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REPORT ON

Environmental indicators affected by the response to the COVID-19 pandemic

WITHIN THE PROJECT

Improved environmental monitoring and assessment in support of the 2030 Sustainable Development Agenda in South-Eastern Europe, Central Asia and the Caucasus

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Scope

This report was prepared by the UNECE consultant Alena Bahadziazh under the United Nations Development Account project "Improved environmental monitoring and assessment in support of the 2030 Sustainable Development Agenda in South-Eastern Europe, Central Asia and the Caucasus".

The project aims to strengthen national capacities in environmental monitoring and assessment for the 2030 Agenda. The target countries are Armenia, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, North Macedonia and Tajikistan. The project was amended due to the COVID-19 pandemic and affected both project delivery and the needs of countries.

The report aims to identify a set of relevant environmental indicators affected by the response to COVID-19 and gather time-series data for the target countries. The information and data on environmental indicators were collected from the official national sources (websites of national statistical offices, ministries of the environment). When the data were not available online, the national focal points addressed these data gaps. To select relevant environmental indicators, the following studies were analysed:

- *The long-term implications of the COVID-19 pandemic and recovery measures on environmental pressures: A quantitative exploration*. OECD Environment Working Papers [1];
- *Air quality in Europe — 2020 report*. European Environment Agency (EEA), 2020, [2].

The report was prepared under the guidance of the UNECE secretariat and in coordination and cooperation with members of the Joint Task Force on Environmental Statistics and Indicators, the Working Group on Environmental Monitoring and Assessment and national focal points in the target countries.

Introduction

The UNECE set of environmental indicators was chosen to identify the relevant environmental indicators affected by the COVID-19 pandemic as it covers multiple environmental topics and refers to the global policy framework such as the Framework for the Development of Environment Statistics (FDES 2013) and the 2030 Agenda. The policy relevance and availability of data time-series were also considered. To track the environmental trends, the data were assessed from 2016 to 2020. The same set of environmental indicators was used to assess the COVID-19 impact for all target countries. However, due to different environmental monitoring systems, data collection procedures, and data availability, the national sets of environmental indicators were evaluated.

The OECD study on the long-term implications of the COVID-19 pandemic and recovery measures [1] uses 2019 as the base year for assessing changes in the state of the environment for 2020 due to restrictions caused by COVID-19. According to the study, the short-term reductions in environmental pressures are significant. For instance, in 2020, energy-related greenhouse gas and air pollutant emissions dropped by around seven per cent. In addition, the percentage reduction in the use of non-metallic minerals, including construction materials, reached double digits. “From 2021, emissions are projected to increase again, gradually getting closer to the pre-COVID-19 baseline projection levels as growth rates recover fully. But there is a long-term –potentially permanent – downward impact on the levels of environmental pressures of between one and three per cent. This estimate reflects the general global trend and may vary from country to country. The situation in each country depends on the measures taken and their effectiveness in terms of reducing the burden on the environment.” Finally, the paper provides an overview of national plans and measures for recovery after the COVID-19 pandemic [1].

The EEA report on air quality in Europe in 2020 [2] states that the COVID-19 lockdown affected many economic activities as they were temporarily closed or reduced, resulting in reductions in air pollutants emissions, particularly from road transport aviation and international shipping. Despite the reduced movement of people during the lockdown, the transportation of goods and its associated emissions were hardly affected. The shutdown or reduction of some business and industrial activities led to drops in air pollutants from certain industrial sites, although with more localized effects than the road transport emissions. Emissions from such sectors as domestic combustion may also have been affected, but such changes have not yet been quantified across Europe.

1. Review and selection of relevant environmental indicators affected by the response to COVID-19

The EEA study on air quality in Europe [2] focused on nitrogen dioxide (NO_2) and particulate matter with a diameter of 10 µm or less (PM_{10}) data to estimate emission changes during the lockdown, based on earlier studies and observations data (by different ways including modelling). It is stressed that meteorology is one of the key factors determining air pollutants' transport and dispersion, chemical transformation, and deposition. Thus, meteorology significantly affects concentrations of air pollutants and their variability from one year to another.

Using observation and modelling data for spring 2020 in comparison with the period 2018–2019, the EEA study [2] shows decreasing nitrogen dioxide (NO_2) concentration in the air. The cities with severe COVID-19 lockdown measures and the urban areas with high population densities (Spain, France and Italy) were mostly affected. Therefore, it is reasonable to use data on NO_2 to evaluate the influence of COVID-19. However, the assessment of the lockdown impact on PM_{10} levels is more complex. PM concentrations depend not only on meteorology and primary PM emissions from anthropogenic sources but also on emissions from natural sources. Therefore, the changes in emissions and PM formation during the lockdown is more complex than for NO_2. For example, in some regions where people had to stay home, there might have been an increase in primary PM emissions from the domestic combustion of coal or wood. In contrast, emissions of NO_2 and primary PM from traffic were reduced. Agricultural emissions of primary PM and ammonia (NH_3) were probably not affected by the lockdown, while some industrial emissions (e.g., primary PM and nitrogen oxide (NO_x) and sulfur oxides (SO_x)) were reduced in several sites and countries. PM_{10} concentrations were also generally reduced across Europe as a result of lockdown measures, although less than for NO_2. The most significant relative reductions were estimated over Spain and Italy. The evaluation of changes in PM_{10} concentrations because of the lockdown is more uncertain than for NO_2 concentrations. Whereas the more considerable impact on NO_2 response is mainly attributed to lockdown measures targeting primarily road transport, which is a key source of NO_X emissions. The lower effect on PM_{10} shows that other sources of air pollutant emissions contribute to PM pollution. Thus, data on PM can also be used for assessment, especially for transport emissions (if it can be distinguished from agriculture sector sources).

Another EEA study on the impacts of COVID-19 on single-use plastic in Europe's environment [3] assesses the quantitative implications of single-use face masks on the environment and climate (greenhouse gas emissions). As a result of the increased consumption of face masks in Europe, additional tons of CO_2 have been emitted in the six-month period from April to September 2020, which is higher than the business-as-usual level. Therefore, it is reasonable to consider the data on CO_2 too.

When it comes to wastewater, one should expect a decrease in the use of industrial wastewater discharged to the environment, total discharge and surface water contamination from wastewater due to lockdown measures. Consequently, such indicators as total wastewater discharged to the environment after treatment, the proportion of domestic and industrial wastewater flows safely treated, the total removal rate of BOD_5, COD, nitrogen, phosphorus from generated wastewater before discharge to the environment can be used to evaluate COVID-19 influence on the environment.

Indicators on forest and biodiversity are secondary and do not reflect rapid changes in anthropogenic pressure, so they were not evaluated in this report.

Furthermore, it is reasonable to consider environmental expenditures and their share to the GDP of the countries.

Information on the state of the environment presents a basis for effective environmental policy, which is why this information is in demand and should be unbiased. Furthermore, environmental indicators allow assessment of the state of the environment to compare countries, regions etc. This information and data can, in turn, be tied to policy goals and provide a mechanism for tracking and evaluating policy implementation [4].

At present, a sufficiently broad set of different indicators provide the information needed by policymakers, civil society, etc. The environmental indicators are designed to answer key policy questions and serve as a basis for sound and informed policymaking. Furthermore, the state-of-the-environment reports are key information products for many UNECE countries. Therefore, UNECE has developed a list of environmental indicators in collaboration with the Working Group on Environmental Monitoring and Assessment (WGEMA) and the Joint Task Force on Environmental Statistics and Indicators (JTF) [4]. As a result, the UNECE list of environmental indicators was selected for analysis.

Based on the considerations mentioned above, it is proposed to follow the list of indicators affected by the response to COVID-19 as presented in Table 1.

Table 1: List of indicators affected by the response to COVID-19. Note: Indicators *in italic* are not mandatory [5].

Indicator		Description
A-2.2	SO_2: Number of days with exceeded daily limit value	The indicators provide for an assessment of air pollution from mobile and stationary sources, the share of different particular economic activities [6].
A-2.4	NO_2: Number of days with exceeded daily limit value	
A-1.1	Emissions of sulfur dioxide per capita	
A-1.2	Emissions of sulfur dioxide per square kilometre	
A-1.3	Emissions of sulfur dioxide per unit of GDP	
A-1.4	Emissions of nitrogen oxides per capita	
A-1.5	Emissions of nitrogen oxides per square kilometre	
A-1.6	Emissions of nitrogen oxides per unit of GDP	

A-1.7	*Emissions of non-methane volatile organic compounds (NMVOC) per capita*	
A-1.8	*Emissions of non-methane volatile organic compounds (NMVOC) per square kilometre*	
A-1.9	*Emissions of non-methane volatile organic compounds (NMVOC) per unit of GDP*	
A-1.10	Share of sulfur dioxide emissions from stationary or mobile sources	
A-1.11	Share of nitrogen oxides emissions from stationary or mobile sources	
A-1.12	*Share of NMVOCs emissions from stationary or mobile sources*	
A-1.14	Share of carbon monoxide emissions from stationary or mobile sources	
A-1.15	Share of hydrocarbons emissions from stationary or mobile sources	
B-3.7	CO_2 emission per unit of value-added (SDG indicator 9.4.1)	The indicator provides a measure of the existing and future anthropogenic impact on the Earth's climate due to emissions of GHGs into the atmosphere. It shows the extent to which countries have achieved their specified goals for emissions and the response to country policies for achieving the emissions target [7].
B-3.12	Total greenhouse gas emissions from production activities	
C-16.2	Proportion of domestic and industrial wastewater flows safely treated (SDG indicator 6.3.1)	The indicators provide an assessment of water pollution from different sources (domestic, enterprise's wastewater) [8].
C-16.3	Total removal rate of BOD_5 from generated wastewater before discharge to the environment	
C-16.4	Total removal rate of COD from generated wastewater before discharge to the environment	
C-16.5	Total removal rate of nitrogen from generated wastewater before discharge to the environment	
C-16.6	Total removal rate of phosphorus from generated wastewater before discharge to the environment	
C-3.4	Freshwater use per unit GDP	The indicator provides a measure of the pressure on the environment in terms of water abstraction from different sources [9].
J-1.2	Environmentally related taxes, per cent GDP	The indicator provides information about expenditures on the environment and is important to assess the measure.
J-1.1	National expenditure on environmental protection, per cent GDP	

2. Status and trends of environmental indicators affected by COVID-19 pandemic

2.1 Armenia

The territory of Armenia is 29,743 sq. km in area. The average altitude above sea level is 1800 m; 76.5 per cent of the country's territory is located at an altitude of 1000–2500 m above sea level. The climate is dry and continental. As of 1 January 2018, the permanent population of the Republic of Armenia with current registration (conducted based on the 2011 census) was 2,972,732. [10]

The coronavirus pandemic had a significant negative impact on the economy of Armenia. Due to the Government's restrictions, which were declared as measures against a COVID-19, in Armenia, industrial production decreased. On 16 March 2020, the Government announced a state of emergency, and people had to stay at home, international and internal traffic were suspended. Then the state of emergency was extended several times until 11 September 2020 [11].

As a result of restrictive measures, it is possible to expect a decrease in air emissions from stationary and mobile (transport) sources and a decrease in discharges of pollutants in wastewater. Therefore, it is reasonable to focus on the indicators of air and water as the most sensitive ones.

Table 2: Gross Domestic Product (GDP) at current prices, US billion dollars [12].

Year	2016	2017	2018	2019	2020
GDP, billion dollars	10.55	11.53	12.46	13.67	12.65

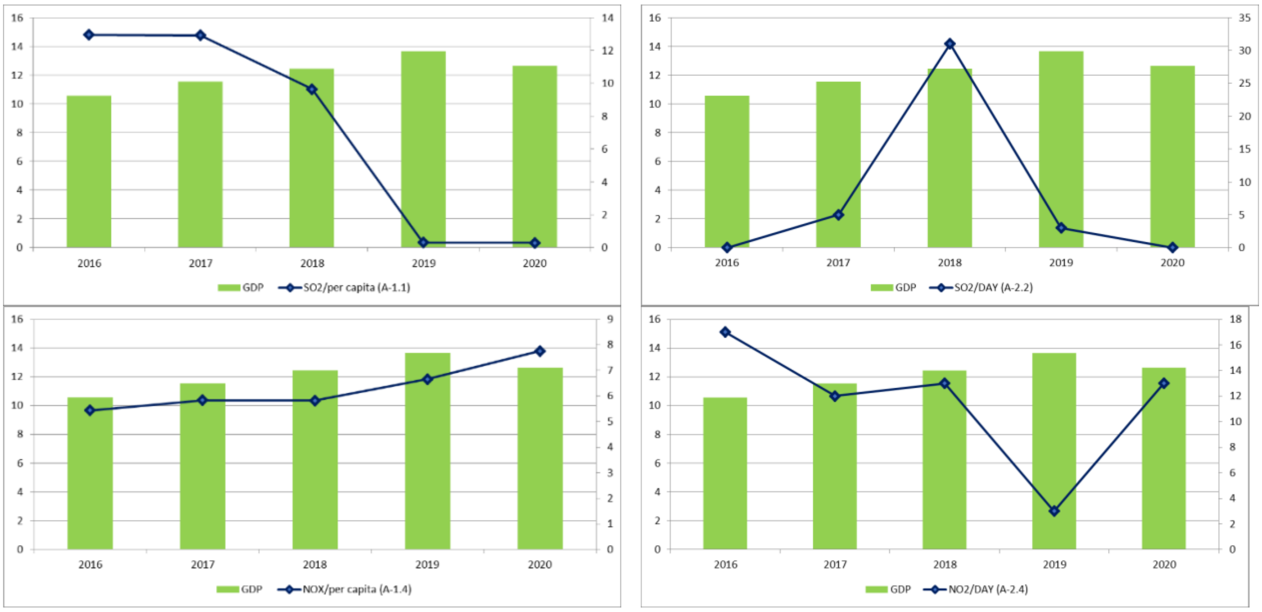
According to the United Nations Development Programme review of Armenia, the main environmental problems in Armenia are lack of water resources, the threat of excessive deforestation, the potential danger of the increased negative impact on the environment caused by mining activities. The main sources of emissions into the atmospheric air are transport, electricity generation, mining and quarrying [13].

The State organization "Hydrometeorology and Monitoring Centre" is responsible for air, surface and groundwater quality and soil monitoring [14]. In 2020, air quality observations covered SO_2, NO_x, CO and O_3 in Yerevan and seven other cities. The data on environmental indicators are available on the website of the Statistical Committee of the Republic of Armenia [15]. According to the data analysis, in 2020, nitrogen dioxide and sulfur dioxide concentrations increased in Yerevan and other cities [16].

Taking into account the developed environmental monitoring system and statistical reporting in Armenia, it seems reasonable to select the following environmental indicators to identify the possible impact of COVID-19:

1. **Air indicators:**
    1.1 SO_2: Number of days with exceeded daily limit value (A-2.2)
    1.2 NO_2: Number of days with exceeded daily limit value (A-2.4)
    1.3 Emissions of sulfur dioxide per capita (A-1.1)
    1.4 Emissions of nitrogen oxides per capita (A-1.4)
    1.5 Share of sulfur dioxide emissions from stationary or mobile sources (A-1.10)
2. **Water indicators:**
    2.1 Share of total wastewater discharged to the environment after treatment (C-16.1)
    2.2 Total removal rate of BOD_5 from generated wastewater before discharge to the environment (C-16.3)
    2.3 Total removal rate of phosphorus from generated wastewater before discharge to the environment (C-16.6)
3. **Economic indicators:**
    3.1 Current expenditure for nature protection (J-1.1)
    3.2 Environmental taxes and payments for nature use (J-1.2)

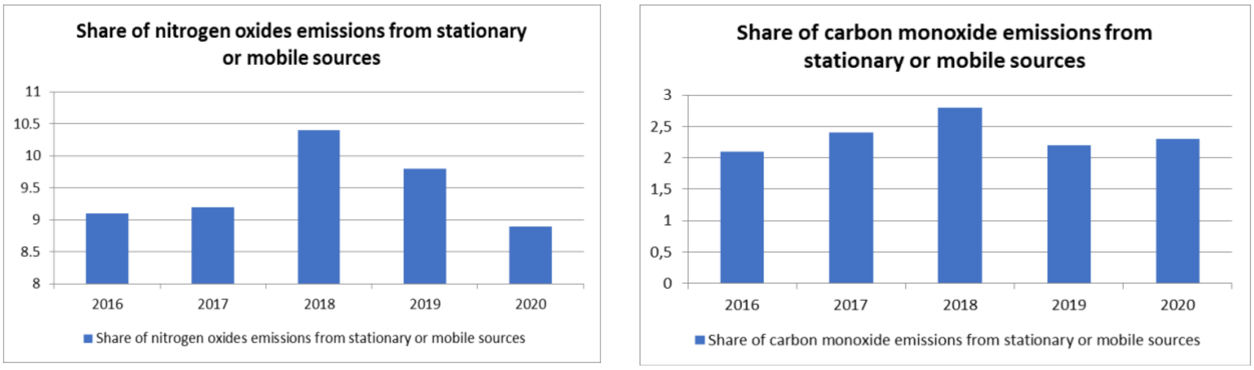
When it comes to atmospheric air pollution, it makes sense to use indicators that show the gross emission of a pollutant relative to GDP since the decreases in GDP levels reflect how sensitive the indicator is. The indicators showing the gross emission of a polluting substance in relation to the country's territory or population are almost equivalent. Therefore, the report focuses on the “per capita” indicators. The data on very useful indicators such as “Aggregated GHG emissions (CO_2 equivalents)” and “Aggregated emissions of Greenhouse gas (Gg CO_2eq) by sectors” are available only for the period 1990–2016, and thus cannot be included in the list of environmental indicators to analyse the impact of COVID-19 on the environment.



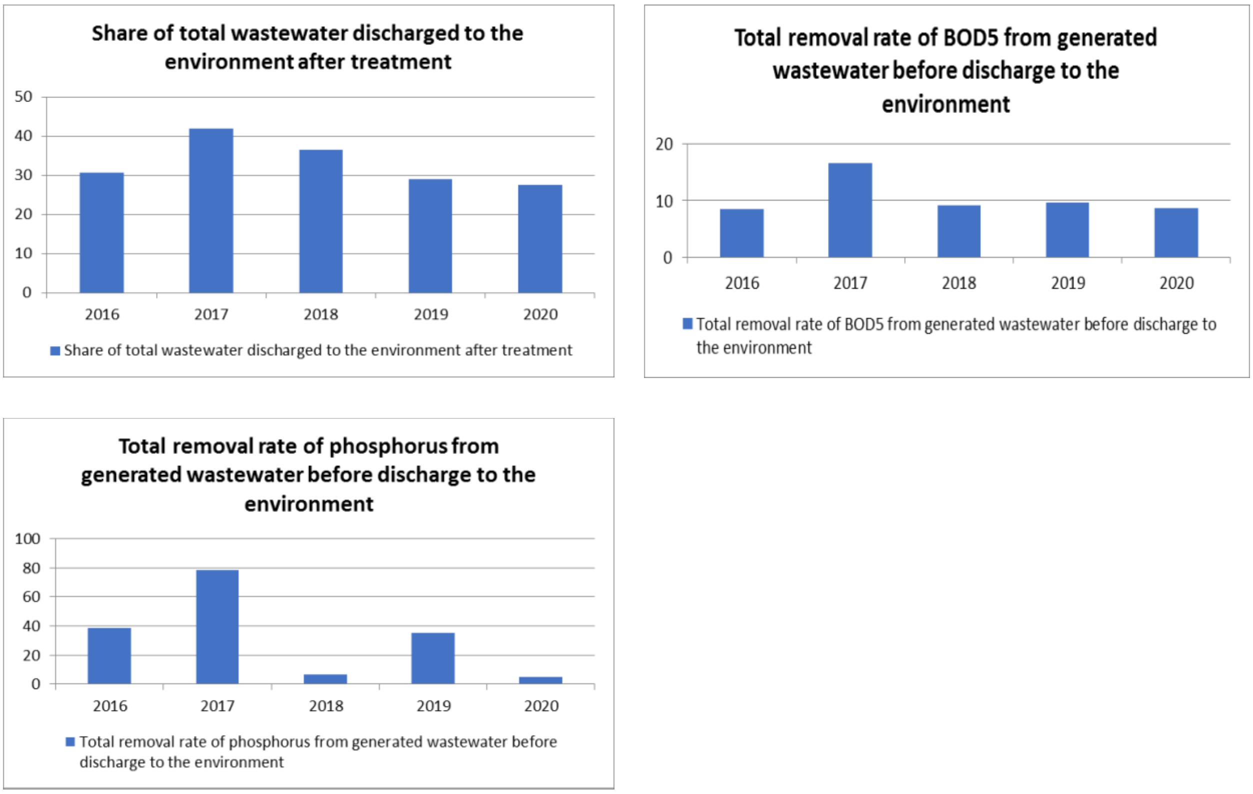
Picture 1: Comparable graphs of main air pollutant and GDP [12]

Note: more graphs can be found in the appended Excel file.

Picture 1 shows that the emission of SO_2 per capita and the number of days with exceeded daily limit value increased until 2018. However, there is a decreasing number of days with exceeded daily limit value in 2020, whereas the emissions were comparable with 2019. The decreasing emission of SO_2 in 2019–2020 might have been because different calculation methods were used (transition to an instrumental method). At the same time, NO_X emissions per capita increased due to emissions from mobile sources, as shown in picture 2. When it comes to the share of CO emissions from stationary or mobile sources, it increased in 2020 a little; this might have happened because of emissions from stationary sources (probably, electricity production).

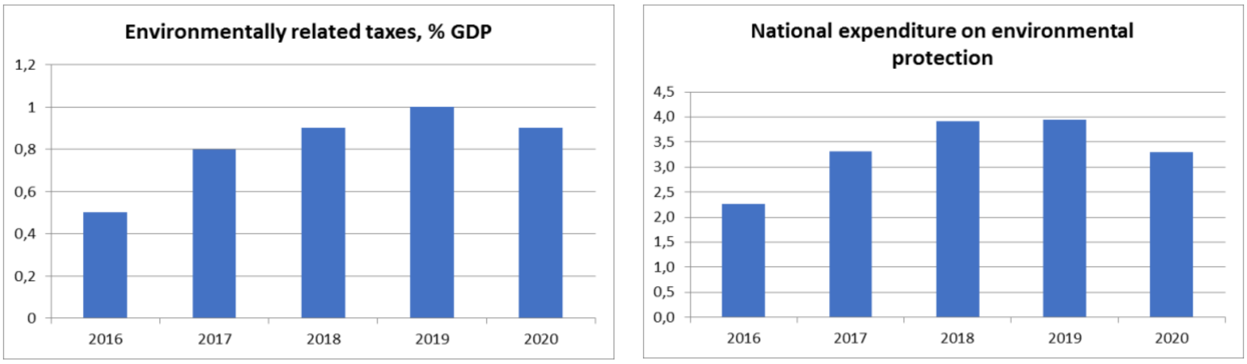


Picture 2: Air indicators [12]



Picture 3: Water indicators [12]

Picture 3 shows that the share of total wastewater to the environment, the total removal rate of phosphorus and BOD_5 from generated wastewater before discharge to the environment decreased. It might be justified by the lockdown measures during the COVID-19 pandemic.



Picture 4: Economic indicators [12]

Picture 4 shows that the environmental-related taxes and national expenditures on environmental protection were reduced in 2020, which can be a consequence of the COVID-pandemic.

2.2 Bosnia and Herzegovina

The territory of Bosnia and Herzegovina consists of the Federation of Bosnia and Herzegovina (capital is Sarajevo), Republika Srpska (capital is Banja Luka) and the Brcko District. The territory of Bosnia and Herzegovina is 51.2 thousand km^2 in area. The population of Bosnia and

Herzegovina is 3,280,815 [17]. Agriculture is the primary sector of the economy of Bosnia and Herzegovina. Besides, the share of the rural population is slightly more than 50 per cent [18].

The main environmental problems of Bosnia and Herzegovina include surface water pollution with untreated wastewater and atmospheric air pollution [19]. In the Federation of Bosnia and Herzegovina, a network of automatic air monitoring stations has been created in recent years: 2019 – 19 stations, 2020 - 21 stations and 2021 - 23 stations [20]. In the Republika Srpska in 2020, there were nine automatic air monitoring stations [21]. The following parameters are measured at most stations: SO_2, NO_2, PM10, PM2.5, O_3 and CO. According to the inventory of pollutant emissions, the main emissions sectors are industry and energy [22, 23].

The first confirmed case of COVID-19 was registered on March 5, 2020. In March, the Government declared a state of emergency across the country, suspended public transport, and closed the country's borders. In the second half of 2020, restrictions on mobility were phased out. In addition, Sarajevo Airport has been reopened. Since July 16, 2020, the borders of Bosnia and Herzegovina have been open to citizens and residents of the European Union and the Schengen countries [24].

The Government of Bosnia and Herzegovina took significant measures in 2020 to mitigate the adverse effects of COVID-19 and support the economy and the households, including measures to support the health sector and affected enterprises [24].

According to the World Bank, the COVID-19 pandemic had a negative impact on the economy of Bosnia and Herzegovina, but not very significant (table 3).

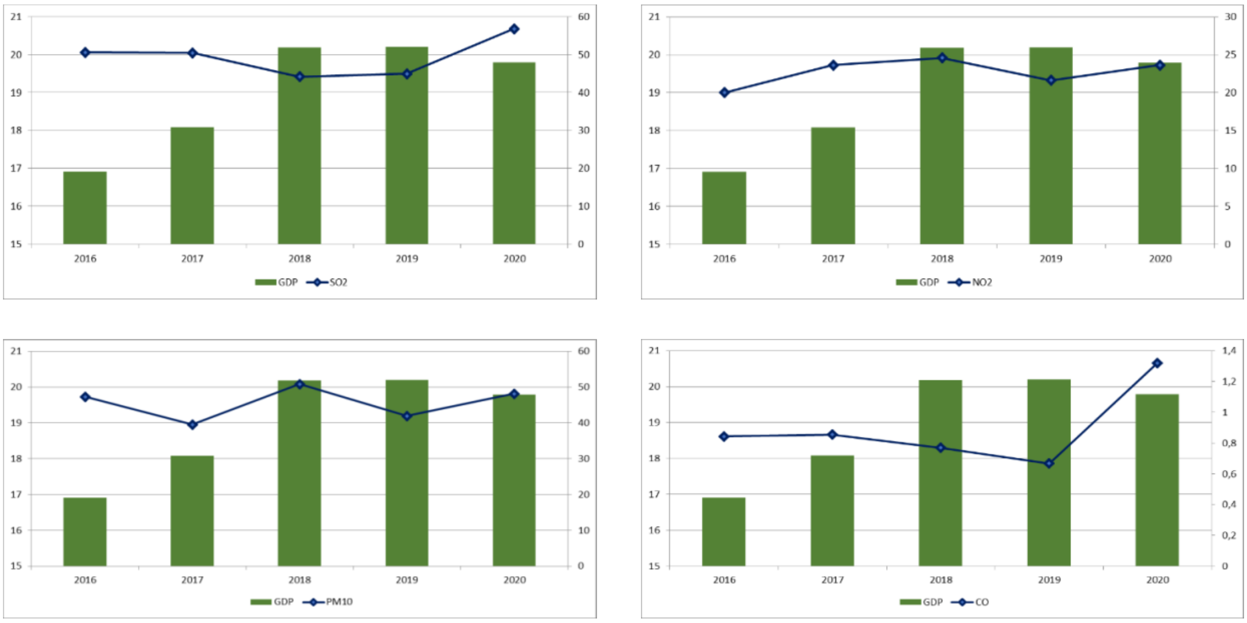
Table 3: Gross Domestic Product at current prices, US billion dollars, [25]

Year	2016	2017	2018	2019	2020
GDP, billion dollars	16.91	18.08	20.18	20.20	19.79

The information on air emissions, wastewater discharge and water quality from the list (table 1) is not available on the European Environment Agency, the European Environment Information and Observation Network (Eionet) and OECD websites. Besides, the data gaps were not addressed by the focal point. Therefore, the 2016-2020 air quality data of the Federal Hydrometeorology Service of the Federation of Bosnia and Herzegovina were analysed to evaluate the COVID-19 influence on the environment [14]. The report analyses the average annual data for each station. The consultant calculated the average for all reported concentrations within the reported year. Therefore, the following indicators can be used to assess the COVID-19 influence on the environment:

1. **Air indicators:**
   1.1 SO2 annual average concentration (national indicator, calculated by the consultant based on air quality monitoring data);

1.2 NO2 annual average concentration (national indicator, calculated by the consultant based on air quality monitoring data);
1.3 PM10 annual average concentration (national indicator, calculated the consultant based on air quality monitoring data);
1.4 CO annual average concentration (national indicator, calculated by the consultant based on air quality monitoring data).



Picture 5: Air quality in 2016-2020 [20]

Picture 5 shows increasing concentrations of all measured parameters of air quality in 2020 in comparison with 2019. According to data from the Federal Hydrometeorology Service of the Federation of Bosnia and Herzegovina [20], concentrations were high in almost all measuring sites. There is a very high concentration of sulphur dioxide in places and surroundings with abundant coal burning. High concentrations of SO_2, CO, NO_2 and PM_{10} occur not only during the cold seasons but also during any period of the year. Although in the period 2016–2019, the values of SO_2 and CO concentrations showed decreasing trends, in 2020, they increased again. It might also be due to specific meteorological conditions and the agricultural nature of the economy, as more than 50 per cent population is rural.

2.3 Georgia

The territory of Georgia ranges up to 5,203 m from sea level (peak Sahkhara). Georgia is distinguished by the complexity of its relief – about two-thirds of its territory is mountainous. The climate of Georgia is characterized by almost every climate zone existing on Earth, from humid subtropical climate to eternal snow and glaciers zone. The population is 3,728,600 as of 1 January 2021. [26]

According to the ENI SEIS II East review [27], atmospheric air pollution in Georgia is one of the most significant environmental problems. The primary sources of pollution are transport, the energy sector, agriculture and industry. In the cities, transport is the main source of pollution in relation to NO_x and CO emissions. "Today, the major challenge for Georgia's largest cities in terms of ambient air quality is nitrogen dioxide and particulate matter pollution (mainly PM_{10})". [29] The industrial sector is the main source of solid particles emissions. For example, SO_2 emissions have increased due to the increase in the use of coal in industry. The discharge of untreated urban wastewater is also a significant problem [30].

The National Environmental Agency of the Ministry of Environmental Protection and Agriculture of Georgia is responsible for ambient air quality monitoring. Air quality monitoring is carried out at eight automatic monitoring stations. The data flows from automatic stations are continuous, and data are kept directly in a database and published on a web portal air.gov.ge [28]. For non-automatic stations, the delivery period is once a month. The data are filled in and published on the same web portal. Furthermore, the reports are prepared yearly. Observations are conducted for the following parameters: NO_2, SO_2, $PM_{2.5}$, PM_{10}, O_3 and CO. It should be noted that data received from automatic air quality monitoring stations are not verified. However, verified data are available in the reports.

Water consumption increased in recent years both in urban and rural areas. Water pollution also increased. The primary wastewater pollutants come from chemical and metallurgic industries, oil production, agriculture [30].

When it comes to COVID-19, the first case of the coronavirus in Georgia was reported on 26 February 2020. The Government declared the state of emergency on 21 March 2020, which was extended until 22 May 2020. Following measures were implemented to slow the spread of the virus:

- Creation of a special information website (www.StopCov.ge). All available information was uploaded to this website.
- Suspension of all activities associated with large gatherings.
- Travel restrictions with neighbouring countries.
- Complete suspension of international passenger traffic.
- Regional travel restrictions (buses and fixed-route taxis).
- The gradual shutdown of various types of economic activities.

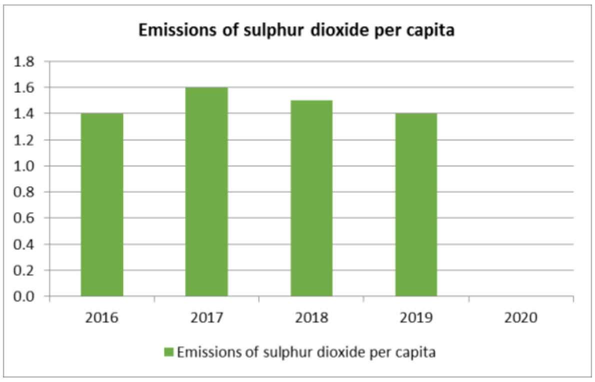
On 5 May 2020, some economic activities were resumed. The Government provided financial support for the recovery of agriculture, tourism, and construction [31].

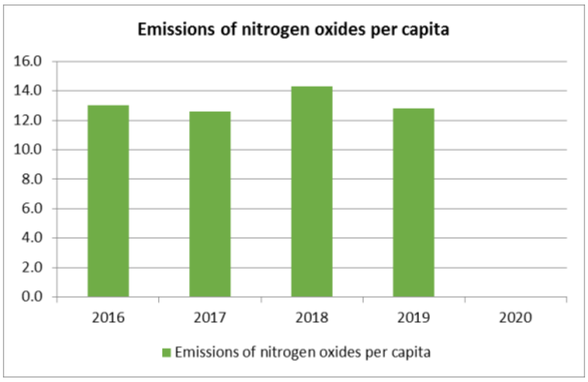
In addition, "the decrease in the influx of tourists has caused Georgia more damage than any other country in Eastern Europe and the Caucasus since almost 10 per cent of the national GDP is created by this industry". The number of visitors in the second quarter of 2020 decreased by 94 per cent compared to the previous year [32].

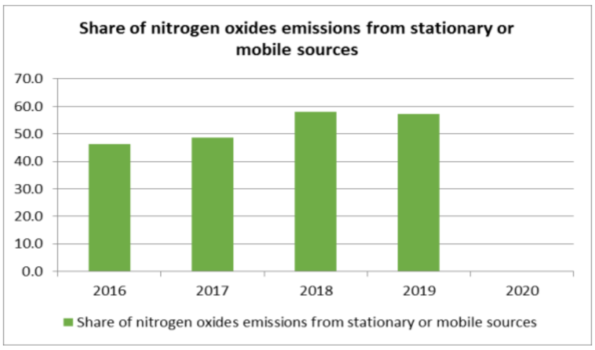
The COVID-19 pandemic had a significant impact on the Georgian economy – the GDP drop in 2020 was 6.2 per cent compared to 2019 [26] – and there was a decrease in the anthropogenic load on the environment. The most dynamic environmental indicators reflecting the impact of changes are the following UNECE indicators: the number of days with exceeded daily limit value for NO_2, SO_2, $PM_{2.5}$, PM_{10} and CO. The data on the pollutant emissions from stationary and mobile sources for the period 2016–2019 and data on wastewater volumes and volumes of insufficiently treated wastewater, which reflect the load on water resources, can be found on the website of the National Statistics Office of Georgia. However, there are limited data available, thus the indicators, as mentioned above, are proposed to analyse the impact of changes on the environment [26].

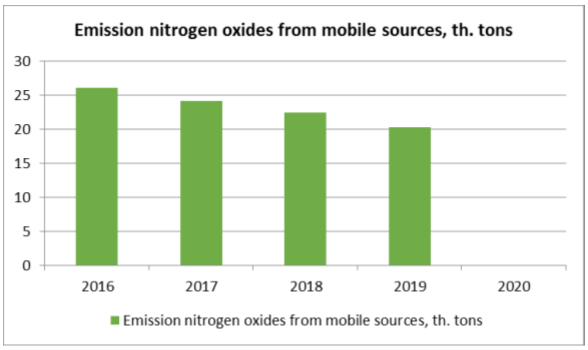
The following list of indicators has been analysed, however, data for 2020 are not available yet:

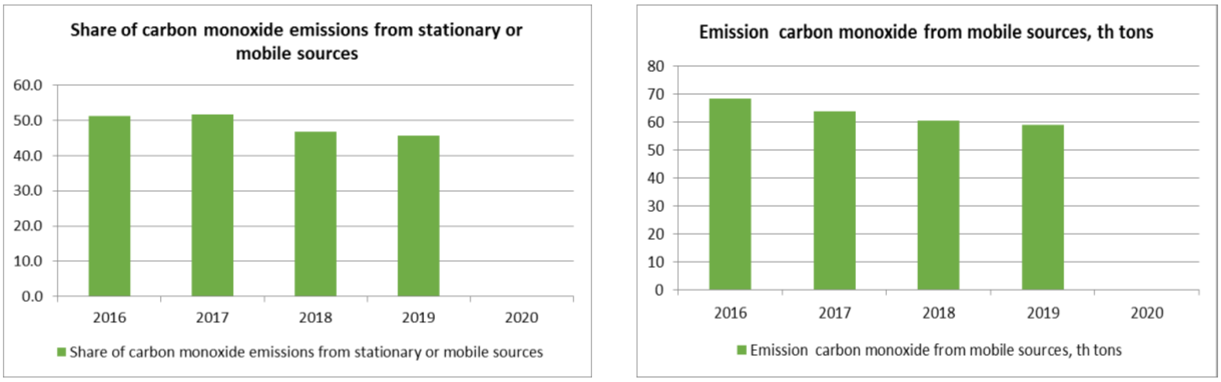
1. **Air indicators:**
   - 1.1. Emissions of sulfur dioxide per capita (A-1.1)
   - 1.2. Share of sulfur dioxide emissions from stationary or mobile sources (A-1.10)
   - 1.3. Emissions of carbon monoxide from mobile sources (national)
   - 1.4. Share of carbon monoxide emissions from stationary or mobile sources (A-1.14)
   - 1.5. Emissions of nitrogen oxides per capita (A-1.4)
   - 1.6. Share of nitrogen oxides emissions from stationary or mobile sources (A-1.11)
   - 1.7. Emissions of nitrogen oxides from mobile sources (national)
2. **Water indicators:**
   - 2.1. Wastewater discharge (national)
   - 2.2. Household water use per capita (C-4)







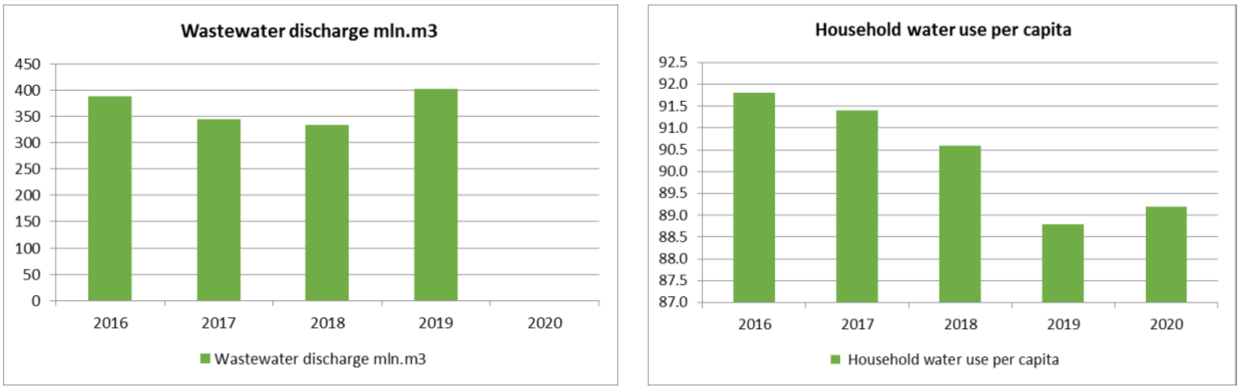




Picture 6: Air indicators [26]

Given the available data, it is possible to expect CO and NO_x emissions to decrease, especially from mobile sources, and the same level of SO_2 emissions based on the information on the main emission substances and primary economy activities causing air pollution.

The group of water indicators shows the increasing household water use per capita in 2020 compared to 2019 as a consequence of lockdown measures during the COVID-19 pandemic (picture 7). Therefore, it is possible to expect wastewater discharge to increase in 2020 too.



Picture 7: Group of water indicators [26]

2.4 Kazakhstan

The population of Kazakhstan is 19,042,100 in 2021. Kazakhstan covers an area of 2,724,900 thousand km^2 and is the ninth largest country by area in the world. Most of the country's territory comprises deserts - 44 %, and semi-deserts - 14 %. Steppes occupy 26 % of Kazakhstan, forests - 5.5 %. The distance from the oceans determines the sharply continental climate of the country [33]. Environmental monitoring of the Republic of Kazakhstan includes:

- Air quality monitoring in 45 localities at 140 observation posts and 15 mobile laboratories.
- Surface water quality monitoring at 424 sites located at 143 water bodies.

- Precipitation quality monitoring at 46 weather stations and snow cover at 39 weather stations.
- Soil monitoring at 102 observation points.

The environmental information received from the above-mentioned monitoring networks is collected, processed, analysed and prepared for state bodies and the population by the Department of Environmental Monitoring of “Kazhydromet” [34]. In addition, air monitoring is carried out for the following parameters: suspended particles (dust), suspended particles PM_{10} and $PM_{2.5}$, sulphur dioxide, soluble sulphates, carbon dioxide, carbon monoxide, nitrogen dioxide, nitrogen oxide, ozone, hydrogen sulphides and other pollutants.

The main data on environmental indicators are available on the website of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan [35].

In 2020 the COVID-19 pandemic had a severe impact on the population, economy and environment of Kazakhstan. As a result, real GDP (at current prices) growth in 2020 was minus 2.6 %. On 15 March 2020, the President of the Republic of Kazakhstan declared a state of emergency until 15 April 2020, then extended it until 11 May 2020. Given the state of emergency, the following measures were introduced: the closure of the border, suspension of mass gathering, travel ban, etc. On 19 May 2020, the Government adopted a comprehensive plan to restore economic growth. Besides, on 1 June 2020, the Government decided to resume transport connections to regional centres and major cities of Kazakhstan. In addition, the Government provided financial support to small and medium-sized businesses [36].

Table 4: Gross Domestic Product at current prices, US billion dollars [37].

Year	2016	2017	2018	2019	2020
GDP, billion dollars	137.28	166.81	179.34	181.67	169.84

What is more, the Government adopted the anti-crisis package (around 9 % of GDP), which included support for employment and businesses [38].

Economic statistics data for 2020 [39] showed a significant decline in a number of sectors of the economy. For example, mining and quarrying showed 96.3 % of the volume of 2019, passenger turnover – 36.8 % of the volume of 2019, the gross output of transport services – 77 % of the volume of 2019.

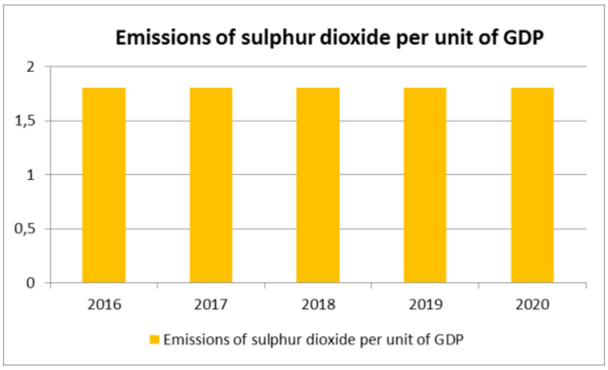
Environmental indicators reflecting the impact of COVID-19 were selected based on the availability of environmental information for the period 2016–2020. The collected data were supplemented and verified by a national focal point. Furthermore, the data were analysed based on the sensitivity of environmental indicators to the reduction of anthropogenic load. For example, the SDG indicators are less dynamic than the UNECE environmental indicators. Therefore, the set of UNECE environmental indicators was chosen for analysis. The most dynamic UNECE environmental indicators reflecting the reduction of anthropogenic pressure on the environment in 2020 compared to 2019 are:

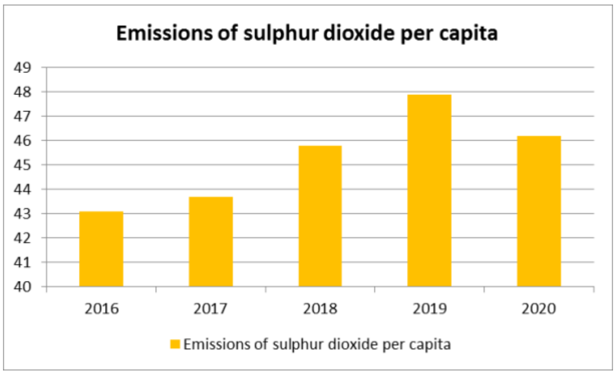
1. **Air emissions indicators:**
   1.1 Emissions of sulfur dioxide per capita (A-1.1)
   1.2 Emissions of sulfur dioxide per GDP (A-1.3)
   1.3 Emissions of nitrogen oxides per capita (A-1.4)
   1.4 Carbon monoxide emissions from stationary sources (national)
2. **Water indicators:**
   2.1 Proportion of domestic and industrial wastewater flows safely treated (SDG indicator 6.3.1) (C-16.2)
   2.2 Freshwater use per unit GDP (C-3.4)
3. **Economic indicators:**
   3.1 Environmentally related taxes, per cent GDP (J-1.2)
   3.2 Environmentally related taxes, per cent total tax revenue (J-1.3)

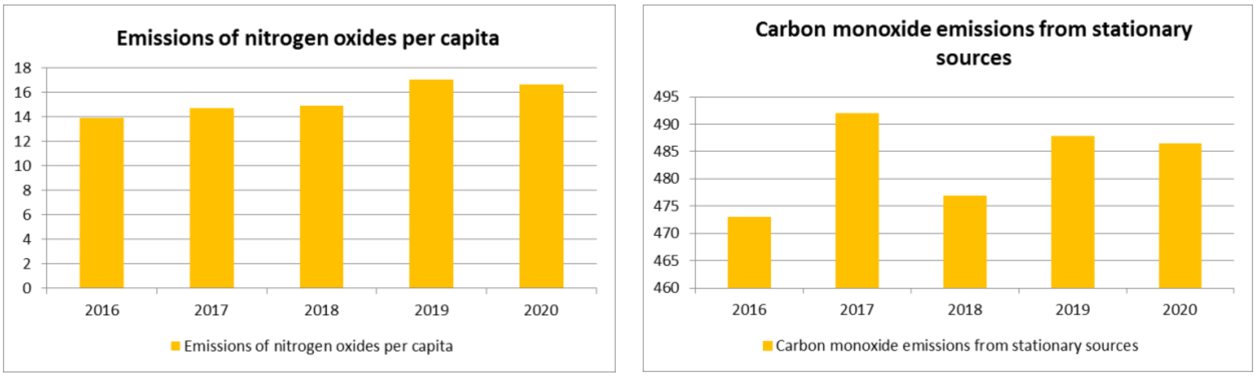
For example, picture 8 shows decreasing CO, NO_x and SO_2 emissions in 2020 compared to 2019 as a result of anti-COVID measures.

In addition, picture 9 shows decreasing trends of freshwater use per unit GDP starting from 2016 and increasing rates of proportions of domestic and industrial wastewater flows safely treated. The most likely group of water indicators does not reflect the influence of pandemic measures.

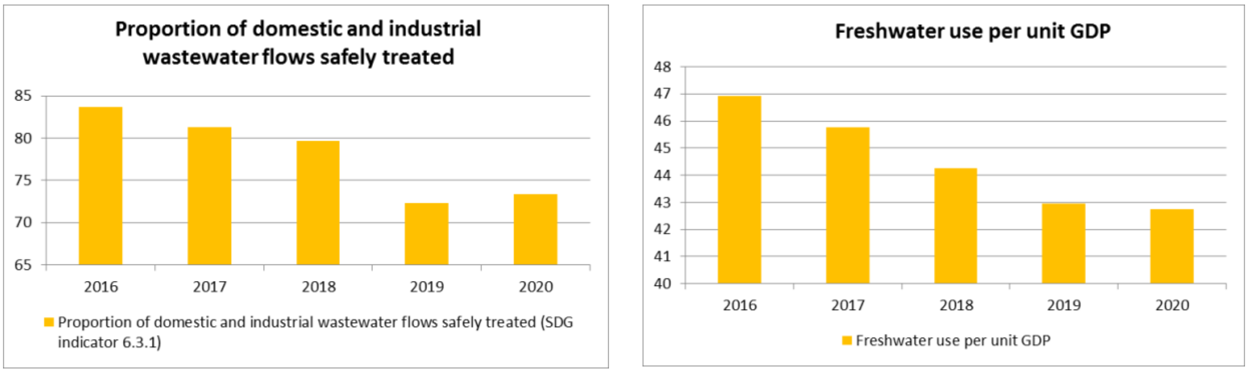
Environmentally related taxes (picture 10) are decreasing in 2019–2020, although in 2016–2018, there was a growing trend.



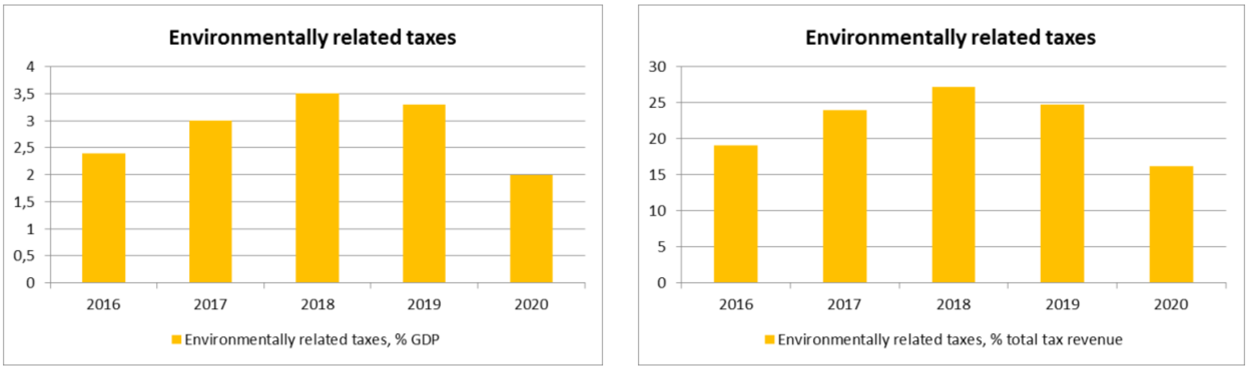




Picture 8: Group of air indicators [35]



Picture 9: Group of water indicators [35]



Picture 10: Group of economic indicators [35]

2.5 Kyrgyzstan

The territory of Kyrgyzstan is 199.9 thousand km^2. Almost 90 % of its territory is 1500 m above sea level. The population was 6.637 million people in 2020, including urban population – 34 % rural population – 66 % [40, 41]

Air pollution is one of the most significant environmental problems in Kyrgyzstan. The primary sources of air pollution are road transport, industry and facilities of the fuel and energy complex, and soil dust from unsettled territories. In addition, 98.0 % of total pollutant emissions from stationary sources are emitted by three types of economic activity [42]:

- Electricity, gas, steam and conditioned air (52 %);
- Manufacturing industry (38 %);

- Mining (8 %).

The primary air pollutant emissions from stationary sources are dust, sulfur dioxide, nitrogen oxides and carbon monoxide. About 70 % of the main pollutants are emitted by mobile sources [42]. “The growing energy needs of the Kyrgyz Republic are increasingly being met by coal, consumption of which almost tripled during 2006–2018. To a large extent, this growth was due to increased dependence on inefficient and highly polluting coal boilers, as well as on the use of coal by the population for heating” [43].

The Agency for Hydrometeorology (Kyrgyzhydromet) is responsible for air and water quality monitoring. Air quality monitoring is carried out in five cities of the Kyrgyz Republic (about 67 % of the urban population live there) at 15 stations. Water quality monitoring is carried out on 78 hydrological posts, five lakes and 23 hydro-chemical river posts [42]. However, there are no aggregated data on water quality. The most dynamic and representative indicators reflecting changes in anthropogenic pressure on water resources are the indicators of wastewater and untreated or insufficiently treated water. In addition, most of the data on other environmental components are not available except for atmospheric air for 2019–2020.

When it comes to COVID-19, the first cases of COVID-19 in the Kyrgyz Republic were detected on 18 March 2020. According to the Decree of the President of Kyrgyzstan “On the introduction of a state of emergency” of 24 March 2020, the state borders were closed, all international and domestic flights were suspended, and movement of vehicles was restricted. The easing of most restrictions occurred after 11 May 2020. Road transport, the busiest mode of transport in the country, has lost part of its cargo turnover and passenger traffic due to the closure of borders and a reduction in imports. The Government has adopted a number of measures to recover the economy. “As part of the third package of comprehensive measures to restore the economy and its further development in the post-crisis period, it is planned to strengthen export potential, support domestic entrepreneurs, activate the policy of import substitution, increase the production of environmentally friendly products, create favourable conditions for doing business, and improve the management of state property. Emphasizing its vulnerability to external shocks, Kyrgyzstan promotes the transition to innovative and less capital-intensive activities through the implementation of the concept of intellectual economy, which aims to transition to a more knowledge-based economy, as well as to a more diversified economy. The key goal is to reduce the economy's dependence on remittances from migrant workers and income from the polluting and energy-intensive mining” [44]. According to the World Bank, Kyrgyzstan experienced a significant decline in GDP in 2020 compared to 2019 (table 5), which led to a reduction in anthropogenic pressure on the environment.

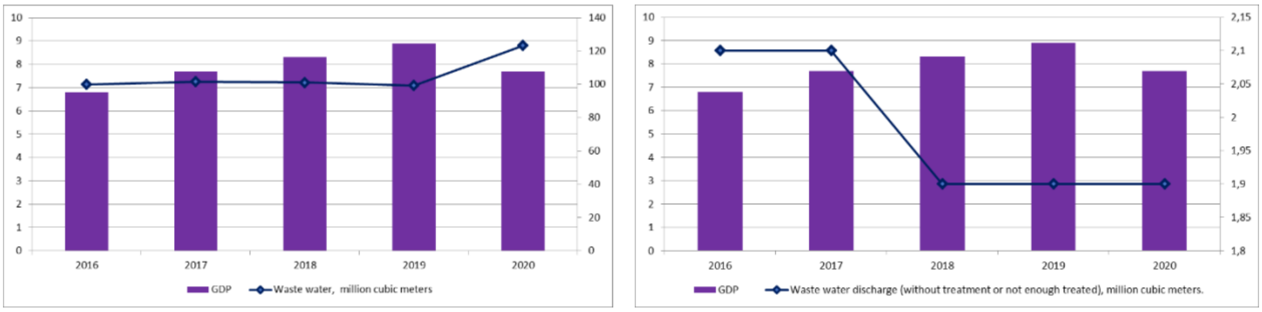
Table 5: Gross Domestic Product at current prices, US billion dollars, [45].

Year	2016	2017	2018	2019	2020
GDP, billion dollars	6.8	7.7	8.3	8.9	7.7

Based on the limited amount of available data on environmental indicators in the Republic of Kyrgyzstan for the period 2016–2020 [45], it is proposed to select some of the indicators from table 1 reflecting the impact of COVID-19:

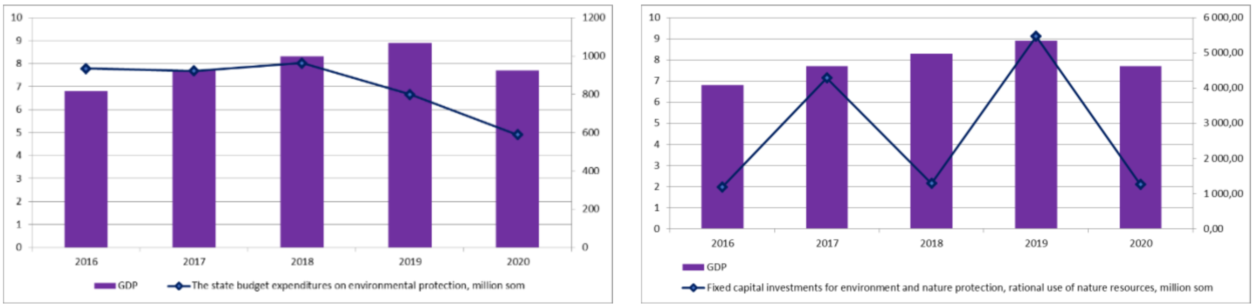
1. **Air indicators:**
    1.1 Emissions into the atmosphere from stationary sources (national);
    1.2 Solid particle emissions from stationary sources (national);
    1.3 Emissions of sulfur dioxide from stationary sources (national);
    1.4 Emissions of carbon oxides from stationary sources (national);
    1.5 Emissions of nitrogen oxides from stationary sources (national);
2. **Water indicators:**
    2.1 Wastewater discharge (national);
    2.2 Wastewater discharge (without treatment or not enough treated) (national);
3. **Economic indicators:**
    3.1 The state budget expenditures on environmental protection (national);
    3.2 Fixed capital investments for environment and nature protection, rational use of natural resources (national).

Picture 11: Group of air indicators (national)[45]



Picture 12: Group of water indicators (national) [45]

Pictures 11 and 12 shows that emissions from stationary sources and wastewater discharge increased in 2020 compared to 2019. It can be explained by the impact of comprehensive measures taken to restore the economy in the post-crisis period. Solid particle and carbon oxides emissions from stationary sources increased in 2020 compared to 2019 as a result of meteorological conditions or coal use for heating. At the same time, sulfur dioxide and nitrogen oxides emissions from stationary sources decreased in 2020 compared to 2019.



Picture 13: Group of economy indicators (national) [45]

2.6 North Macedonia

According to the State Statistical Office of the Republic of North Macedonia, the population of North Macedonia was more than 2 million people in 2020. For example, 57 % of the population lives in urban areas, mainly in the five largest cities. The country's territory is 25,333 km^2. North Macedonia has a temperate continental mountain climate. Economic development is weak. Speaking about the industry, North Macedonia mines chromium, copper, lead zinc and iron ores, and manganese. In addition, there are enterprises of ferrous and non-ferrous metallurgy, machine-building, chemical and pharmaceutical, light and food industries [46].

Air pollution is a main ecological issue in North Macedonia. Transport and road traffic significantly contribute to air pollution, especially in urban areas, due to the low share of public transport and the widespread use of old vehicles (average age of vehicles is around 19.1 years). The main source of SO_2 and NO_x emissions is electricity production which depends on coal consumption. The main emissions sources of $PM_{2.5}$, PM_{10} are residential heating and industrial processes [47].

North Macedonia has a system of automatic air quality monitoring stations, which is operated by the Macedonian Environmental Information Centre. The Information Centre is a structural unit of the Ministry of Environment and Physical Planning. The air quality monitoring stations continuously monitor the following parameters: SO_2, NO, NO_x, NO_2, O_3, CO, PM_{10}, $PM_{2.5}$ and BTEX (benzene, toluene, ethylbenzene, o-xylene, p-xylene). However, some of the stations do not monitor all these parameters.

There is a web portal on air quality in the Republic of North Macedonia [48], which contains publications on atmospheric air quality in North Macedonia, including data on atmospheric air monitoring stations, measured parameters, and observation results. In total, there are seven stations in the Skopje agglomeration, six stations in the Western zone, seven stations in the Eastern zone, and two mobile stations. Measured parameters are SO_2, NO_x, CO, PM_{10}, $PM_{2.5}$, O_3, metals, and other pollutants. The data of the inventory of pollutant emissions for 1990-2019 are also available. In addition, monthly publications in Macedonian with average daily concentrations of pollutants for each atmospheric air monitoring station are posted.

When it comes to surface water, North Macedonia has developed a surface water quality monitoring network, which comprises 20 sampling points, 17 of which are located in the Vardar River Basin. In addition, the network of surface water monitoring also consists of 110 hydrological stations [47].

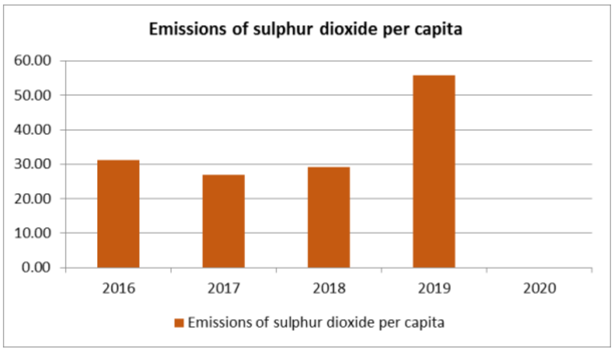
The first case of COVID-19 was reported on 26 February 2020. The Government has taken measures to mitigate the adverse effects of restrictions on the economy. In May 2020, the Government adopted the four packages of measures. The first two were implemented between March and May 2020 and intended to support the economy and the health sector. On 17 May 2020, the Government introduced a third package to boost economic recovery. The fourth package, adopted on 24 September 2020, is a direct extension of the three previous ones. COVID-19 had significant negative effects on North Macedonia's economy. For example, GDP declined by 4.5 per cent in 2020 [49].

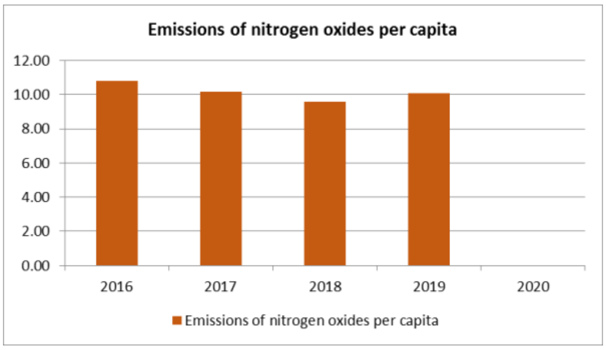
Therefore, it is proposed to use the following list of indicators to assess the COVID-19 influence on the environment:

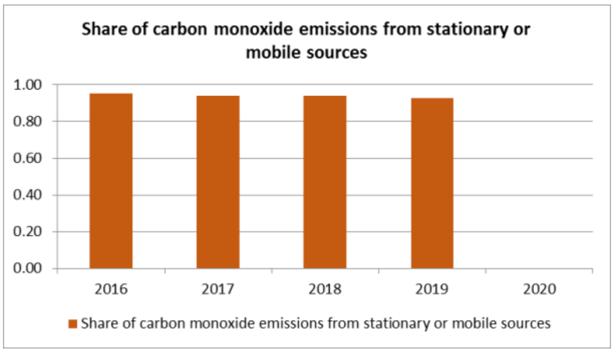
1. **Air emissions indicators:**
    - 1.5 Emissions of sulfur dioxide per capita (A-1.1);
    - 1.6 Emissions of nitrogen oxides per capita (A-1.4);
    - 1.7 Share of nitrogen oxides emissions from stationary or mobile sources (A-1.11);
    - 1.8 Share of carbon monoxide emissions from stationary or mobile sources (A-1.14);
2. **Water indicators:**
    - 2.1 Freshwater use per unit GDP (C-3.4);
3. **Economic indicators:**
    - 3.1 Environmentally related taxes, per cent GDP (J-1.2);
    - 3.2 National expenditure on environmental protection, per cent GDP (J-1.1).

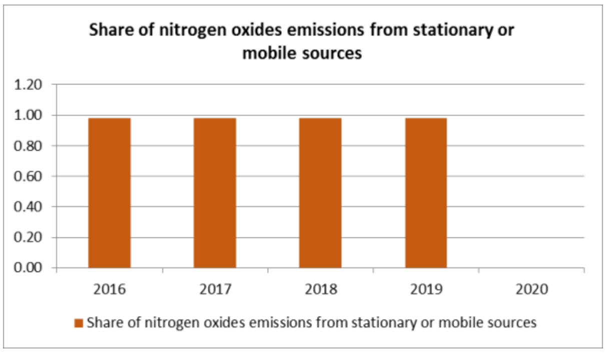
Analysing the above-mentioned environmental indicators presented in picture 14, it is possible to expect the same level of SO_2 and NO_x emissions and a decrease of CO emissions in 2020, based on information on the main air emission substances and main air-polluting economic activities. But, unfortunately, the data for 2020 on the selected environmental indicators were absent.

In addition, picture 15 shows an increase in freshwater use due to the COVID-19 pandemic.

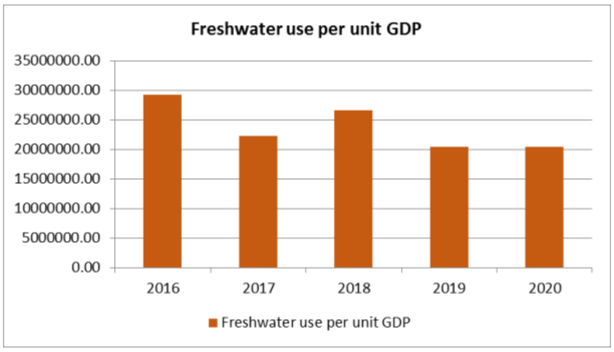




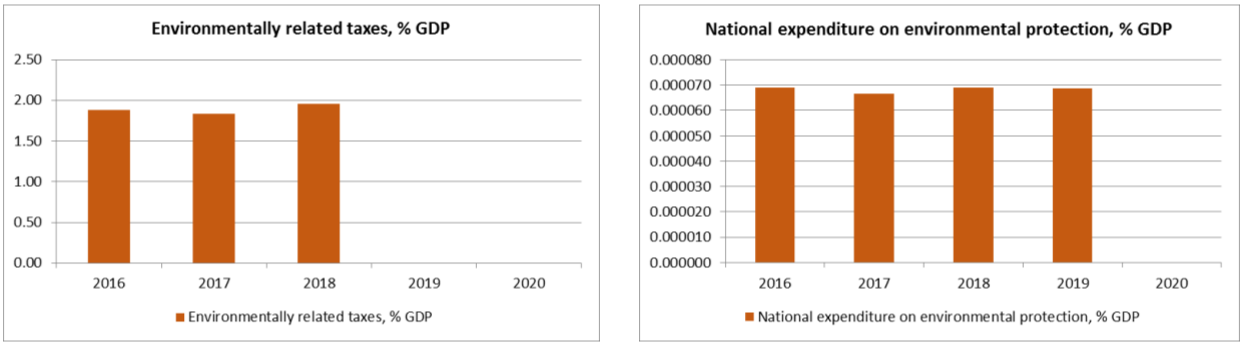




Picture 14: Group of air indicators [46]



Picture 15: Group of water indicators [46]



Picture 16: Group of economy indicators [46]

2.7 Tajikistan

The territory of Tajikistan is 143.1 thousand km^2. In 2020, the population was 9,547,642 [17]. For example, the urban population represent 26.3 %, the rural population represent 73.7 %. By the nature of the surface, Tajikistan is typically a mountainous country with absolute altitude ranging from 300 to 7495 m, with 93 % of its territory occupied by mountains. The subsoil of Tajikistan is very rich [50].

According to the statistical data [50], the most significant emissions of harmful substances from stationary and mobile sources occur in industrial areas of the country. The primary stationary sources of emissions are metallurgical and cement plants and coal-fired thermal power plants. Also, individual and central heating systems running on coal and firewood worsen the air quality in settlements during the cold winters. On the other hand, motor transport is the main source of carbon monoxide emissions, nitrogen oxides, and solid particles due to the widespread use of old vehicles [51].

The source of information on air emissions of harmful substances in Tajikistan is the Statistics Agency (www.stat.tj). It provides aggregated data.

Air monitoring in Tajikistan is carried out at five stations, but the observation time series are short. Observation in Dushanbe is operated at an automatic station. The stations monitor the following parameters: CO, NO_2, NO, NO_x, SO_2, suspended solids (PM_1, $PM_{2.5}$ and PM_{10}). Furthermore, in 2020, observations of the chemical composition of surface waters in the Republic of Tajikistan were carried out at 43 observation points, where water samples are taken from 18 rivers and one reservoir [51].

Regarding COVID-19, Tajikistan reported its first confirmed COVID-19 case on 1 May 2020. The Government adopted the measures to contain the spread of the COVID-19, including border closures, travel restrictions. On 5 June 2020, the President of Tajikistan issued a decree on Countering the Socio-Economic Impact of COVID-19. No COVID-19 cases have been recorded in Tajikistan since January 2021. Tajikistan started resuming its economic activity relatively quickly. On 6 June 2020, the Government presented a recovery plan: restrictions on public transport were removed, etc. Besides, the Government provided VAT exemptions on essential imports and financial support for industry and small enterprises [52].

According to the World Bank, restrictive measures in connection with the COVID-19 pandemic led to a decrease in GDP in 2020 compared to 2019 (table 6).

Table 6: Gross Domestic Product at current prices, US billion dollars [53].

Year	2016	2017	2018	2019	2020
GDP, US billion dollars	6.99	7.54	7.77	8.30	8.19

Given a limited choice of environmental indicators for the Republic of Tajikistan, the following indicators were selected:

1. **Air indicators**:
    1.1 Emissions of sulfur dioxide from stationary or mobile sources (national);
    1.2 Emissions of carbon monoxide from stationary or mobile sources (national);
    1.3 Emissions of nitrogen oxides from stationary or mobile sources (national);
    1.4 Hydrocarbon emissions from stationary or mobile sources (national).

It can be summarized that there was an increase in NO_x and SO_2 emissions and a decrease in hydrocarbons emissions in 2020 as a result of coal-fired thermal power plants. It should be noted that environmental statistical data was provided by the focal point (picture 17).

Picture 17: Statistical data on air emissions

Conclusion

The common feature for all countries is the reduction of environmental expenditures (indicators J-1.1, J-1.2), which can be explained by the budget redistribution to healthcare and economic measures during the COVID-19 pandemic.

Ambient air pollutants are the main indicators for assessing the impact of the pandemic.

The influence of the COVID-19 pandemic on the environment depends not only on measures taken and restrictions but also on the relevant economic activity in the country that mainly pollutes the environment, especially ambient air. Therefore, air pollution is caused by natural factors and geographic conditions of countries. Thus,

- in the countries with a prominent agricultural economic sector or rural population, environmental quality was not improved, and emissions of air pollutants did not decrease.
- in the countries with coal combustion for energy production or heating, there was no improvement in air quality.
- in the countries where the use of transport, passenger traffic, and cargo transportation were decreasing, a decrease in CO and NO_x emissions can be observed.

Armenia. The COVID-19 pandemic led to a decrease in emissions of SO_2 (indicators A-1.1, A-1.2, A-1.3) and the discharge of wastewater to the environment (indicators C-16.1, C-16.2, C-16.3, C-16.4, C-16.6), an increase in emissions of CO from stationary sources, NO_x from mobile sources (A-1.4, A-1.5, A-1.6, A-1.14), total removal rate of nitrogen from generated wastewater before discharge to the environment, and increase in freshwater use per unit GDP (indicators C-3.4, C-16.5).

Bosnia and Herzegovina. Given the limited amount of data available, the national indicators were used to assess the effects of COVID-19. Data show increasing concentrations of all measured parameters of air quality due to coal burning. Taking into account the prominence of agriculture in the economy and the fact that more than 50 % of the population is rural, it is important to have UNECE indicators (A-1.1, A-1.2, A-1.3, A-1.4, A-1.5, A-1.6, A-1.10, A-1.11, A-1.14, A-1.15) available in open official sources to evaluate correctly the COVID-19 pandemic influence on the environment.

Georgia. Given the unavailability of data for 2020, it was possible only to anticipate that the COVID-19 pandemic led to decreases in CO and NO_x emissions (A-1.4, A-1.5, A-1.6, A-1.14), especially from mobile sources, and the same level of SO_2 emissions (A-1.1, A-1.2, A-1.3). Also, wastewater discharge (national indicator) increased, based on statistical data on household water use per capita (C-4).

Kazakhstan. COVID-19 pandemic led to decreases in CO, NO_x and SO_2 emissions (national, A-1.1, A-1.3, A-1.4) and decreases in freshwater use per unit GDP (C-3.4).

Kyrgyzstan. The COVID-19 pandemic led to decreasing NO_x and SO_2 emissions from stationary sources. Increases in emissions from stationary sources and wastewater discharges can be due to the results of the comprehensive measures taken by the Government to restore the economy in the post-crisis. On the other hand, solid particle and carbon oxides emissions from stationary sources increased due to meteorological conditions or the use of coal for heating. Therefore, national indicators were used for the assessment.

North Macedonia. It is only possible to anticipate that the COVID-19 pandemic led to the same level of SO_2 and NO_x emissions and decreased CO emissions in 2020. In addition, an increase in freshwater use in 2020 is a consequence of the COVID-19 pandemic influence.

Tajikistan. The COVID-19 pandemic led to a decrease in hydrocarbons emissions. Increases in NO_x, SO_2 emissions can be due to coal-fired thermal power plants. National indicators were used for the assessment.

Collected data on UNECE or national (when UNECE indicators were unavailable) indicators and graphs are in the appended Excel file.

Results of this report were used to develop the report on the National COVID-19 pandemic response and future trends of the environmental indicators.

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Appendix: Data_COVID_Impact_GRAPHS.xlsx