, J. (1999). Biodiversity hotspots for conservation priorities. Nature 403, 853-858.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G. & Kent, J. (1999). Biodiversity hotspots for conservation priorities. *Nature* 403, 853-858.

Okvirna energetska strategija Bosne i Hercegovine do 2035. godine (Službeni glasnik BiH, br. 70/18)

Plan upravljanja oblasnim riječnim slivom rijeke Save Republike Srpske 2017-2021

Plan upravljanja oblasnim riječnim slivom rijeke Trebišnjice Republike Srpske 2017-2021

Plan upravljanja vodama za vodno područje Jadranskog mora u Federaciji BiH

Plan upravljanja vodama za vodno područje rijeke Save u Federaciji Bosne i Hercegovine 2016-2021

Popov, T., Gnjato, S., & Trbić, G. (2017):Trendovi indeksa ekstremnih temperatura u Bosni i Hercegovini – primjer Mostara. Herald, 21, 107−132doi:10.7251/HER2117107P

Popov, T., Gnjato, S., & Trbić, G. (2017): Trends in frost days in Bosnia and Herzegovina, Glasnik Srpskog geografskog društva 2017 Volume 97, Issue 1, Pages: 35-55. https://doi.org/10.2298/GSGD1701035P

Popov, T., Gnjato, S., & Trbić, G. (2018). CHANGES IN TEMPERATURE EXTREMES IN BOSNIA AND HERZEGOVINA: A FIXED THRESHOLDS-BASED INDEX ANALYSIS. *Journal of the Geographical Institute "Jovan Cvijić" SASA*, *68*(1), 17–33. https://doi.org/10.2298/IJGI1801017P

Proračun na procjeni stanovništva (za 30.06.2016.), Agencija za statistiku Bosne i Hercegovine (2017): Bosna i Hercegovina u brojevima

Republika Srpska - Procjena ugroženosti od elementarne nepogode i druge nesreće, 2013.

Scott, D., Wall, G., McBoyle, G. 2004. Climate change and the distribution of climatic resources for tourism in North America. *Climate Research* 27 (2), pp. 105-117.

SIZ Vodoprivrede Bosne i Hercegovine: Osnovne karakteristike vodoprivrede Bosne i Hercegovine, Sarajevo, februar 1981.

Statistički godišnjak Federacije BiH, Federalni zavod za statistiku (2018).

Statistika turizma – mjesečno saopštenje, br. 18/19 Republički zavod za statistiku Republike Srpske (2018).

Stefanović, V., Beus, V., Burlica, Č., Dizdarević, H., Vukorep, I. 1983. Ecological and vegetational dellineation of Bosnia and Herzegovina. Special edition No 18. Faculty of Forestry Sarajevo: 1-49.

Stefanović, V., Beus, V., Burlica, Č., Dizdarević, H., Vukorep, I. 1983. Ecological and vegetational dellineation of Bosnia and Herzegovina. Special edition No 18. Faculty of Forestry Sarajevo: 1-49.

Strategija integralnog upravljanja vodama Republike Srpske 2015-2024

Strategija prilagođavanja na klimatske promjene i niskoemisionog razvoja za Bosnu i Hercegovinu, 2013.

Strategija upravljanja vodama Federacije BiH 2010-2022

Swanston, Christopher W.; Janowiak, Maria K.; Brandt, Leslie A.; Butler, Patricia R.; Handler, Stephen D.; Shannon, P. Danielle; Derby Lewis, Abigail; Hall, Kimberly; Fahey, Robert T.; Scott, Lydia; Kerber, Angela; Miesbauer, Jason W.; Darling, Lindsay; Parker, Linda; St. Pierre, Matt. 2016. Forest Adaptation Resources: climate change tools and approaches for land managers, 2nd ed. Gen. Tech. Rep. NRS-GTR-87-2. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 161 p. http://dx.doi.org/10.2737/NRS-GTR-87-2.

Tatem AJ, Hay SI, Rogers DJ. Global traffic and disease vector dispersal. PNAS 2006 ; 103: 6242 – 7

The assessment report on Land degradation and restoration summary for policymakers, IPBES, 2018

Treći nacionalni izvještaj i Drugi dvogodišnji izvještaj o emisiji stakleničkih plinova Bosne i Hercegovine u skladu sa Okvirnom konvencijom Ujedinjenih nacija o klimatskim promjenama, 2016.

Turizam statistički bilten, Republički zavod za statistiku Republike Srpske (2018).

UN WATER: Water Security and the Global Water Agenda. A UN Water analytical brief. United Nations University, 2013.

UNDP (2014). Possibilities of using biomass from forestry and wood industry in Bosnia and Hercegovina, 1-21.

UNDP (2014). Possibilities of using biomass from forestry and wood industry in Bosnia and Hercegovina, 1-21.

UNDP (2014). Possibilities of using biomass from forestry and wood industry in Bosnia and Hercegovina, 1-21.

Vlahinić M., Čustović H., Alagić E., 2006: Prijeti li kriza vode potrebne za navodnjavanje u poljoprivredi Bosne i Hercegovine, Godišnji skup agronoma u Neumu, Radovi Poljoprivredno-prehrambenog fakulteta Univerziteta u Sarajevu, god. LII, br.58/2, str.25-36.

Walter V. Reid and et al. (2005): Millennium Ecosystem Assessment

Witmer, U., 1986.*Erfassung, Bearbeitung und Kartierung von Schneedaten in der Schweiz*. Geographica Bernensia G25, Geo-graphical Institiute, University of Bern.

World Health Organization Regional Office for Europe (2012), WHO Statement on the state of the global climate in 2012

Zavod za javno zdravstvo Federacije BiH, Izvještaji o zdravstvenom stanju stanovništva Federacije BiH, 2013-2017.