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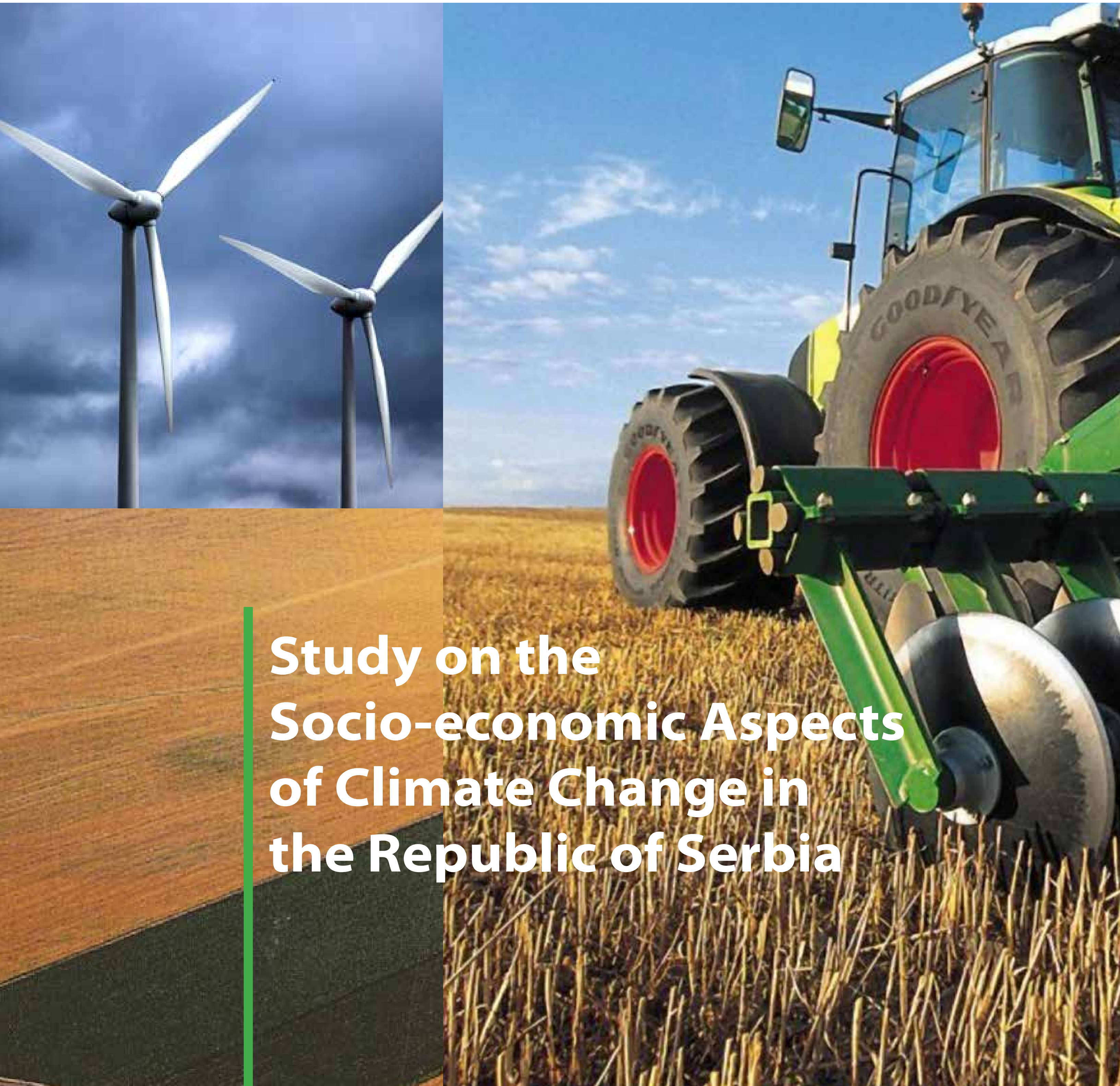

Study on the Socio-economic Aspects of Climate Change in the Republic of Serbia

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Contents

Abbreviations

GHG	Greenhouse gases
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
ILO	International Labour Organization
IPPU	Industrial processes and product use
OECD	Organization for Economic Development and Cooperation
RCP	Representative Concentration Pathways
USD	US dollar

SUMMARY

The impact of climate change on the global economy and society are already visible. The expected climate change will result in a series of new negative consequences for society and its development in the future. The worst direct consequences of climate change include a rise in temperature, which affects human health and life, as well as agricultural and energy production, causes forest fires, etc. On the other hand, extreme rainfall, resulting in floods, landslides and rockslides, directly threatens lives and property, as well as the supply and availability of food, water, and energy.

In terms of the impact of climate change on the Serbian society and economy, the impact of climate change on sectors and systems is significant, as well as the need to adapt to climate change and reduce greenhouse gas (GHG) emissions. Including those aspects in development planning ensures the sustainability of planning and investments, as well as the competitiveness of the Serbian economy.

Clearly, climate change needs to be included in planning, both in sector development and infrastructure, since the total material damages caused by extreme climate and weather conditions in Serbia exceed 5 billion EUR, in the 2000-2015 period alone, and more than 70% of losses are caused by drought and high temperatures. Flooding is another major cause of losses. In 2014 alone, floods caused enormous damages and recovery requires an estimated EUR 1.35 billion. Additionally, it is worth mentioning that

In terms of temperature rise, Serbia is more affected by climate change than most places on Earth

Since temperatures will continue rising in future and precipitation will drop in summer and increase in other seasons with continuing weather extremes, it is clear that the negative effects of climate change will be worse.

This study shows the results of those changes based on different temperature increase scenarios. The consequences are presented as a drop in the GDP due to global warming caused by climate change, based on four different IPCC Scenarios (RCP2.6, RCP4.5, RCP6 and RCP8.5), which means four different increases in mean global temperature by the end of the century (1°C, 2°C, 3°C and 4°C, respectively). It also includes additional expenses for the health care system because of climate change and labor hours lost to heat waves by sector in Serbia, as well as drops in the GDP depending on the rise of mean global temperatures, GDP losses due to: expected decrease in water flow and the availability of drinking water, declining cereal yields, reduced power generation and reduced forestry production as the result of global warming.

The Study shows the GHG emission reduction potential up to 2030 and 2050, and monitors the effects on the economy, society and the environment.

The study also focuses on the fact that climate change will affect all population groups and every individual and that their vulnerability depends on a number of things.

The changes in climate parameters already affect GDP, as well as revenues within sectors which are particularly important to the growth and development of the Serbian economy. Moreover, given the expected climate changes, the impact on the GDP of the Republic of Serbia is expected to continue. It is also apparent that the negative impacts of climate change on the GDP are increasing with the rise in mean global temperatures.

The drop in labour productivity can be expected to cause a decrease of the GDP of the Republic of Serbia by USD 171 million by 2040, with a minimal increase in the mean global temperature (10C).

An increase in the mean global temperature of 10C leads to a decrease in the availability of water resources, which results in a GDP drop of USD 8,424 billion by the end of the century, while a decrease in the yield of cereals is also expected to cause losses of USD 121,380 billion by the end of the century. If the mean global temperature rises by 20C, Serbia's GDP will be USD 242,760 billion lower by the end of the century than it would have been without climate change, because of the decline in the production of cereals. A temperature increase of 20C means that the drop in electricity generation can cause the GDP to decrease by USD 8,567 billion by 2040, or by USD 183,875 billion in the second half of the century, which means a total drop in the GDP of USD 192,442 billion and USD 216,247 billion due to a drop in forestry production between 2020 and 2100.

The impact of the mean global temperature rise on the total value of the GDP differs depending on the growth scenario. However, even a minimal increase in the mean global temperature will result in a drop in the GDP as compared to the value that would be achieved without global warming. A reduction in the total GDP relative to the potential GDP without global warming (including all activities affected by the temperature increase) is presented in the table below.

Rise in T by:	2020-2040	2040-2100	2020-2100
1°C	15,465 (1.20%)	328,899 (4.74%)	344,364 (4.19%)
2°C	58,124 (4.53%)	708,193 (10.20%)	766,317 (9.32%)
3°C	59,107 (4.97%)	831,296 (12.88%)	890,403 (11.65%)
4°C	97,536 (6.87%)	1,904,874 (18.46%)	2,002,410 (17.06%)

Table 0.1: Decrease in the total GDP relative to that under no climate change conditions (and including all the activities affected by temperature increase) expressed in billions of USD and %

Limiting the increase of mean global temperature by the end of the century within the scope set by the Paris Agreement (2°C) would lead to a loss of Serbia's GDP of 4.53% by the mid-21st century. That loss could be reduced significantly by investing in adaptation to climate change.

On the other hand, investing in GHG emission reduction could cause a drop in the GDP by as much as **3.4% by 2030 and 3.9% by 2050, and a subsequent job loss of up to 2.1% in 2030 and 2.5% in 2050 as compared to what would happen if nothing was done to reduce GHG emissions.** The fact that the maximum job loss in 2050 would be 0.93% of the losses that would happen without investing in the reduction of GHG emissions justifies those investments.

In 2030, heat waves can be expected to cause a loss of 0.03% of work hours or 1,000 jobs, mostly in the agriculture and construction sectors. Measures to counter the heat waves would lead to the creation of net new jobs. Job losses are expected in the **fossil fuel and agriculture sectors**. Also, a **decrease in the number of employees in large companies and increase in the number of employees in small and medium-sized enterprises is expected. An increase in the number of employees can be expected in forestry sector-related activities**.

Analyses in this study confirm that transformation into a carbon-neutral and climate-adapted society, as well as all other processes, could additionally jeopardise already vulnerable social groups that require special care, as well as a need for timely retraining or an education system adapted to new practices, technologies and sectors in which more employment is expected in future.

Economic development and investment in adapting to and reducing the effects of climate change do not exclude each other. Moreover, they complement each other and offer a greater range of possibilities for the transformation of Serbian society in ongoing transition.

The drafting of this Study confirmed the need for further analyses of possibilities for this transformation and their financial and social justifiability and sustainability.

1. INTRODUCTION

The impact of climate change on the global economy and society are already visible. The expected climate change will result in a series of new negative consequences for society and its development in the future.

Among the most harmful and direct consequences of the climate change the increase of temperature is the most evident one, which affects human health and life, as well as agricultural and energy production, causes forest fires, etc. On the other hand, extreme rainfall, resulting in floods, landslides and rockslides, directly threatens lives and property, as well as the supply and availability of food, water, and energy.

Starting from these direct effects of climate change on life and labour, it is clear that they can cause economic development to slow down, reduce access to health and social care, and increase poverty.

According to World Bank estimates, by 2030, climate change could take more than 100 million people down below the poverty line, primarily as a result of loss of housing, more health problems and declining agricultural yields. The poorest part of the population will certainly be affected the most, so this part of the population is also the most vulnerable to climate change.

In terms of the impact of climate change on the Serbian society and economy, the impact of climate change on sectors and systems is significant, as well as the need to adapt to climate change and reduce greenhouse gas (GHG) emissions. Including those aspects in development planning ensures the sustainability of planning and investments, as well as the competitiveness of the Serbian economy.

Clearly, climate change needs to be included in planning, both in sector development and infrastructure, since the total material damages caused by extreme climate and weather conditions in Serbia exceed 5 billion EUR, in the 2000-2015 period alone, and more than 70% of losses are caused by drought and high temperatures. Flooding is another major cause of losses. In 2014 alone, floods caused enormous damages and recovery requires an estimated EUR 1.35 billion. The damages and losses caused by the May 2014 flooding to those sectors are shown in Table 1.

Sector		Disaster effects (millions of Euros)		
Social sector		Damage	Losses	Total*
		234.6	**7.1**	**241.7**
	Housing	227.3	3.7	230.9
	Education	3.4	0.1	3.5
	Health	3.0	2.7	5.7
	Culture	1.0	0.6	1.6
Production		**516.1**	**547.6**	**1,063.6**
	Agriculture	107.9	120.1	228.0
	Production	56.1	64.9	121.0
	Trade	169.6	55.2	224.8
	Tourism	0.6	1.6	2.2
	Mining and Energy	181.9	305.8	487.7
Infrastructure		**117.3**	**74.8**	**192.1**
	Transportation	96.0	70.4	166.5
	Communications	8.9	1.1	10.0
	Water supply and sanitation	12.4	3.2	15.7
General problems		**17.2**	**10.6**	**27.9**
	Environment	10.6	10.1	20.6
	Governance	6.7	0.6	7.2
Total		**885.2**	**640.1**	**1,525.3**

Table 1[1]: Overview of estimated damage and losses (in millions of Euros)

Climate change parameters in the Republic of Serbia are presented below, as well as the priorities identified to adapt to the changes and ease them at national level, showing the link between climate change and damages and losses, i.e. the socio-economic consequences of climate change in Serbia, the characteristics of climate change.

1 http://www.obnova.gov.rs/uploads/useruploads/Documents/Izvestaj-o-proceni-potreba-za-oporavak-i-obnovu-posledica-poplava.pdf

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2. CLIMATE CHANGE RISKS

2.1. CLIMATE AND CLIMATE CHANGE

2.1.1. Climate characteristics

The climate of Serbia can be described as moderately continental with more or less pronounced local characteristics. All four seasons are distinguishable. Summer is the warmest with a mean seasonal temperature from 21°C to 22°C. July is the hottest month with a mean monthly temperature between 20°C and 23°C while, in the mountains, a mean July temperature is between 13°C and 17°C. The coldest month is January with an average air temperature at most stations from 0°C to 1°C and, in the mountains, to -4.5°C.

On average, annual precipitation totals increase with altitude. Most of Serbia has a continental precipitation regime with higher rainfall in the warmer part of the year. The highest monthly rainfall totals at most stations are recorded in June, which accounts for 12% to 13% of the total annual rainfall on average. February and October have the lowest rainfall.

2.1.2. Observed climate change

According to official data covering the 1950-2017 period, nine of the 10 hottest years were recorded after the year 2000. On average, the hottest year was 2014, followed by 2015. In principle, the number of dry days per year and dry years is constantly increasing.

In the 1998-2017 period, a mean annual temperature in all of Serbia was 0.5 to 1.5°C higher than the values in the 1961-1990 period. In the 2008-2017 period, a mean annual temperature was 1.5°C higher than the values in the 1961-1990 period in most of the territory of Serbia.

The upwards trend in average temperatures in Serbia is three times higher than the mean global temperature rise trend and the mean global land temperature. This leads to the conclusion that:

In terms of temperature rise, Serbia is more affected by climate change than most places on Earth

In the 1998-2017 period, 2014 was the year with the highest precipitation in Serbia with a deviation of about +40%, and the year with the lowest precipitation was 2000 with about -40% as compared to the reference period - 1961-1990. Changes in the redistribution of precipitation during the year were also observed in this period, with a distinct drop in accumulated rainfall during the summer season (June-August).

Changes in temperature are increasingly pronounced and are the cause of more frequent and more intensive heat waves and extreme events. The lowlands, especially in central and southern parts of Serbia, are affected the most by extreme temperatures.

The number of extreme hot waves in the period of 1961-1990 was 1 per decade while, under the current climate conditions, they occur each year or even more than once a year.

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Rainfall deficit, accompanied by an increase in intensive rainfall, has been observed during the summer. Dry periods and extreme temperatures usually coincide with the summer period, which increases the magnitude of the impact.

The number of days with heavy precipitation is constantly increasing. During the 2008-2017 period, on average, the number of days with precipitation of over 40mm was twice higher in the major part of the territory of Serbia, with the exception of southern areas where a five-fold increase was recorded.

In addition, climate indices have shown a significant increase over the years, exacerbating the negative consequences for the country's society and economy.

CLIMATE INDICES	CHANGE
Number of frost days	- 20-30 days
Number of ice days	- 3 to 9 days
Number of summer days	+ 20-30 days
Number of tropical days	+ 20-30 days
Number of days with heat waves	+ 30 days
Number of days with extreme heat waves	+ 2-4/per annum

Table 2[2]: Change of climate indicates in the period 2008-2017 as compared to 1961-1990

2.1.3. Climate change scenarios

The temperature will continue to rise in the future as well (according to the RCP8.5 and RCP4.5 scenarios) as compared to the 1986-2005 reference period. According to the RCP4.5 scenario, the mean annual temperature for the territory of Serbia, on average, will increase by 0.5°C in the 2016 – 2035 period, it will reach the level of 1.5°C in the 2046-2065 period and, by the end of the century (2081- 2100), it will be at 2°C as compared to the reference period. The average annual temperature (according to RCP8.5) will increase by 1°C in the 2016 – 2035 period, it will reach 2°C in the 2046 - 2065 period and, by the end of the century (2081 - 2100), the mean annual temperature should be higher by as much as 4.3°C compared to the reference period.

Changes in mean seasonal temperatures indicate that the increase in temperatures in the first half of the century will be faster during the summers and also faster during the winters in the second half of the century, and higher than the anomalies in the first half of the century.

Precipitation decreases in summer and increases in the other seasons.

[2] http://www.klimatskepromene.rs/wp-content/uploads/2019/04/Osmotrene-promene-klime-Final_compressed.pdf

Extreme trends continue to have the same signature and intensity. Extreme heat waves, which are by definition rare events (once in every 10 years in the 1986-2005 period), will occur several times a year and, by the end of the century, seven times a year on average.

The length of the vegetation period will be significantly longer, in lowlands by up to two months and, in some parts of the country, even by up to three months.

Heavy precipitation will increase over time. By the end of the century, heavy precipitation during the days with extremely heavy precipitation (over 40mm) will be, on average, 40% to 60% higher (RCP4.5 and RCP8.5).

2.2. CLIMATE CHANGE IMPACTS

2.2.1. TEMPERATURE INCREASE

Analyses at international and European Union level show that climate change has already had a multiple negative impact on the development of the society and the economy as a whole. Damages and losses in Serbia caused by natural disasters and natural catastrophes, in the previous period [3], confirm that climate change/global warming is a significant risk factor for further development. The future level of risk depends to a large extent on the increase in the mean global temperature, which cannot be significantly influenced by Serbia individually. However, those losses will undoubtedly be much higher in the absence of measures to adapt to the situation.

The drop in the GDP due to global warming caused by climate change, starting from four different IPCC Scenarios (RCP2.6, RCP4.5, RCP6 and RCP8.5), which mean four different increases in mean global temperatures by the end of the century (1°C, 2°C, 3°C and 4°C, respectively), and the OECD GDP projections are shown in Table 3.

[3] http://www.obnova.gov.rs/uploads/useruploads/Documents/Izvestaj-o-proceni-potreba-za-oporavak-i-obnovu-posledica-poplava.pdf

	2020	2030	2040	2050	2060	2070	2080	2090	2100
Scenario 1 (RCP2.6)									
GDP growth rate without climate change (% per annum)	2.979	2.945	2.281	1.751	1.307	0.674	0.341	0.021	-0.326
Change in GDP due to climate change (% per annum)	-0.089	-0.089	-0.089	-0.089	-0.089	-0.089	-0.089	-0.089	-0.089
GDP growth rate with climate change (% per annum)	2.890	2.856	2.192	1.662	1.218	0.585	0.252	-0.068	-0.415
Potential GDP (Billion USD per annum)	45.109	60.777	78.565	95.376	111.035	121.921	128.084	130.223	128.028
GDP change due to climate change (billion USD per year)	-0.117	-0.679	-1.549	-2.694	-4.078	-5.509	-6.867	-8.072	-9.002
GDP at an increase of T of 10C (billion USD per year)	44.992	60.097	77.016	92.682	106.956	116.412	121.217	122.151	119.025
Scenario 2 (RCP4.5)									
GDP growth rate without climate change (% per annum)	2.979	2.945	2.281	1.751	1.307	0.674	0.341	0.021	-0.326
Change in GDP due to climate change (% per annum)	-0.150	-0.150	-0.150	-0.150	-0.150	-0.150	-0.150	-0.150	-0.150
GDP growth rate with climate change (% per annum)	2.829	2.795	2.131	1.601	1.157	0.524	0.191	-0.129	-0.476
Potential GDP (Billion USD per annum)	45.109	60.777	78.565	95.376	111.035	121.921	128.084	130.223	128.028
GDP change due to climate change (billion USD per year)	-1.345	-2.665	-4.537	-6.821	-9.454	-12.027	-14.347	-16.306	-17.703
GDP at an increase of T of 20C (billion USD per year)	43.764	58.111	74.029	88.555	101.581	109.894	113.737	113.917	110.325

Scenario 3 (RCP6)									
GDP growth rate without climate change (% per annum)	2.685	2.084	1.732	1.666	1.553	1.206	0.990	0.783	0.619
Change in GDP due to climate change (% per annum)	-0.205	-0.205	-0.205	-0.205	-0.205	-0.205	-0.205	-0.205	-0.205
GDP growth rate with climate change (% per annum)	2.480	1.879	1.527	1.461	1.348	1.001	0.785	0.578	0.414
Potential GDP (Billion USD per annum)	44.789	56.689	68.302	80.615	94.839	108.455	120.901	131.895	141.319
GDP change due to climate change (billion USD per year)	-1.301	-2.738	-4.596	-6.927	-9.881	-13.247	-16.900	-20.722	-24.606
GDP at an increase of T of 30C (billion USD per year)	43.488	53.950	63.706	73.689	84.958	95.208	104.000	111.173	116.714
Scenario 4 (RCP8.5)									
GDP growth rate without climate change (% per annum)	3.458	3.905	3.129	2.498	1.980	1.267	0.872	0.561	0.233
Change in GDP due to climate change (% per annum)	-0.318	-0.318	-0.318	-0.318	-0.318	-0.318	-0.318	-0.318	-0.318
GDP growth rate with climate change (% per annum)	3.140	3.587	2.811	2.180	1.662	0.949	0.554	0.243	-0.085
Potential GDP (Billion USD per annum)	45.637	66.380	93.584	122.724	153.191	179.015	198.588	212.915	221.162
GDP change due to climate change (billion USD per year)	-1.642	-4.321	-8.744	-14.862	-22.681	-31.213	-39.713	-47.882	-55.090
GDP at an increase of T of 40C (billion USD per year)	43.995	62.059	84.840	107.862	130.510	147.802	158.875	165.033	166.072

Table 3: Estimation of GDP losses by 2100 depending on the global warming scenario

The negative impact of climate change on GDP obviously increases with the rise in mean global temperatures over time. Given the fact that projections of a 10C temperature rise have been surpassed and that it is hardly feasible that the an increase in mean global temperatures will drop back to that level by the end of the century, we can expect GDP drops due to climate change ranging from 0.150% to 0.318 % per annum. This is equivalent to a loss of about USD 7 billion to about USD 15 billion a year by the mid-21st century. By comparison, Serbia's GDP in 2018 was USD 50.5 billion, which is USD 7,200 per capita, while damages and losses from natural disasters, in the 2000-2015 period, amounted to about USD 4.5 billion. In addition, climate change evidently causes a drop in GDP growth rates (about 1.5 times in the 2020-2050 period). This further confirms the justification for investments into measures to adapt to climate change (Figure 1).

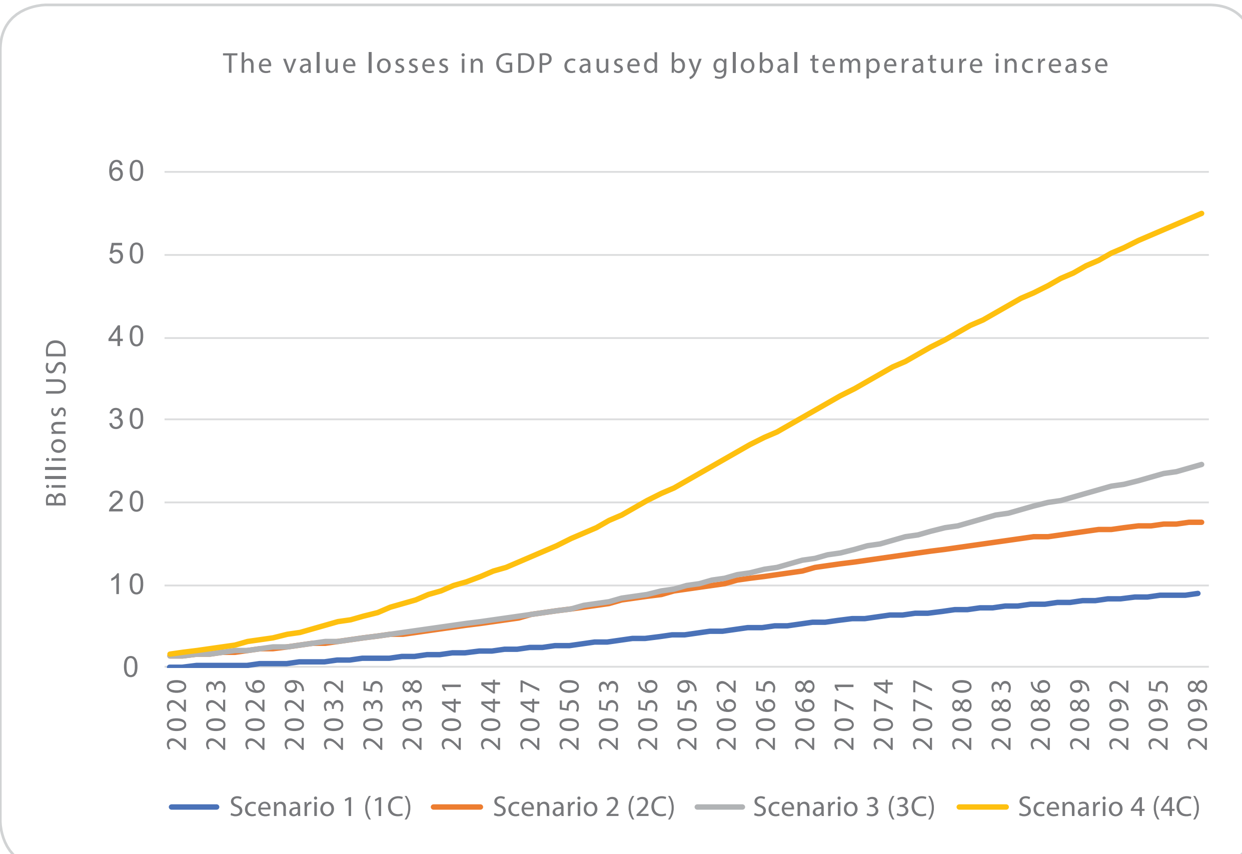

Figure 1: Projections of GDP losses due to mean global temperature increase (in billion USD)

A look at the impact of climate change through GDP changes shows that they are expected to affect the poor more than the rich. Declining GDP can mean a drop in employment and, consequently, an increase in the number of people living below the poverty line, in the absence of timely response or adaptation to it.

Given that the lowest average net wage is in the Šumadija and Western Serbia regions, it is expected that the individual impact will be the highest particularly in this region, but also in the region of South and East Serbia, which has the lowest employment. On the other hand, since the Vojvodina region produces the most vulnerable agricultural crops and varieties (maize and wheat),[4] it can be expected that the degree of impact on this region will increase over time.

[4] https://data.stat.gov.rs/?caller=SDDB

On the other hand, decreasing GDP increases the population's vulnerability by reducing its ability to adapt to climate change as well. This will further increase the pressure on economic development and the welfare of society if, in addition to personal, there is a lack of timely recognition of the problem and an adequate response to it by the government. In support of the need for response is the global assessment that, if there is no response, the expected loss of GDP by 2100 may be 2-10%, while the implementation of policies in both adapting and mitigation can reduce the GDP by 1-3%.

2.2.2. IMPACTS ON HEALTH

Heat stress is one of the most negative effects of climate change and leads to increased mortality and diseases (respiratory, cardiovascular, renal failure, etc.), especially among the **elderly and the parts of the population suffering from chronic diseases.** The population living in areas without and with little green areas, especially **urban environments,** are especially vulnerable. At the same time, an effective adaptation measure, involving green infrastructure, has had added positive effects on air quality and health in general.

An increase in the number of heat waves and the number of heat wave days has been observed in Europe, including Serbia. For example, in 2007, during the heat wave in Serbia, 90% of the total number of deaths were people over the age of 75, which increased the mortality rate of that part of the population by 76%. The largest number of people who died were cardiovascular patients, but the largest increase was observed in diabetics (286%), renal (200%), and respiratory (73%) patients and patients with nervous system diseases (67%). **The mortality rate of the female population was twice that of the male population (54% vs. 23%)[5].**

Given that data and the rising mortality rate in Serbia (13.9 to 14.8 deaths per 1,000), predominantly among patients with circulatory and neoplasm related diseases, both in women and men, we can assume, but not claim with certainty, that a part of this increase was caused by climate change. Expectations in this context, as well as projections on the need for investment in the health care system, are even more pronounced if we take into consideration the expected spreading of vectors (e.g. mosquitoes) and diseases from tropical regions to Serbia, based on analyses drafted for Europe as a whole. The introduction of those diseases has already been observed in the previous period. Therefore, climate change can have a significant negative impact on the stability of Serbia's health care system, due to an increase in cardiovascular and respiratory diseases and associated costs, including those for hospitalisation. In addition to these direct costs in prevention or treatment, the intensification of climate extremes (specifically heat waves) is expected to increase the number of calls to emergency services and their interventions. This results in the need for additional numbers of staff, as well as for support tools and equipment to respond appropriately. Providing for these needs leads to an additional increase in costs for the health care system, or an increased mortality rate in the event of their absence.

Estimates show that the total heat-stress losses could reach USD 2.4 billion by 2030 globally, if the global mean temperature increases by 1.50C by the end of the century. If that happens, the share of health care expenditure in the GDP will increase by 0.04%, on average. In case of an increase in mean global temperatures in excess of this scenario, the losses will certainly be even greater.

In the case of Serbia, additional expenditures for the health care system caused by climate change in the 2020-2040, 2040-2100 and 2020-2100 periods were calculated based on four different IPCC scenarios (RCP2.6, RCP4.5, RCP6 and RCP8.5). Generally, additional expenditures are caused by increased investments in prevention and protection from diseases, increases in the number of employees and the like. (Table 4).

5 http://www.klimatskepromene.rs/wp-content/uploads/2017/05/Klimatske-promene-i-zdravlje-PRESS.pdf

Increase of T by:	2020-2040	2040-2100	2020-2100
1°C	0.343	1.851	2.194
2°C	0.685	3.703	4.388
3°C	0.951	5.163	6.115
4°C	1.513	11.010	12.523

Table 4: **Additional expenditures for the health care system of Serbia due to climate change (billion USD)**

In case of a mean global temperature increase of 4^{0}C, expenditures for the Serbian health care system, at the end of the century, will be 5.7 times higher than in the case of an optimistic global GHG emission reduction scenario (1^{0}C temperature increase), while this ratio in the near future (2020-2040) will be 4.4. An increase of mean global temperatures of 2^{0}C will increase costs for Serbia's health care system by USD 3,703 billion or 0.05% of the expected compared to those without climate change.

Also, it should be noted that, for example, in 2012, the costs of health care systems in the 28 EU member states averaged 8.7% of the GDP (the OECD, 2014) and, in Europe region, 8–10% of the GDP, according to the WHO [6]. In 2015, health care system costs in Serbia totalled 9.4% of the GDP, and the previously analysed impact of climate change based on scenarios (1 to 4^{0}C) would increase this share to 9.62%, 9.64%, 9.66% and 9.72% of GDP in 2040.

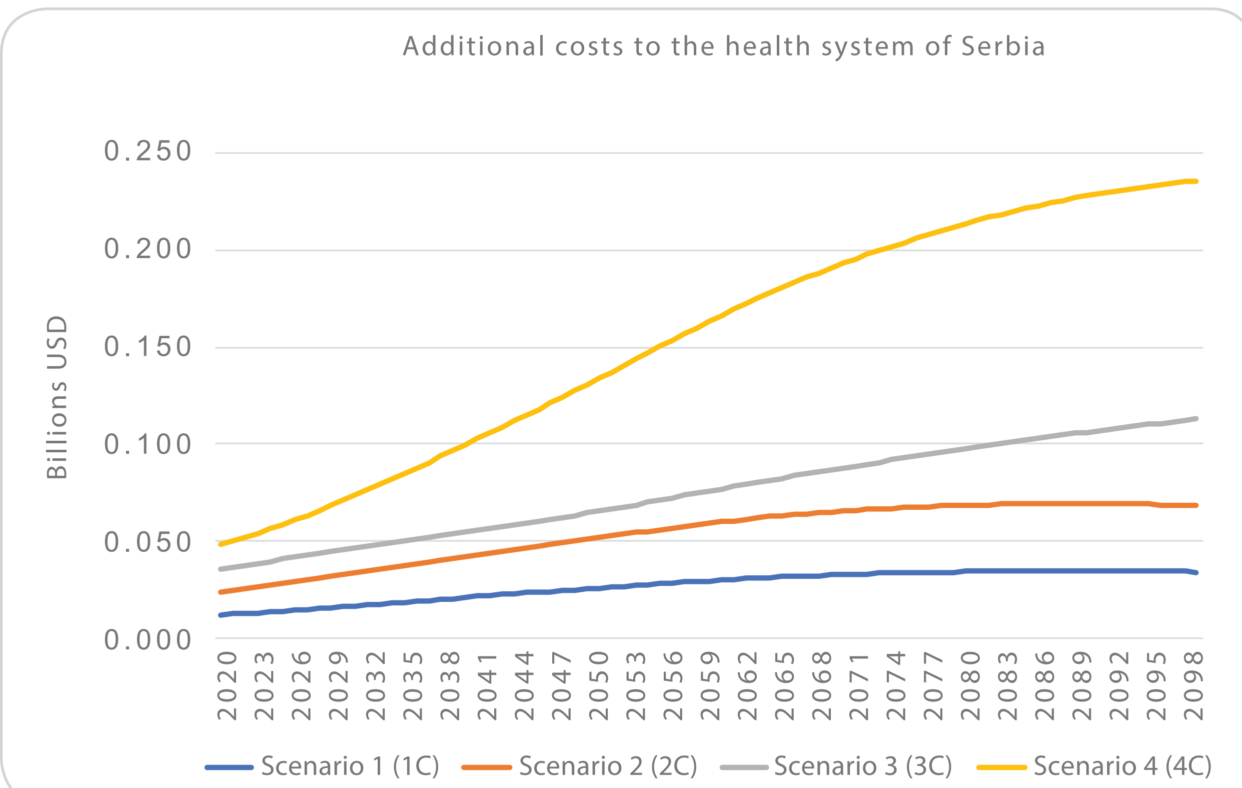

Figure 2: **Projections of additional costs to the health care system of Serbia (billion USD)**

[6] WHO Regional Office for Europe, 2016

The elderly population, patients with chronic ailments and small children are most vulnerable to the impacts of climate change in the health sector, including heat stress. On the other hand, since climate change affects the security of water supply and energy and food supply, the quality of food and adequate housing, it has an additional indirect impact on health and Serbia's health care system and poses a significant risk to their stability. That impact leads to further increases in health care costs and reduced labour ability.

2.2.3. IMPACTS ON LABOR PRODUCTIVITY

Heat stress is increasingly becoming one of the main factors in labour efficiency and productivity both in Serbia and globally. Increasingly, heat waves are the cause of injuries and diseases as well as a decline in work ability and productivity.

Heat waves and rising mean temperatures do not affect all occupations and types of jobs equally. The jobs that require a lot of physical activity and/or prolonged time spent outdoors are particularly affected. **Farmers and construction workers** are expected to be particularly affected by climate change. They are considered to be particularly vulnerable groups in terms of the impact of climate change.

If temperatures increase further, physically less demanding jobs and occupations, such as **office and indoor jobs** (teachers, doctors, salespersons, etc.), will also become vulnerable to climate change. In this case, the pressure is mostly of psychological, especially when working in non-air-conditioned rooms. It is clear that a scenario with a higher increase of mean global temperatures would have a more catastrophic impact on health and lives in general.

It is difficult to determine the vulnerability of particular occupations to climate change, since it also depends greatly on personal temperature tolerance thresholds. What is certain is that **older** workers have a lower physiological resistance to heat and thereby lower resilience to climate change. At the same time, given that the older population is beginning to make up an increasing portion of Serbia's workforce, the vulnerability of Serbian society to climate change is also clear.

The impact of heat waves on the population, in addition to serious health problems, is reflected on labour productivity among the population of working age. Based on ILO analyses[7], by 2030, more than 2% of total working hours will be lost globally, due to excessive temperatures which will make it impossible to work or will slow down labour considerably. In Europe, the greatest drop in labour productivity can be expected in the southern parts of the continent, including Serbia.

Estimates are that, in 1995, 0.01% of working hours were lost on average in the countries of the region due to heat stress (equivalent to the loss of 6,300 jobs) and that, in 2030, 0.02% (around 14,400 jobs) will be lost. Table 4 shows the percentages of working hours lost to heat stress in different sectors and the economy as a whole, in the countries of Southern Europe. The estimates assume that agricultural and construction work take place in the shade and an increase in mean global temperatures of 1.5 °C by the end of the century.[8]

[7] Source: The ILO estimates based on data from the ILOSTAT database and the HadGEM2 and GFDL-ESM2M climate models.

[8] Source: The ILO estimates based on data from the ILOSTAT database and the HadGEM2 and GFDL-ESM2M climate models.

Country	1995						2030					
	Agriculture (in shade) (%)	Industry (%)	Construction (in shade) (%)	Services (%)	Total (%)	Total (thousand full-time jobs)°	Agriculture (in shade) (%)	Industry (%)	Construction (in shade) (%)	Services (%)	Total (%)	Total (thousand full-time jobs)
Albania	0.05	0.01	0.05	0	**0.04**	**0.4**	0.14	0.05	0.14	0	**0.07**	**0.7**
Bosnia and Herzegovina	0.02	0	0.02	0	**0.01**	**0.1**	0.04	0.01	0.04	0	**0.01**	**0.1**
Croatia	0.03	0.01	0.03	0	**0.01**	**0.2**	0.07	0.02	0.07	0	**0.02**	**0.2**
Greece	0.03	0	0.03	0	**0.01**	**0.4**	0.08	0.02	0.08	0	**0,01**	**0.7**
Italy	0.05	0.01	0.05	0	**0.01**	**2.0**	0.10	0.03	0.10	0	**0.01**	**3.6**
Malta	0.02	0	0.02	0	**0**	**0.0**	0.06	0	0.06	0	**0**	**0.0**
Montenegro	0.02	0	0.02	0	**0**	**0.0**	0.04	0.01	0.04	0	**0.01**	**0.0**
North Macedonia	0.01	0	0.01	0	**0**	**0.0**	0.03	0.01	0.03	0	**0.01**	**0.1**
Portugal	0.01	0	0.01	0	**0**	**0.1**	0.03	0	0.03	0	**0.01**	**0.2**
Serbia	0.04	0.01	0.04	0	**0.01**	**0.4**	0.09	0.03	0.09	0	**0.03**	**1.0**
Slovenia	0.01	0	0.01	0	**0**	**0.0**	0.02	0	0.02	0	**0**	**0.0**
Spain	0.08	0.02	0.08	0	**0.02**	**2.7**	0.23	0.08	0.23	0.01	**0.03**	**7.7**
Southern Europe	**0.04**	**0.01**	**0.04**	**0**	**0.01**	**6.3**	**0.11**	**0.04**	**0.11**	**0**	**0.02**	**14.4**

Table 5: Working hours lost due to heat stress, by sector and by country, Southern Europe, 1995 and 2030 (projections).[9]

For Serbia, the same analyses[10] show that a loss of 0.03% of working hours or 1,000 jobs due to heat waves can be expected in 2030. Hours of work lost due to heat waves by sector in Serbia in 1995 and 2030 are shown below (Table 6):

Sector	1995	2030
Agriculture (in shade) (%)	**0.04**	**0.09**
Industry (%)	**0.0**	**0.03**
Construction (in shade) (%)	**0.04**	**0.09**
Services (%)	**0**	**0**
Total (%)	**0.01**	**0.03**
Total (in thousands of jobs)	**0.4**	**1.0**

Table 6: Working hours lost in Serbia due to heat stress by sector

9 Source: "Working on a warmer planet: The impact of heat stress on labour productivity and decent work"

10 http://www.obnova.gov.rs/uploads/useruploads/Document/Izvestaj-o-proceni-potreba-za-oporavak-i-obnovu-posledica-poplava.pdf

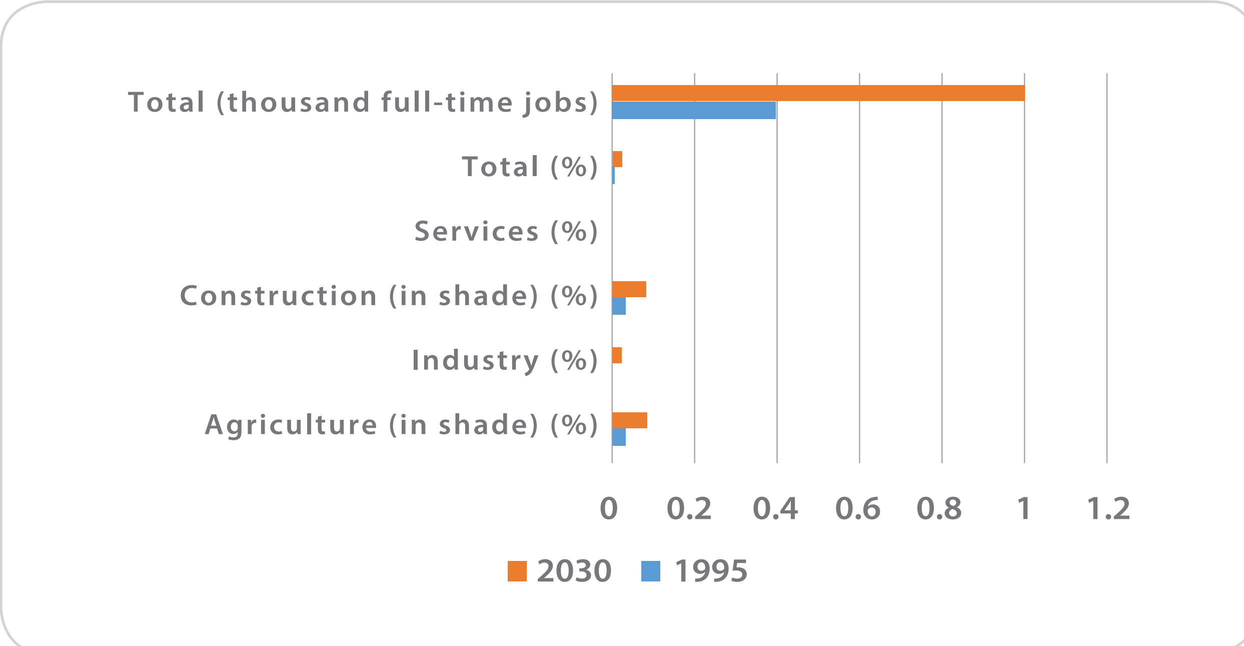

Figure 3: **Comparison of lost working hours per sector in Serbia, in 1995 and 2030**

The decrease in working hours certainly causes a drop in the GDP. Research shows that, as a result of the rise in the mean global temperatures of 1.5°C, the GDP can drop by 0.02% (most often due to a drop in labour productivity in agriculture, construction and tourism).

At the same time, the drops in the GDP depending on the rise in mean global temperatures for the periods: 2020-2040, 2040-2100 and 2020-2100 are shown in Table 7.

Increase of T by:	2020-2040	2040-2100	2020-2100
1°C	0.171	0.926	1.097
2°C	0.343	1.851	2.194
3°C	0.476	2.582	3.057
4°C	0.757	5.505	6.261

Table 7: **GDP losses due to reduced labour productivity (billion USD)**

Due to the decrease in labour productivity, Serbia's GDP will be lower by USD 171 million than in the case of no climate change, to wit already in the immediate future (2020 - 2040) and with minimal change in the mean global temperature (10C). Losses rise to USD 1,097 billion, or USD 6 billion 261 million by the end of the century, with global warming rising to 4°C. If the Paris Agreement is not fulfilled, GDP losses will increase at least 1.4 times in the immediate future. GDP losses due to reduced labour productivity will rise by 0.01%, 0.03%, 0.04% and 0.05% with temperature increase of 10C, 20C, 30C and 40C respectively, by the end of the century.

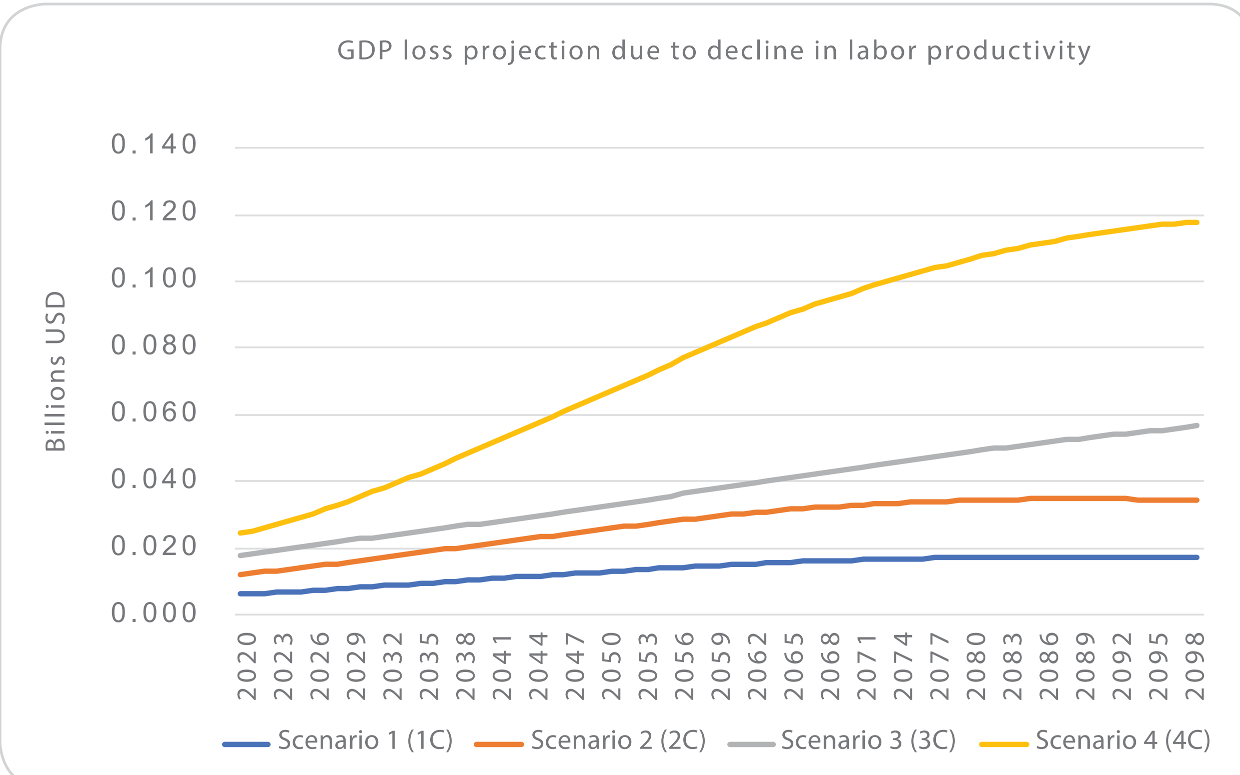

Figure 4: **GDP loss projection due to decline in labour productivity (billion USD)**

Finally, it should be kept in mind that natural disasters and natural catastrophes caused by climate change can damage infrastructure, affecting work efficiency and reducing the availability of health and social care. Given that there are millions of people on the planet without adequate social protection, the increase in the intensity and frequency of natural disasters could cause that number to be even higher.

Although climate change may have impact on increased unemployment in one, it also opens up job opportunities in another "climate-oriented" sector. In other words, we should bear in mind that

Job losses in one sector do not necessarily mean absolute job losses

2.2.4. WATER LOSSES

A negative trend in river flows has been observed in Serbia. The long-term trend in domestic rivers was about -30%/100 years, while the spatial distribution varies. The long-term trend for the Danube and Sava rivers in the territory of Serbia is negative and it is about -10%/100 years.

Future climate scenarios indicate a further decline in flows, especially in the 2071-2100 period. In terms of the magnitude of the changes, the basins of the Kolubara River in central Serbia and the Toplica River in southern Serbia will be the most susceptible to change, with up to -40% in the 2071-2100 period compared to the 1961-1990 period. For the foreseeable future, flow changes are within the range of a few percent, rarely exceeding 10%.[11] Thus, in terms of the impact of climate change on waters, it can be expected that areas of **central and southern Serbi**a will be the most affected, as well as the **sectors and individuals whose earnings depend on the water sector** (agriculture for example).

There is a declining trend in groundwater availability, but lower than in surface waters. This is especially true of the deep aquifers. We should remember that water supply in most of Serbia, is linked to ground waters.

Declining water quality can be an additional cause of climate change pressures on the health of the population and on health care system costs, as well as on economic development in general. The effects of climate change on water resources are reflected in a decrease in the quality and availability of water: to households, agricultural production and industry. These consequences can cause a drop in the GDP, both through the provision of water through purchases and the increase in prices of water, food and energy.

Additional pressure on the GDP can be caused by unsustainable and unprofitable investments in irrigation systems, as an adaptation measure. In other words, when planning irrigation and the construction of systems, climate change projections need to be included along with sector vulnerability to climate change.

The water collection, treatment and distribution sector accounts for 0.5% of Serbia's total GDP. Given the expected decrease in water flow and the availability of drinking water in Serbia due to climate change, GDP losses are also expected (Table 8, Figure 5).

Increase of T by:	2020-2040	2040-2100	2020-2100
10 C	0.425 (0.03%)	8.424 (0.12%)	8.849 (0.11%)
20 C	0.850 (0.07%)	16.849 (0.24%)	17.698 (0.22%)
30 C	1.156 (0.10%)	23.721 (0.37%)	24.877 (0.33%)
40 C	1.922 (0.14%)	50.869 (0.49%)	52.792 (0.45%)

Table 8: GDP losses due to decreased availability of drinking water (billion USD)

[11] The Second National Communication of the Republic of Serbia to the UNFCCC, http://www.klimatskepromene.rs/wp-content/uploads/2017/12/Drugi-izvestaj-o-promeni-klime-SNC_Srbija.pdf

The direct impact of water loss on Serbia's GDP is increasing with time and with rising global temperatures. This growth is reflected in losses ranging from USD 0.425 to USD 52.792 billion. Already, a rise in temperature of 20C leads to a growth in GDP losses of USD 17.698 billion by the end of the century. With the increase of the mean global temperature, the losses increase significantly.

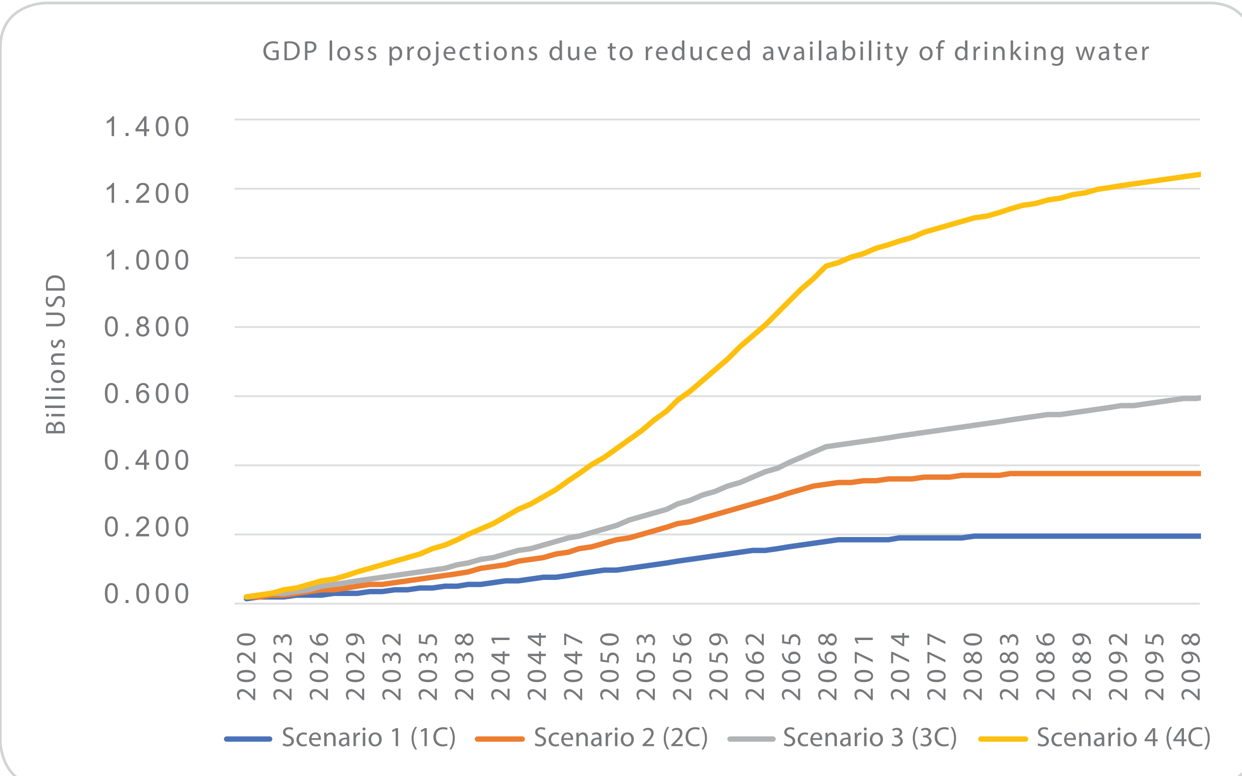

Figure 5: GDP loss projections due to reduced availability of drinking water (billion USD)

GDP losses are one of the reasons why we need to adapt to climate change and an indicator that adaptation does not necessarily have to increase investment costs and have a negative impact on GDP growth. In fact, the key adaptation measures for the water sector include measures that have already been defined as necessary to reduce the risk of natural disasters and to improve water management. Their implementation, in addition to the need to include climate projections in planning and implementation, does not have to represent an additional requirement, i.e. cause a negative impact on GDP growth.

Reduced water availability can also have an impact on agricultural products and electricity prices, which can directly affect the **poorer part of the population.** The scarcity of water will certainly endanger the population in rural areas, through its negative impact on agricultural production. At the same time, the floods pose the greatest risk to the **elderly population, children, pregnant women and people with disabilities.** In other words, this natural disaster, as well as heat waves, can have a particularly negative impact on the so-called **socially isolated population groups**, which by definition include: the elderly, patients with chronic ailments and the handicapped, people depending on social aid, people living alone, members of ethnic minorities, homeless people, as well as residents of remote and poorly connected regions in terms of infrastructure.

2.2.5. DROP IN AGRICULTURAL PRODUCTION

Rising temperatures and more frequent extreme events can lead to a significant decrease in yields and an increase in yield fluctuation from year to year in Serbia. Climate change will most affect maize yields. Unless adaptation measures are implemented by 2030, maize yields are expected to decrease as much as up to 58% under non-irrigated conditions. Wheat yield will decrease as much as up to 16% in the period by 2030. Sugar production per hectare of sugar beet is also expected to decrease and, by 2100, soybean and grapevine production is expected to decrease, too.

At the same time, a decrease in yield means a decrease in income, especially in case of **small agricultural producers and seasonal workers.** However, the impact on the entire population cannot be ruled out through decrease of the availability of food, and especially on the **poorer part of the population** due to the possible rise in food prices.

Cereal production accounts for about 50% of the total agricultural production in Serbia and has a share of 6.3% in Serbia's total GDP. Thus, any reduction in yields, especially cereals, has a noticeable impact on GDP of the Republic of Serbia, i.e. its projections in the future (Table 9).

Increase of T by:	2020-2040	2040-2100	2020-2100
1^0 C	6,025 (0.47%)	115,355 (1.66%)	121,380 (1.48%)
2^0 C	12,050 (0.94%)	230,710 (3.32%)	242,760 (2.95%)
3^0 C	16,368 (1.38%)	324,683 (5.03%)	341,051 (4.46%)
4^0 C	27,305 (1.92%)	696,126 (6.74%)	723,430 (6.16%)

Table 9: GDP losses due to declining cereal yields (billion USD)

In case of an increase in the mean global temperature by 2^{0}C, Serbia's GDP will be USD 242,760 billion less by the end of the century than the projected one without climate change, and a double temperature increase (40C) will lead to three times higher GDP losses.

Differences in GDP losses depending on the reduced agricultural production of cereals due to the rise of the mean global temperature are shown in Figure 6 below.

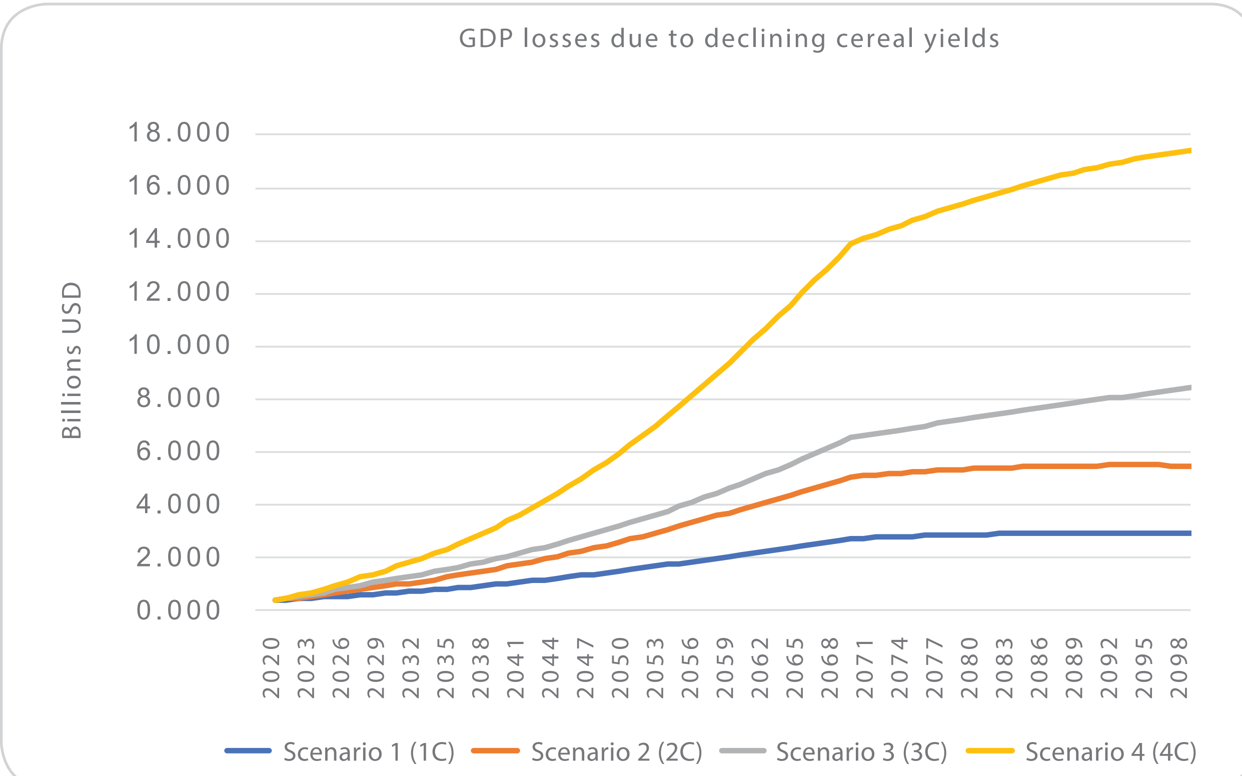

Figure 6: Projections of GDP losses due to declining production of cereals (billion USD)

To understand the impact of climate change on Serbian society, it is important to note that an increase in the mean global temperatures of not more than 10C and in the 1994 and later period, for 43% of the total area of agricultural land, direct damage caused by lower yields amounted to USD 4.6 billion. Thereby the direct losses resulting from the decline in maize yields alone were USD 2.2 billion. Moreover, the damages and losses caused by climate change (drought, primarily) on fruit production were not included in this estimate, and that would significantly increase the damages. In the future, damages and losses could be even greater because of a lack of water for irrigation and lower quality and availability of land, but also the damages caused by ice days and storms by the middle of the century.

In addition to irrigation, the development and application of new crops more adaptable to climate conditions would be a significant adaptation measure. This requires research and development of new plant species, which is also a sector in which new jobs are being created. New crops require farmers to have new knowledge, which may be difficult to access, especially for low-income farmers in remote mountainous areas, the elderly and the poor population. In some parts of the country it will be almost impossible to continue agricultural production, which can lead to migration, especially to urban areas.

Evidently, climate change can significantly affect production and the availability of food. Global estimates indicate that a decrease in yields by 2050 could cause an increase of famine by 10% to 20%, as compared to the absence of climate change[12]. In other words, by 2060, prices of some of the key cereals, such as maize, wheat and rice, could grow by as much as 150%. From this, it is clear that the impact of climate change on the agriculture sector has both a direct impact on the rural population and an indirect impact on the urban population. Certainly, in this case as well, the greatest burden of climate change is borne by the poor population, and population growth below the poverty line can also be expected.

In terms of adaptation, the same is true as in the case of water, key measures are actually the measures already foreseen to reduce the risk of natural disasters and improve agricultural production. Consequently, the implementation of adaptation measures should not significantly change investments in the agriculture sector or at least the profit that the population would ultimately benefit from those investments.

2.2.6. REDUCED PRODUCTION AND INCREASE IN ENERGY PRICES

Climate change is one of the main factors behind seasonal changes in the demand for energy and production. Rising temperatures in the summer are driving up the demand for electricity to cool households, as well as in the service sector and offices. A change like that in the demand for energy will affect the stability of energy production and will lead to a change in the distribution of production compared to the current situation. On the other hand, energy sources also change in relation to the standard share in production. This could further jeopardize the stability of power generation and increase the price of electricity, as well as the quality of life of Serbian society as a whole.

For example, the year 2013 was one of the warmest years after the year 2000. The mean annual temperature was 13.6°C, 1.8°C higher than the 120-year average. The largest deviations in temperature were in August (3.3°C) and in the fourth quarter of the year (October and November were warmer by about 3°C and December by about 1°C). Viewed at annual level, the consumption of electricity by consumers was by 2% **or about 700 GWh lower** than usual (due to warmer weather). In the fourth, warmest quarter alone, consumption was **down by about 470 GWh.**[13]

The impact of climate change on electricity generation in Serbia is also reflected in reduced production in **hydro power plants,** which produce about 20% of the total. In the **first half** of 2013, inflows were higher than the average by 30% (into the Danube and the Drina), which **does not favour power generation.** On the other hand, inflows **into the Danube were 12% lower than the average in the fourth quarter and 35% lower into the Drina**. The annual inflow into the Danube was 10.9% higher than the average. In recent years, the maximum and minimum inflow ratios have been increasing both into the Danube and the Drina, not favouring power generation.

For the same reasons (change in climate parameters), electricity consumption in Serbia increased in July 2012, with **peak consumption shifting from evening to afternoon hours.** At daily peaks, between 12 noon and 2:00 pm, 600 megawatts of power were required for air-conditioners alone, which is equal to the power produced by the RHP "Bajina Bašta" hydropower plant. The continuing drought caused a drop in power **generation at run-of-river hydropower plants,** and so the negative balance was offset by the greater operation of pumped-storage hydropower plants. Due to the difficult hydrological situation and reduced inflows into hydropower plants since August 15 the **most expensive** sources have been included in power generation – the „Panonian power plants". Their last engagement in this month was in 2007. The natural inflow into the Drina was 47 cubic meters per second, which is seven times less than the average inflow of 330 cubic meters per second.

[12] How to Feed the World in 2050, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

[13] Yearly report 2013, Electropower company Serbia

Estimates show that, between 2000 and 2011, electricity generation in Serbia increased by 15% and consumption by 13.1%. Due to the uneven demand, the Electric Power Industry of Serbia could not fully meet demand in each year, and in 2012, for example, electricity procurement was 38% higher than planned, with most of that procurement due to high consumption in the first quarter (77%).

Electricity generation accounts for 3.4% of Serbia's total GDP. Estimates indicate that, due to a 3°C rise in temperatures and global warming, annual electricity generation will be lower on average, by 0.115% by 2037, 0.249% by 2067 and 0.740% after 2067. In line with those assumptions and the data on the share of electricity generation in the GDP, the economic losses resulting from the drop in power generation were recalculated for the scenarios used in this Study (Table 10).

Increase of T by:	2020-2040	2040-2100	2020-2100
1^0 C	4,283 (0.17%)	91,938 (0.66%)	96,221 (0.58%)
2^0 C	8,567 (0.33%)	183,875 (1.32%)	192,442 (1.17%)
3^0 C	11,632 (0.49%)	258,952 (2.01%)	270,584 (1.77%)
4^0 C	19,421 (0.68%)	555,430 (2.69%)	574,852 (2.45%)

Table 10: GDP losses due to reduced power generation (billion USD)

With a temperature rise of 20C and a decline in electricity generation, The GDP can be expected to drop by USD 8.567 billion by 2040, or by USD 183,875 billion in the second half of the century, leading to an overall decrease in the GDP in the 2020-2100 period by USD 192,442 billion. This decrease will be twice as large in the first half of the century, as well as by the end of the century compared to GDP losses that can be expected in the event of a 10C temperature rise.

Differences in GDP loss trends according to different scenarios of mean global temperature increase relative to the expected GDP without climate change are shown in Figure 7.

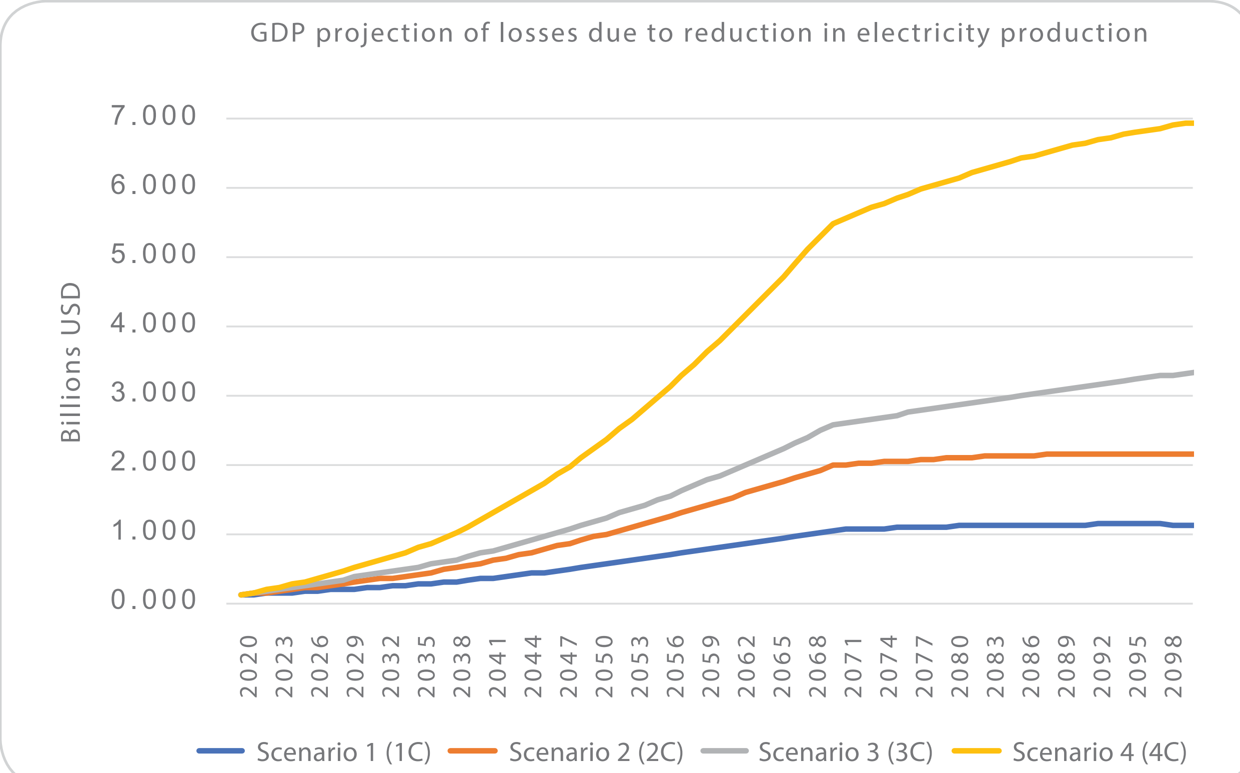

Figure 7: Projection of GDP losses due to reduction in electricity generation (billion USD)

In addition to droughts and rising temperatures, the system and the sustainability of electricity generation in Serbia is also greatly affected by floods. The 2014 flooding inflicted USD 197 million in damages to the energy sector.

The entire impact on the energy sector can lead to a significant increase in electricity prices, especially if the development of the energy sector is not planned based on climate change principles. In addition, the rise in energy prices could also be affected by its inevitable transformation into a carbon-neutral sector. What should be kept in mind is that this transformation is a long-term process, that its sustainable planning can lead to smaller energy price increases than in the case of "no action" (details are presented in Chapter 4 of this Study), and will certainly have an impact on a drop in the costs to the health care system and decrease in the number of patients suffering from respiratory and allergic diseases, but also on mortality, especially in areas where the population is constantly exposed to emissions from energy generation from fossil fuels.

In Serbia, this transformation would actually mean the implementation of the EU Emissions Trading System. Energy production plants in Serbia emit about 37MtCO2e annually, accounting for 75% of emissions falling under the EU Emissions Trading System. Electricity generation emits 32MtCO2e annually. This means that, assuming the cost of an emission allowance in the EU Emissions Trading System after Serbia's accession to the EU, of 23 and 28 EUR/tCO2 in 2025 and 2030 respectively, between EUR 736 and 896 million should be transferred to consumers by the indicated years. If these amounts are redistributed over a larger number of years, they will clearly have a smaller impact on consumers. Also, by effectively defining social categories and strengthening the general economic parameters in the country, the impact on the household budgets of the most vulnerable groups does not have to be fatal.

In other words, the change in the price of electricity should not be seen as an isolated system that does not depend on other parameters that describe the progress of the society. In this way, the energy producer would have to invest the collected funds into reducing GHG emissions, so that, after accession to the EU which includes a complete opening of the market even without state aid, it would remain competitive compared to EU producers.

In the heat energy production sector, more than EUR 25 million annually would spill over to consumers, which further justifies the investments initiated in the fuel type switch in the district heating system of Serbia.

2.2.7. DAMAGES IN FORESTRY

Estimates are that, in the 2000-2009 period, the total damage from fires in Serbia amounted to about RSD 34 million[14]. During this period, the largest areas under fire were recorded during the very dry 2007. On the other hand, after a very dry 2003, insect attacks and diseases were recorded over the following three years. Several major fires broke out in 2013 after a long drought. The projected rise in temperatures and more frequent and longer droughts will contribute to the faster expansion and increase in wooded areas affected by wildfires.

Research shows that, after 1970, there was a decline in growth rates in oak forests in the Srem area. Preliminary research showed that the poor condition of these forests has been linked to climate change over the last 35 years and that the most dominant factor is the reduction of ground waters in this area. Additionally, a drop in precipitation and rising temperatures are expected to have an even more pronounced negative impact in the future.

Estimates for Serbia indicate changes of bio-climatic niches for individual species. For example, by the end of the 21st century, about 90% of today's beech forests are expected to be outside their 20th-century bio-climatic niche, and about 50% will be found in an area where mass mortality is expected. Pests and diseases are additional negative effects in forest ecosystems, but there is no data to indicate a clear correlation with climate change.

These effects show an evident major impact of climate change and global warming on forestry production. The forestry industry accounts for 0.3% of Serbia's total GDP. Research has shown that if mean global temperatures rise by 3°C, the additional gross value of the forestry industry can be expected to decrease annually on average by 0.020% by 2027, 0.300% by 2037, 0.608% by 2067, and by 1.645% after 2067. In line with those assumptions and data on the forestry industry share in Serbia's GDP, the economic losses resulting from the drop in production are shown in Table 11.

Increase of T by:	2020-2040	2040-2100	2020-2100
1° C	5,337 (0.42%)	102,787 (1.48%)	108,124 (1.31%)
2° C	10,674 (0.83%)	205,574 (2.96%)	216,247 (2.63%)

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3⁰ C	14,515 (1.22%)	289,354 (4.48%)	303,869 (3.98%)
4⁰ C	24,154 (1.70%)	620,438 (6.01%)	644,592 (5.49%)

Table 11: Losses due to reduced production in the forestry activity due to global warming (billion USD)

If the rise in mean global temperatures is limited to the standards set out in the Paris Agreement (up to 20C), the losses from a drop in production in the forestry industry can be expected to amount to USD 10,674, in the 2020-2040 period and to USD 216,247 billion by the end of the century. These losses would be three times higher with a twofold increase of the mean global temperature.

Figure 8 shows the projection of losses due to a decrease in forestry production in Serbia for all the four scenarios in the 2020-2100 period.

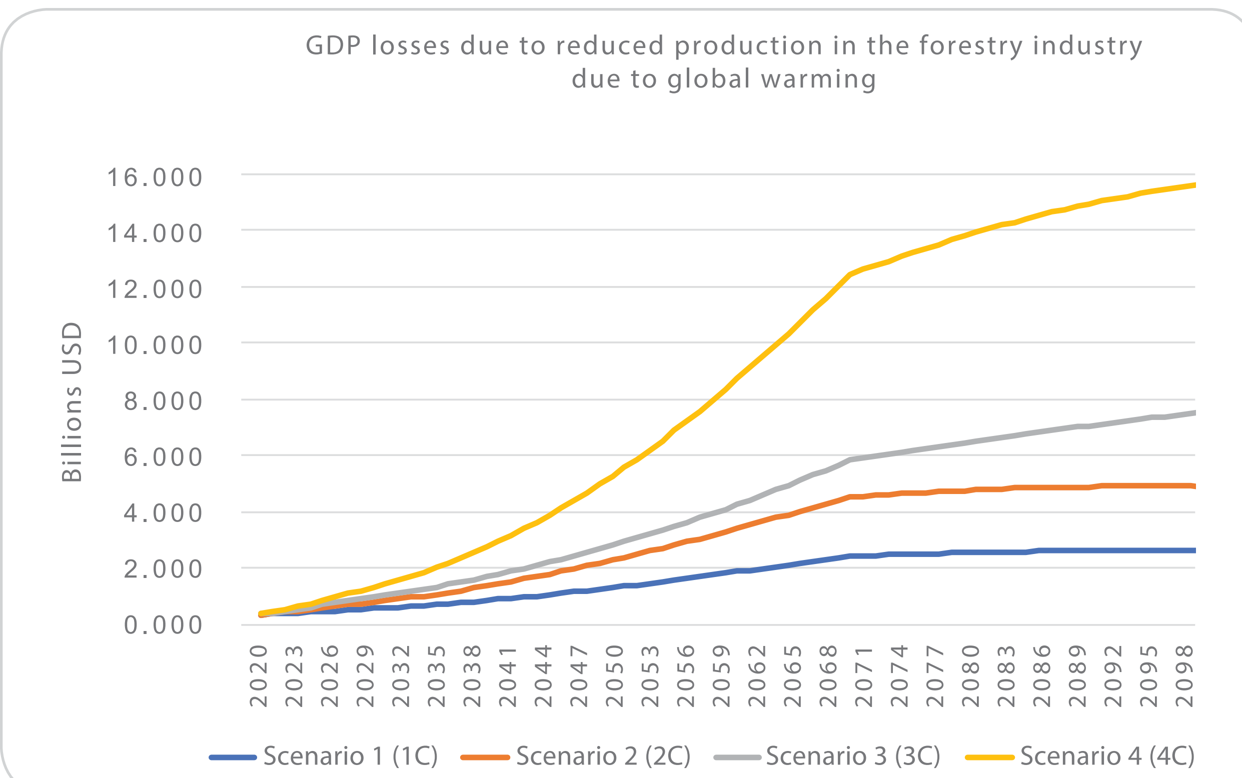


Figure 8: The projection of losses due to reduced production in the forestry activity due to global warming (billion USD)

3. IMPACTS ON CLIMATE CHANGE - GHG EMISSIONS REDUCTION

The reduction of GHG emissions is the obligation of the Republic of Serbia under the UN Framework Convention on Climate Change, and under the Paris Agreement. More important than the binding reduction of GHG emissions due to international commitments is the fact that GHG emission reduction is increasingly becoming a prerequisite for competitiveness in the international and the EU markets.

Planning economic development in a way that leads to carbon neutrality and climate change resilience is the requirement of both the international community and EU legislation, but is also a basis for investment sustainability. The basis for that in Serbia lies in the Low Carbon Development Strategy (draft), which defines the GHG emissions reduction trend with GHG emissions in 2010 as the baseline.

3.1. GHG EMISSIONS

In order to assess GHG emissions at national level, as well as the contribution of individual sectors to the total GHG emissions, we should look at GHG inventories over the past few years.

According to official GHG inventories, the total GHG emissions in 2015 were 2.3% lower than in 2010 and 24.9% compared to 1990 emissions, while removal through the Land Use, Land Use Change and Forestry (the LULUCF) they were 19.4% lower compared to 2010.

The energy sector has traditionally contributed most to the total emissions and, in 2015, it accounted for 80.6% of the total national GHG emissions. The Energy Industry sub-sector (electricity and heat generation, refineries and fuel production) accounts for 70% of GHG emissions from the Energy sector and 56% of the total national emissions. In 2015, GHG emissions from the Energy sector were 5% lower than in 2010 and 21.4% lower than the 1990 emissions. Bear in mind that the GHG emission reductions in the energy sector are primarily the result of lower demand and production, rather than structural changes in the sector.

The GHG emissions from the Industrial Processes and Product Use (the IPPU) sector are directly related to economic activities and, in 2015, they were 28.8% lower than emissions from this sector in 1990 and 16.7% lower than in 2010. However, emissions from this sector could increase significantly if economic development is based on outdated and inefficient technologies.

The GHG emissions from the agriculture sector, in 2015, accounted for 8.6% of the total emissions and were 15% lower than 1990 emissions and 0.9% lower than 2010 emissions from this sector.

The GHG emissions from the waste management sector have been reduced by 29.9% since 1990 and by 0.7% since 2007. The GHG emissions from wastewaters have decreased by 29.9% since 1990 and by 3.9% compared to 2010 emissions.

3.2. GHG EMISSION REDUCTION

The reduction of GHG emissions which help meet commitments under the Paris Agreement (the revision of the national GHG emission reduction targets) have been identified in the draft Low Carbon Development Strategy of the Republic of Serbia.

The scenarios of possible low carbon development options[15] are defined assuming the implementation of EU legislation, which is either directly or indirectly related to mitigation (by the GHG emission reduction) and lead to the reduction of GHG emissions by:

- 13.2% by 2030 compared to 2010 (which is 33% compared to 1990) and between 55% and 69% by 2050 compared to 2010, which corresponds to a GHG emission reduction between 65% and 76% compared to 1990 (M2 scenario)
- 40% compared to 1990 and 28.7% compared to 2010 (M3 scenario)
- 76.2% compared to 1990 in 2050 (M4 scenario).

The impact of these three low-carbon development scenarios on society, the economy and the environment has been assessed.

[15] Weighing of the social, economic and environmental impacts of the mitigation scenarios – Accompanying Document – Draft Low Carbon development strategy, http://www.klimatskastrategija.eu/wp-content/uploads/2019/05/Weighing-Exercise-Accompanying-Document-V1.0.pdf

Estimates[16] are that the implementation of measures to reduce GHG emissions, as in scenarios M2, M3 and M4, affects GDP growth[17] by reducing expected growth by: -1.0% in the case of M2 by 2025 and -1.4% by 2030, or -2.7% by 2050, as well as -2.6% in M3 and -3.8% in M4 compared to the scenario that implies the implementation only of measures currently in place.

In other words, all the scenarios follow GDP growth, which is slightly smaller than it would have been had the measures and policies assumed under the scenarios not been applied. This is shown in Table 12.

	2020	2025	2030	2050
M2	0.0 %	-1.0%	-1.4%	-2.7%
M3	-	-	-	-2.6%
M4	-	-	-	-3.8%

Table 12: Changes in GDP as compared to the expected without climate actions

Implementation of measures to reduce GHG emissions and transform the sector, i.e. the implementation of the three scenarios, will certainly have a different impact on employment, as well as on the sector's share in the overall employment rate. If we look at the expected change in the net number of jobs, to wit starting from those that will be created in case of no climate actions (without the scenarios), it will be negligibly low (Table 13).

	2020	2025	2030	2050
Without climate actions	2,462	2,468	2,473	2,483
M2 (%)	0.0	-1.3	-1.4	-2.0
M3 (%)	-	-	-	-1.7
M4 (%)	-	-	-	-2.5

Table 13: Impact of achieving different GHG emission reduction ambitions on employment

Implementation of the M2, M3 and M4 scenarios will lead to job losses of: **-1.4% in M2 in 2030 and -2% in case of M2, -1.7% in M3 and -2.5% in M4 in 2050** relative to the net number of jobs (the difference between jobs created and those lost) in the scenario without climate action. In other words, in 2030, instead of 2,473 new jobs, 2,438

[16] Weighing of the social, economic and environmental impacts of the mitigation scenarios – Accompanying Document – Draft Low Carbon development strategy, http://www.klimatskastrategija.eu/wp-content/uploads/2019/05/Weighing-Exercise-Accompanying-Document-V1.0.pdf

[17] The assumed GDP growth is 3.68% in M2, 3.68% in M3 and 3.64% in M4 and this growth was achieved using the macro-economic model GEM-E3

new jobs could be created. However, new job creation will not occur in the sectors where employment is traditionally the highest.

Job losses are primarily expected in the **fossil fuel and agriculture sectors.** It is also significant that the expected loss of jobs in agriculture is higher due to structural reforms required by market standards than those resulting directly from the restructuring of the sector in order to reduce GHG emissions. Also, a **drop is expected in the number of employees in large companies as is an increase in small and medium-sized enterprises.**

The share of electricity prices in total household costs is projected to change from 18% in 2030 to 15% in 2050 without changes in power generation practices and methods. If GHG emission reductions or the assumed scenarios are implemented, the share will be 19.1% in 2030 according to M2, as the optimal GHG emission reduction model at the national level. The differences with respect to the scenario that does not include mitigation measures are shown in Table 14.

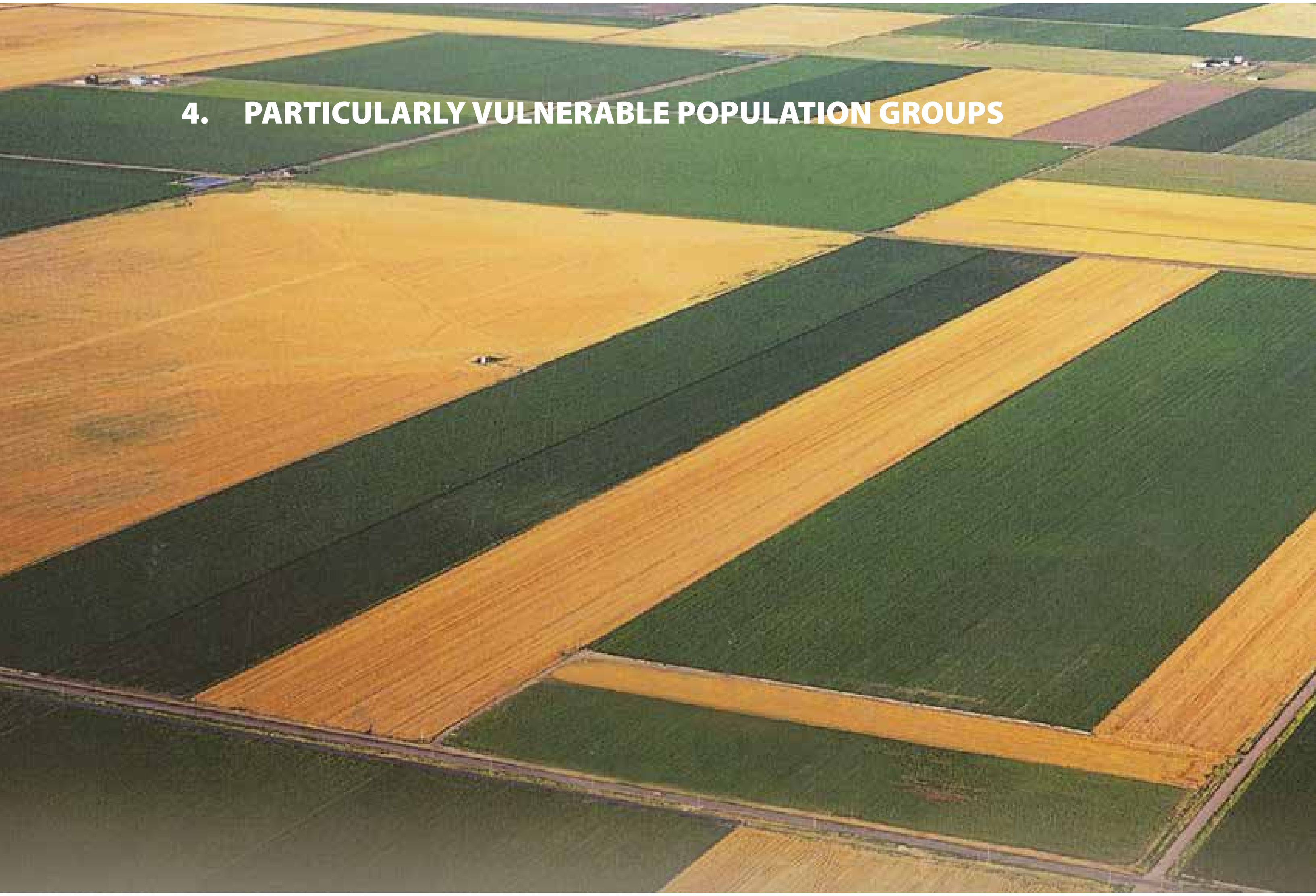
	2020	2025	2030	2050
Without climate actions (%)	18	19	18	15
M2 (change)	0.3	0.8	1.1	2.7
M3 (change)	-	-	-	2.8
M4 (change)	-	-	-	5.3

Table 14: Share of energy prices in total household expenses

In addition, estimates[18] show that energy production costs, in the 2020-2050 period, can be expected to total EUR 113 billion if the current energy production practices (without GHG emission reduction) remain in place, which is **EUR 53 billion more** than if the optimal development model or the scenario M2 is implemented.

[18] Weighing of the social, economic and environmental impacts of the mitigation scenarios – Accompanying Document – Draft Low Carbon development strategy, http://www.klimatskastrategija.eu/wp-content/uploads/2019/05/Weighing-Exercise-Accompanying-Document-V1.0.pdf

4. PARTICULARLY VULNERABLE POPULATION GROUPS



Climate change will certainly affect all population groups and every individual. On the other hand, the vulnerabilities of individual population groups and individuals are different and depend on a series of factors.

Climate change impact depends on factors such as: age, income, education, health, social environment, access to services, and level of exposure to climate change.

Place of residence (cities or rural areas) has its own forms and manifestations, but is certainly affected by climate change.

According to this preliminary analysis, the impact of climate change on the population in rural areas is primarily reflected in lower income due to a drop in agricultural production, but also increased health risks due to a decrease in the availability of water resources and more difficult access to health care. Among them, farmers with minimal capital are certainly the most vulnerable because, most often, they are completely dependent on agricultural production and natural resources. Seasonal workers in the agriculture sector are also among the most vulnerable.

In urban areas, climate change impact is also linked to air quality, as well as to the price and availability of food and water, which are increasingly affected by climate change. As a result, urban living costs are rising. In addition, the direct cumulative impact of heat waves is significantly higher in urban than in rural areas.

Heat and heat waves primarily cause negative effects in younger (children) and older populations, as well as on jobs where employees are exposed to the direct effects of heat and the sun. Farmers and construction workers are expected to be particularly affected by climate change bringing them into the particularly vulnerable groups. Fire-fighters, police officers, health services and natural disasters emergency services should not be forgotten either.

In the event of further major temperature increases, physically less demanding jobs and occupations, such as office and indoor jobs (teachers, doctors, salespeople, etc.), will become vulnerable to climate change. In this case, the pressure is mostly physiological, especially in the case of working in non-air-conditioned spaces.

The vulnerability of particular occupations to climate change is difficult to determine, because it is also highly dependent on temperature tolerance thresholds. What is certain is that older workers have a lower physiological resistance to heat and, therefore, a lower resilience to climate change. The vulnerability of this group is greater in the case of workers with chronic diseases or disabilities.

The younger generation, or children, is certainly a particularly vulnerable group. This vulnerability is clear when the impact of heat waves and other natural disasters are taken into account, but also due to physiological under-development that can be significant with prolonged exposure to climate change.

In addition to the direct impact of climate change, the vulnerability of groups can also be a consequence of mitigation and adaptation measures. Reducing GHG emissions, i.e. their mitigation, and its accompanying transformation of sectors into low-carbon sectors, can cause loss of jobs and increase electricity costs. Job losses are expected primarily in the sectors linked to fossil fuels and in the agriculture sector, as well as in large enterprises. On the other hand, employment in forestry and small and medium-sized enterprises can be expected to increase. The increase in energy prices and the negative impact of this aspect of mitigation is not necessarily greater than the increase in energy prices that can be expected if energy production continues as it is. However, this impact is directly related to the income of an individual household, and those whose incomes are at and below the poverty line are the categories of the population that must be particularly taken into consideration.

Floods and heat waves can have particularly negative effects on so-called socially isolated population groups, which by definition include the elderly, patients with chronic ailments and the disabled, those who depend on social assistance, live alone, members of ethnic minorities, homeless people, but also residents of remote and infrastructure-wise poorly connected areas.

Vulnerability to climate change is greatest among the already vulnerable groups, including the poorest population which is certainly one of the categories most vulnerable to climate change.

5. CONCLUSION

The analyses for this Study confirm the vulnerability of Serbia's economy and population to climate change. The level of vulnerability depends on the population group and activity, their income and expenditures, as well as on a series of individual parameters for each individual.

However, it is evident that changes in climate parameters already affect the value of the GDP, as well as revenues within the sectors of particular importance for the growth and development of the Serbian economy. Moreover, given the expected climate change, that impact on the GDP of the Republic of Serbia is expected to continue. It is also apparent that the negative impact of climate change on the GDP is increasing with the rise in mean global temperatures.

Due to the drop in labour productivity, the GDP of the Republic of Serbia can be expected to decrease by USD 171 million by 2040, with a minimal increase in the average global temperature (10C).

A rise in the average global temperature of 10C leads to a decrease in the availability of water resources, which results in a GDP decline of USD 8,424 billion by the end of the century, while lower cereals yields expected in this scenario will result in losses of USD 121,380 billion by the end of the century. A rise in the mean global temperature by 20C would mean a drop in Serbia's GDP of USD 242,760 billion by the end of the century compared to projections without climate change, only due to yield losses in agricultural cereals production. With a temperature rise of 20C due to a drop in electricity generation, the GDP can be expected to drop by USD 8,567 billion by 2040, or by USD 183,875 billion in the second half of the century, which means a total drop in the GDP of USD 192,442 billion and USD 216,247 billion due to a decrease in forestry production in the 2020 – 2100 period.

The impact of the rise in mean global temperatures on the total value of the GDP is different depending on the growth scenario. However, even a minimal rise in mean global temperatures will result in a drop in the GDP compared to the possible value without global warming. A drop in the total GDP relative to the GDP that could have been achieved without global warming (including all activities affected by the temperature increase) would have been (Table 15)::

Increase of T by:	2020-2040	2040-2100	2020-2100
1°C	15,465 (1.20%)	328,899 (4.74%)	344,364 (4.19%)
2°C	58,124 (4.53%)	708,193 (10.20%)	766,317 (9.32%)
3°C	59,107 (4.97%)	831,296 (12.88%)	890,403 (11.65%)
4°C	97,536 (6.87%)	1,904,874 (18.46%)	2,002,410 (17.06%)

Table 15: Drop in the total GDP relative to the possible GDP without climate change conditions (including all activities affected by temperature increase) expressed in billions of USD and %

Limiting the rise in mean global temperatures by the end of the century within the scope set by the Paris Agreement (2°C) would lead to a loss in Serbia's GDP of 4.53% by the middle of the century, which can be significantly reduced by investing in measures to adapt to climate change.

On the other hand, investing in GHG emission reduction could give rise to a drop in the GDP by as much as 3.4% by 2030 and 3.9% by 2050, and a consequent job loss of up to 2.1% in 2030 and 2.5% in 2050 compared to a situation in which no action is taken to reduce GHG emissions. The social justification to invest in the reduction of GHG emissions lies in the fact that the maximum job loss in 2050 would be equal to 0.93% of the loss that would certainly occur if no investments were made into reducing GHG emissions.

In 2030, a loss of 0.03% of working hours or 1,000 jobs can be expected due to heat waves alone, mostly in the agriculture and construction sectors. Mitigation measures, on the other hand, lead to the creation of net new jobs. Job losses are expected in the fossil fuel and agriculture sectors. Also, a drop in the number of employees in large and increase in the number of employees in small and medium-sized enterprises is expected. An increase in the number of employees can be expected in activities related to the forestry sector.

Analyses done in this study confirm that the process of transformation into a carbon-neutral and climate-adapted society, as well as all other processes, can additionally endanger already vulnerable population groups that must be given particular care. They also confirm the need for timely retraining or an adapted education system for new practices, technologies and sectors in which more employment is expected in the coming period.

Economic development and investment in adapting to climate change and mitigating its effects are not in conflict and do not exclude one another. Moreover, they complement each other and offer a wider range of possibilities for the transformation of the Serbian society in the ongoing transition process.

The making of this Study confirmed the need for further analyses of possibilities for this transformation and their financial and social justifiability and sustainability.

Annex I : Methodology

Economic effects of global warming in Serbia are assessed as GDP expected in a situation without a rise in mean global temperatures to the end of the century minus GDP in conditions with a rise in temperatures.

The analysis of economic effects was done based on four climate change scenarios that assume rises in mean global temperatures by 1°C, 2°C, 3°C and 4°C up to the year 2100. These scenarios are called: Representative Concentration Pathways (RCP) of the IPCC[19] and these are global models.

The first scenario (RCP 2.6) assumes mitigation policies and measures that keep the rise in temperatures at 1°C. Two scenarios (RCP 4.5 and RCP 6) assume less efficient GHG emission reduction that results in temperature rises of 2°C and 3°C. The fourth scenario (RCP 8.5) assumes continuing GHG emissions and a rise in mean global temperatures of 4°C.

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[19] IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Socio-economic projection is based on Shared Socioeconomic Pathways (SSP) scenarios[20]. GDP increase is assumed as by OECD[21] for the 2020-2100 period.

The GHG emission scenarios: M2, M3, M4 presented in chapter 3.2., were developed under the draft Low Carbon development strategy of the Republic of Serbia and are the result of three different models

- The PRIMES – GEM-E3[22] suite: PRIMES[23] energy system model and GEM-E3[24] for macroeconomic modelling
- CAPRI[25] (Common Agricultural Policy Regional Impacts) model for agriculture and land use, land use change and forestry (LULUCF)
- The IPCC 2006 Waste model[26] for the waste sector.

The same models were used for impact assessment. Also, these models are used for the EU low-carbon development pathway.

The vulnerability of population groups is assessed using official demographics and other data and information of importance for sustainable development and poverty reduction, international practices and expert judgement.

20 Crespo Cuaresma, Jesus (2017). Income Projections for Climate Change Research: A Framework Based on Human Capital Dynamics. *Global Environmental Change*, 42, pp. 226-236. ISSN 0959-3780. http://epub.wu.ac.at/5678/

21 Rob Dellink, Jean Chateau, Elisa Lanzi, Bertrand Magné, Long-term economic growth projections in the Shared Socioeconomic Pathways, *Global Environmental Change*, Volume 42, 2017, pp. 200-214, ISSN 0959-3780, DOI:10.1016/j.gloenvcha.2015.06.004

22 https://ec.europa.eu/clima/policies/strategies/analysis/models_en

23 https://e3modelling.gr/modelling-tools/primes/

24 https://e3modelling.gr/modelling-tools/gem-e3/

25 https://ec.europa.eu/clima/sites/clima/files/strategies/analysis/models/docs/capri_model_methodology_en.pdf

26 https://www.ipcc.ch/site/assets/uploads/2019/06/2019-Refinement_Waste_SBSTA-IPCC_Special-Event.pdf

References

www.klimatskepromene.rs

http://www.klimatskepromene.rs/wp-content/uploads/2019/04/Osmotrene-promene-klime-Final_compressed.pdf

http://www.skgo.org/

https://www.ohchr.org/EN/pages/home.aspx

Climate change and poverty Report of the Special Rapporteur on extreme poverty and human rights (https://www.ohchr.org/Documents/Issues/Poverty/A_HRC_41_39.pdf)

UNEP Climate change and Human rights (https://wedocs.unep.org/bitstream/handle/20.500.11822/9530/-Climate_Change_and_Human_Rightshuman-rights-climate-change.pdf.pdf?sequence=2&amp%3BisAllowed)

https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_711919.pdf

http://www.euro.who.int/__data/assets/pdf_file/0016/74401/E91865.pdf

https://www.ipcc.ch/site/.../02/WGIIAR5-Chap23_FINAL.pdf

http://www.euro.who.int/__data/assets/pdf_file/0004/355792/ProtectingHealthEuropeFromClimateChange.pdf?ua=1

How to Feed the World in 2050, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/human-health-impacts-climate-change-europe-report-peseta-ii-project

http://www.obnova.gov.rs/uploads/useruploads/Documents/Izvestaj-o-proceni-potreba-za-oporavak-i-obnovu-posledica-poplava.pdf

http://www.hidmet.gov.rs/podaci/meteorologija/Klimatske_karakteristike_Srbije_prosirena_verzija.pdf

https://www.env-health.org/wp-content/uploads/2019/02/Chronic-Coal-Pollution-report.pdf

Varghese BM, Barnett AG, Hansen AL, et al. The effects of ambient temperatures on the risk of work-related injuries and illnesses: Evidence from Adelaide, Australia 2003-2013. Environ Res2019;170:101-9. doi:10.1016/j.envres.2018.12.024 pmid:30579159

CrossRefPubMedGoogle Scholar

Varghese BM, Hansen A, Bi P, Pisaniello D. Are workers at risk of occupational injuries due to heat exposure? A comprehensive literature review. Saf Sci2018;110:380-92. doi:10.1016/j.ssci.2018.04.027.CrossRefGoogle Scholar

The World Bank. Climate cange. https://www.worldbank.org/en/topic/climatechange/overview

Google Scholar

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, p.151.

Crespo Cuaresma, Jesus (2017). Income Projections for Climate Change Research: A Framework Based on Human Capital Dynamics. Global Environmental Change, 42, pp. 226-236. ISSN 0959-3780. http://epub.wu.ac.at/5678/

Rob Dellink, Jean Chateau, Elisa Lanzi, Bertrand Magné, Long-term economic growth projections in the Shared Socioeconomic Pathways, Global Environmental Change, Volume 42, 2017, pp. 200-214, ISSN 0959-3780, DOI:10.1016/j.gloenvcha.2015.06.004

Kompas, T., Pham, V. H., & Che, T. N. (2018). The effects of climate change on GDP by country and the global economic gains from complying with the Paris Climate Accord. Earth's Future, 6, 1153–1173. https://doi.org/10.1029/2018EF000922

Hutton and Menne. Economic Evidence on the Health Impacts of Climate Change in Europe. Environmental Health Insights 2014:8 43–52 doi: 10.4137/EHI.S16486; Hutton: The economics of health and climate change: key evidence for decision making. Globalization and Health, 2011, 7:18. doi:10.1186/1744-8603-7-18

Roberto Roson and Martina Sartori. (2016). Estimation of Climate Change Damage Functions for 140 Regions in the GTAP 9 Database, Journal of Global Economic Analysis, Volume 1 (2016), No. 2, pp. 78-115.

https://www.oecd.org/env/cc/Adapting-to-the-impacts-of-climate-change-2015-Policy-Perspectives-27.10.15%20WEB.pdf

Weighing of the social, economic and environmental impacts of the mitigation scenarios – Accompanying Document – Draft Low Carbon development strategy, http://www.klimatskastrategija.eu/wp-content/uploads/2019/05/Weighing-Exercise-Accompanying-Document-V1.0.pdf

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