CHAPTER 9

Environment, Climate Change and Depopulation in Serbia

Jelisaveta Petrović

1 Introduction

Climate change is one of the biggest societal challenges of today (IPCC, 2021). Climate change in a *broader sense* is considered to be a consequence of complex abiotic and biotic processes and is reflected in statistically significant changes in climatic parameters over longer periods of time. Factors driving climate change are divided between anthropogenic (human induced) and non-anthropogenic such as astronomical, geophysical, and biotical. However, today climate change usually means changes that occur as a consequence of human activities, that is, *climate change in the narrower sense*. Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC, 1992) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". Climate change is induced by unsustainable human practices that are deeply embedded in the existing political, social and economic systems that are also environmentally unsustainable. Therefore, climate change is a natural but also a social phenomenon (Dunlap & Brulle, 2015).

Climate change *negatively affects* societies in many ways by aggravating existing social problems and creating new ones. The vulnerability of a society to climate risks depends on a plethora of factors. Some of the factors are environmental and geographical (e.g. coastal areas are at greater risk of flooding than inland areas), but the majority of them are social such as poverty, social inequalities, discrimination, marginalization, unequal economic exchange, the colonial legacy, unequal access to natural resources, etc. (Cannon, 2006). The harmful consequences of climate change are not equally distributed in any population, meaning they differ across social groups, intersecting with other types of social inequality (e.g. poverty, gender, race). Climate change also asymmetrically affects different geopolitical locations (e.g. developed and developing countries) and types of economies (e.g. economies based on the extraction of natural resources vs. technologically hyperdeveloped) creating climate change winners and losers (O'Brien and Leichenko, 2003). The literature on climate change and security warns of a high probability of environmental and climate change induced conflicts in the near future, both locally and internationally (Alcamo et al., 2007; Barnett & Adger, 2007; Puđak, 2019).

The *response to climate change* risks can be broadly categorized into mitigation (preventive measures) and adaptation practices. Those activities can be short-term or long-term; and they can be cursory and unidimensional or comprehensive and aiming at multiple systemic changes (Moser and Ekstrom, 2010). Developed countries are able to invest in mitigation and adaptation strategies to prepare for future risks, while developing countries usually invest in recovering from the disasters that have already occurred (Puđak, 2019). While preparation for climate change in developed countries is mostly planned and systematic, in developing countries the implementation of mitigation and adaptation mechanisms are usually sporadic, partial, bound to the local level, and typically initiated as a reaction to some catastrophic event (Mirza, 2003; Ford et al., 2011).

As the 2020 Human Development Report made clear, many inequalities in human development have been increasing and continue to do so, and climate change will only make them worse (UNDP, 2020). In countries with high environmental threats, there is also greater social vulnerability. Combined with other environmental factors (such as air, water and soil pollution), climate change is most directly related to the depopulation process. Pollution and climate change affect the fertility, morbidity and mortality of the population, and have an extremely adverse effect on the overall quality of life inducing mass migrations. Regarding the unfavourable effects on fertility (e.g. Deng et al., 2016; Wu et al., 2017) the concept of reproductive environmental justice has been introduced to emphasise that people living in polluted areas and so-called "zones of environmental sacrifice" (e.g. in the vicinity of mining sites, toxic industries etc.) are at an elevated risk of subfertility and infertility due to the environmental factors (Lappe et al., 2019). Additionally, a number of studies show significant impacts of pollution and climate change on public health and mortality (Orru at al., 2017). Finally, according to the Intergovernmental Panel on Climate Change (IPCC) projections, ecological (climate) migrations will be the most common form of spatial mobility of the population in the future. It is estimated that in 2018 alone, over 17 million people changed their place of residence as a result of the destruction of the natural habitat and human-built environment under the influence of climate change (Pickup, 2019).

In this chapter, our goal is to shed light on a part of the complex set of factors that affect the process of depopulation in Serbia. These are environmental and climatic factors of depopulation. In that sense, we will try to provide an answer to the question to what extent environmental and climatic factors affect fertility, mortality and migration as the basic components of the depopulation process in Serbia. At the very beginning, it should be emphasized that this is a pioneering endeavour, bearing in mind that environmental and climatic factors have only recently become recognized as influencing socio-economic and demographic trends in the world, and that relevant data (especially for Serbia) are not available in many cases. Bearing in mind the complexity of the phenomena in question – climate change and environmental problems (ranging from air, water and soil pollution, through illegal landfills, unplanned construction, lack of sanitary infrastructure, to threats to biodiversity and an underdeveloped circular economy, etc.), and the complexity of the depopulation process and the impact of other factors on it (discussed in other chapters), as well as due to the unavailability of data for Serbia, in this chapter it was necessary to limit ourselves to examining the impact of two factors – climate change and air pollution. In addition to the relative unavailability of data, we singled out these two factors from the wide range of other potential environmental impacts on the health, fertility and migration of the Serbian population. In addition, although we consider the influence of other environmental factors to be important, the format of this report does not allow the inclusion of all of them, as such an endeavour would, at the very least, require a separate and rather extensive study.

When it comes to data sources, the text primarily relies on climate models and projections because they represent the gold standard in the scientific study of the impact of climate change on socio-demographic trends. As these models are complex and far from everyday experience, as an additional source we use case studies that well illustrate the impact of climate change and environmental challenges on the quality of life of the Serbian population and the accompanying socio-demographic changes.

2 Climate Change and Depopulation Processes in Serbia

2.1 Serbia and Climate Change

2.1.1 Socio-political Context of Climate Change in Serbia

Despite being a global problem, climate change has disproportionately large impacts outside the Global North (Sabherwal & Kácha, 2021). Regarding climate change causes and consequences, post-socialist countries, Serbia being one of them, belong to the "Global East" meaning somewhere in between the North and the South (Muller, 2020). The socialist legacy and specific trajectory of post-socialist development seems to matter in terms of mitigation and adaptation to environmental and climate risks. For instance, the most important infrastructure and the material environment were built during socialism, and then (re)constructed since the 1990s, alongside the structural transformations of other post-socialist societies (Ferenčuhova, 2020). The legacies of the state-socialist era, including environmental burdens from the past (e.g. from intensive industrialisation), energy-consuming and unsustainable infrastructure built before 1989, seem highly relevant even 30 years after the collapse of state-socialism (Petrović & Backović, 2019; Pavlinek & Pickles, 2004). Moreover, profit-oriented private developments (investor urbanism) and the mushrooming of the foreign owned high-polluting plants that occurred in the post-socialist era, have created new environmental problems in the region, contributing to the countries' vulnerability to climate change and their capacity to adapt (Ferenčuhova, 2020; Petrović & Backović, 2019; Filipović, 2021; Zeković et al., 2015).

The process of European integration, on the other hand, has an important and mostly positive influence on environmental and climate policies in the region, especially among the countries that have already be- come EU members, but on the candidate countries as well (Braun, 2016; Borzel & Buzogany, 2019, Petrović, 2020). Taking into consideration the general orientation of Serbia towards EU integration and harmonization of domestic legislation within the EU acquis, it is not surprising that the country has undergone significant changes regarding environmental and climate legislation and the institutional framework in the past decade. Today, Serbia has comprehensive environmental and climate legislation, with more than a hundred laws and bylaws. It also should be noted that Serbia has ratified all relevant climate change framework agreements such as the Kyoto Protocol, UNFCCC, The Par- is Agreement etc. For instance, under the Paris Agreement Serbia has committed to reduce GHG emissions by 9.8% before 2030 compared to 1990 levels[211] (Draft Climate Strategy and Action Plan RS, 2019: 6-7).[212] There are still some important drawbacks regarding harmonization with the EU legislative framework (Antić, 2020: 22).

Although the environmental acquis has been transposed into national legislation in the past two decades, what is most concerning is that implementation is largely missing. Negotiation on Chapter 27 is considered to be one of the hardest and most expensive segments of the accession process, with approximately 15 billion euros of investments needed[213] (Antić, 2020; Starinac, 2019). As a consequence, improvements in the environmental sector are slow, the environmental impact assessments largely remain a formality and public participation in decision-making is limited and mostly ineffective. Judicial practice in environmental matters remains under-developed while the Inspection for Environmental Protection lacks the capacity to supervise environment protection adequately (Antić, 2020: 26). The weaknesses regarding national legislation and implementation of the environmental and climate laws are noted in the European Commission Progress Report which states that: "Serbia has some level of preparation on climate change, but implementation is at a very early stage. Recent

[211] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Serbia%20First/Republic_of_Serbia.pdf (accessed 25/01/2022)

[212] However, Serbia failed to submit updated contributions during Glasgow meeting in 2021.

[213] https://www.emins.org/otpad-kosta-15-milijardi-evra-za-poglavlje-27/ (accessed 25/10/2021).

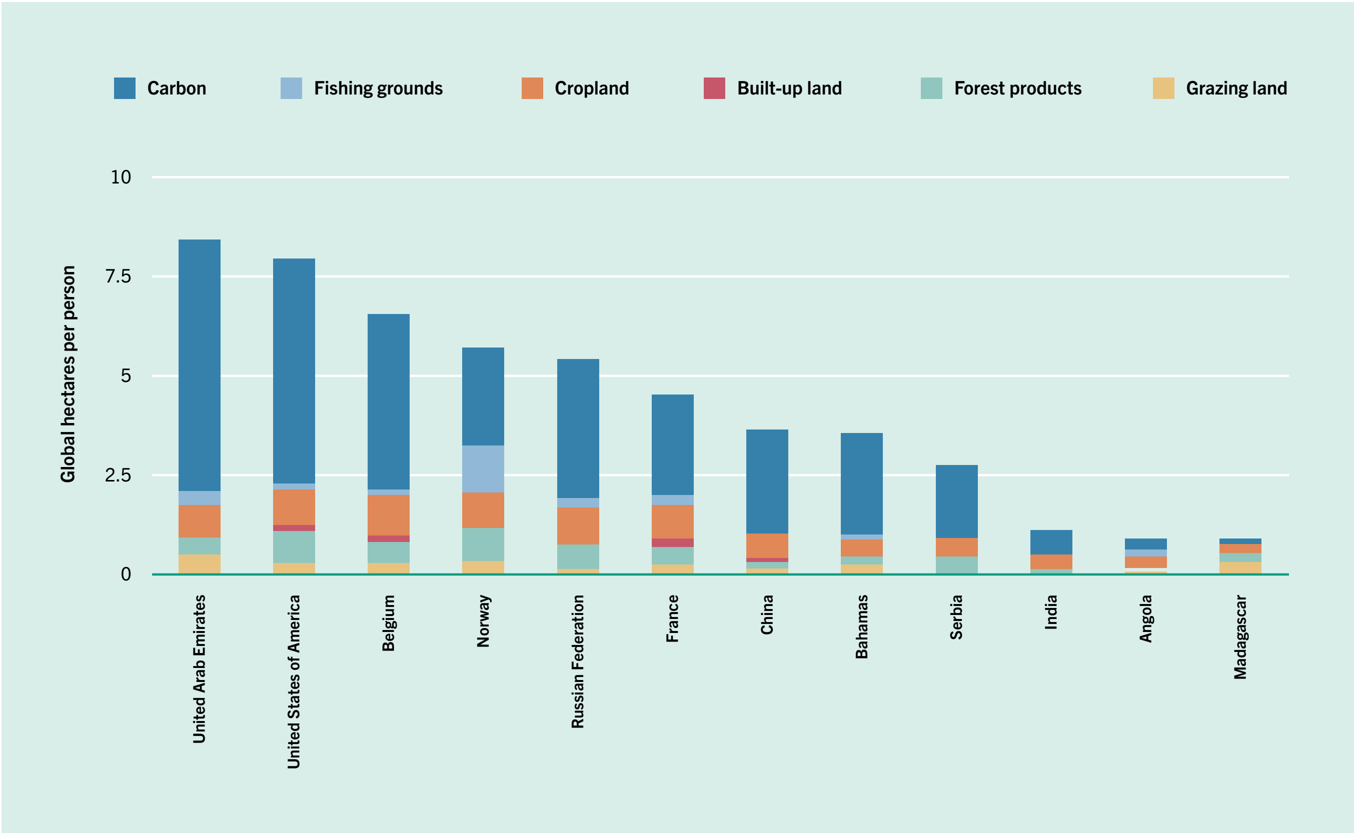


Figure 1. Environmental Footprint per Capita of Selected Countries, 2017.

Source: https://data.footprintnetwork.org (Accessed 8/10/2021)

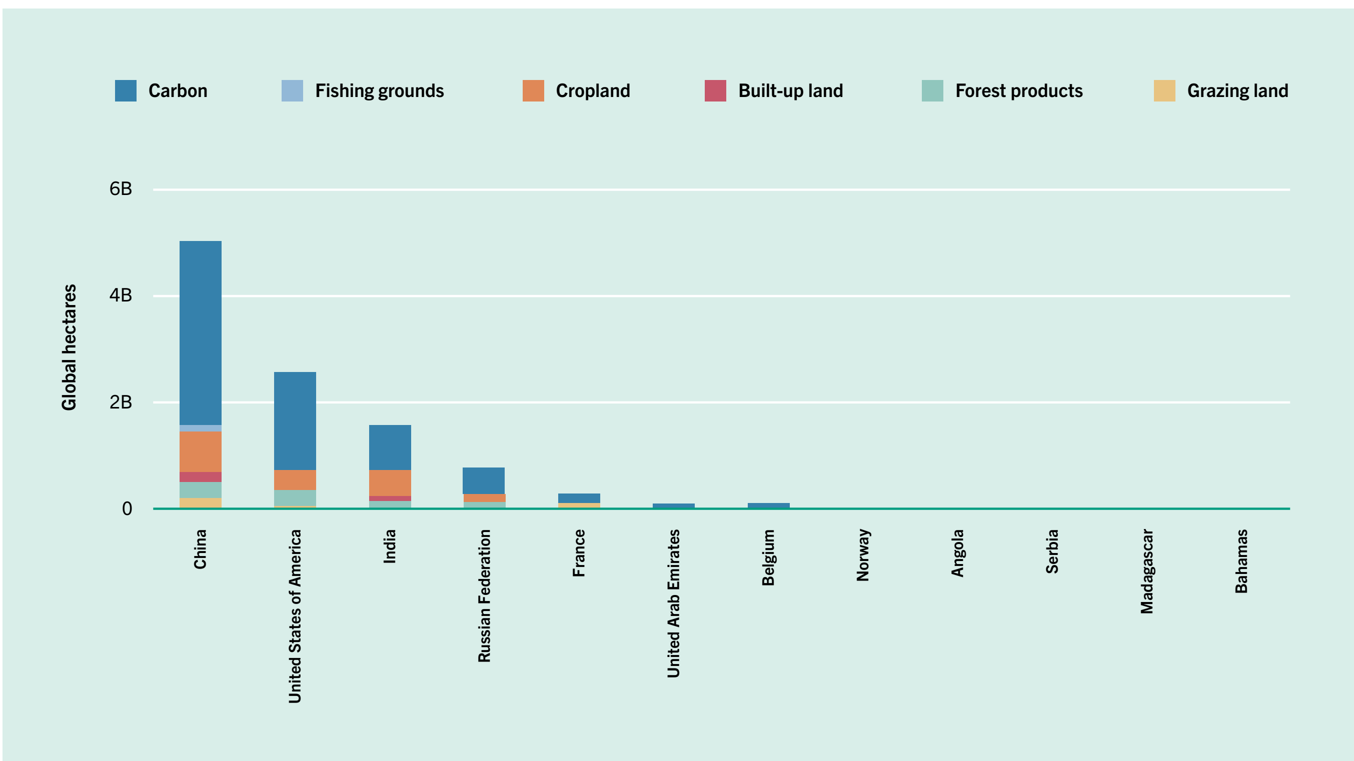


Figure 2. Total Environmental Footprint of Selected Countries, 2017

Source: https://data.footprintnetwork.org (accessed 8/10/2021)

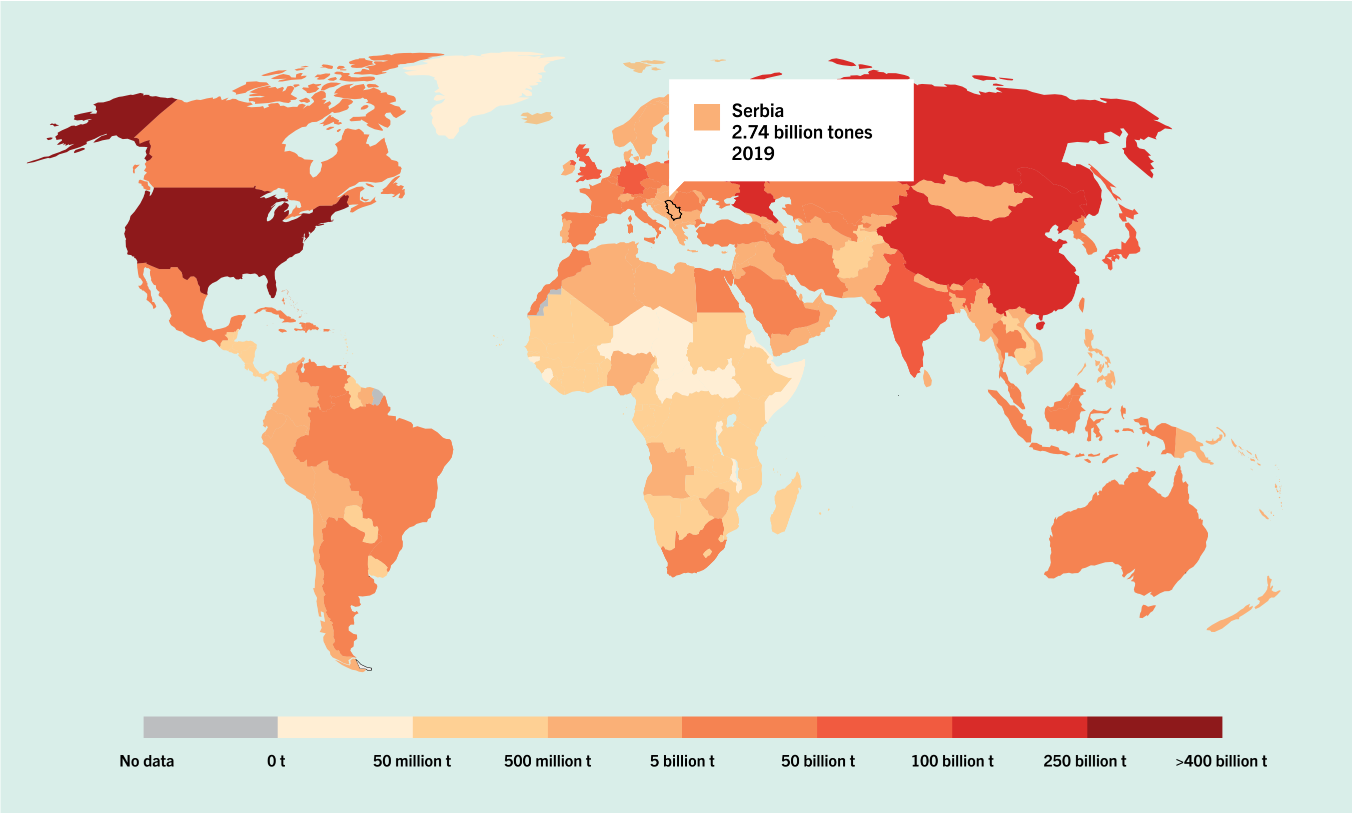


Figure 3. Cumulative CO_2 emissions, 2019

Source: https://ourworldindata.org/contributed-most-global-co2 (accessed 8/10/2021)

positive developments include the adoption of the long-prepared Law on climate change in March 2021. Serbia should develop an ambitious integrated National energy and climate plan (NECP) in a transparent and effective way, translating its commitment to the Green Agenda for the Western Balkans into concrete action including on introducing carbon-pricing instruments and phasing out coal subsidies". On the other hand, some harsher critics of the Europeanization of former socialist states suggest that, in many respects, the harmonization with the environmental and climate legislation is a "Potemkin harmonization" meaning that changes exist mainly on paper, while old practices remain intact (Ruso & Filipović, 2019; Bugaric, 2015; Crnčević & Orlović Lovren, 2017; Petrović, 2020).

Within the post-socialist bloc Serbia is anything but an exception in terms of the development and the implementation of environmental and climate policies. Former socialist countries are still lagging behind the level of environmental protection achieved in the older member states, sometimes being criticized and referred to as "enfants terribles" of the EU climate policy. Since large populations have greater impacts on the climate than smaller ones, in total amounts, the climate footprint of Serbia is rather low. However, the per capita contribution is significant. In comparative terms, the historical impact of Serbia on climate change is assessed as medium, with a total of 2.74 billion tons of CO2 (Figures 1, 2, and 3).

It should be noted that over 80% of total GHG emissions in Serbia come from the energy sector while EPS[214] is responsible for 50% percent of emissions.[215] Although certain changes in individual consumption pat- terns (e.g. reduction of electricity use within households and improvements in energy efficiency) can contribute to lowering emissions, the large emitters' reliance on unrenewable energy sources and energy losses in the process of transmission (estimated at 15%) should be taken as the most important factor contributing to climate change in Serbia. It is expected that by joining the European Union, Serbia will be obliged to drastically reduce GHG emissions, and success in this process will primarily depend on EPS's readiness to invest in cleaner forms of electricity production. The total value of these investments is measured in billions of euros (Antić, 2020: 146, 154). The transition to a low-carbon economy is expected to bring significant social, economic and environmental benefits to Serbia as a whole, but these benefits and associated costs will not be evenly distributed throughout society, creating winners and losers of decarbonization (Cavalheiro, 2020: 5).

[214] Public Enterprise Electric Power Industry of Serbia (JP Elektroprivreda Srbije)

[215] The effects of the COVID-19 pandemic should also be taken into account. At the beginning, the Pandemic led to a reduction in GHG emissions worldwide (and in Serbia), however emissions have returned to the same level and will probably increase as was the case after the Global Recession (2008-9). Moreover, recent research on urban mobility in Belgrade show that, while the overall reduction in urban mobility had a positive effect on the environment (reduction in the air pollution and GHG emissions), changes in the structure of the means of transport have a potentially negative impact due to a significant decrease in the use of public transport, with increasing use of private vehicles and more or less unchanged use of alternative (ecological) means of transport (Petrović, 2021).

One of the biggest challenges will be to make a decision regarding the futture of lignite use (the main source of the energy at the moment), since relying on low-quality lignite requires advanced technological systems to cope with the industry's low productivity and its vast environmental externalities (Young & Macura, 2020: 2).

Regarding public attitudes towards climate change, the data from the 8th round of the European Social Survey (2016/2017) show that citizens in post-socialist countries are often more sceptical about climate change than the European average; they are less sure that climate change is happening and are more sceptical regarding the idea that changes in individual energy consumption could mitigate climate change (Portinga et al. 2018). Unfortunately, Serbia was not included in this research wave, but the results from other research show that, despite the evidently unfavourable trends and the relatively high general awareness of environmental problems and climate change, Serbian citizens are not particularly willing to engage in environmental protection (Petrović, 2020). Although over three quarters of the respondents are aware of the environmental risks and express concern regarding health consequences, only 5% are willing to engage more actively in this area (e.g. recycling, reducing energy consumption, signing petitions, participating in environmental actions etc.). In other words, there is a noticeable "value-action" gap between environmental awareness and everyday practices. The development of environmental practices in the future might be expected with the growth of information about environmental problems in the media and their problematization in public discourse (Petrović, 2020). Moreover, as other research demonstrates, direct experience of extreme negative climatic events such as heat waves, wildfires and floods can enhance citizens' environmental and climate awareness (Li et al., 2011; Zaval, Keenan et al., 2014). However, there are currently insufficient data on the extent to which the perception of vulnerability to environmental and climate risks affects individual assessments of quality of life in Serbia, as well as decision-making in this regard (e.g. relocation to less risky areas; individual measures of prevention and protection against pollution, etc.). Certainly, research that takes these factors into account would be of great value.

To conclude, environmental burdens, suboptimal infrastructure, and unsustainable practices of environmental protection and planning inherited from socialism and aggravated by the specific trajectory of post-socialist transformations in Serbia (characterised by postponed Europeanization and intensive neoliberalisation) largely shaped the system of environmental protection. As the following sections will demonstrate, the situation regarding climate change and air pollution in Serbia is far from optimal.

2.1.2 Observed and Predicted Socio-environmental Consequences of Climate Change in Serbia

Serbia will be one of the areas strongly affected by climate change, especially regarding the increase in average temperatures (Božanić & Mitrović, 2019). The mean state of climate in Serbia is already significantly altered in comparison to the mid-twentieth century base-

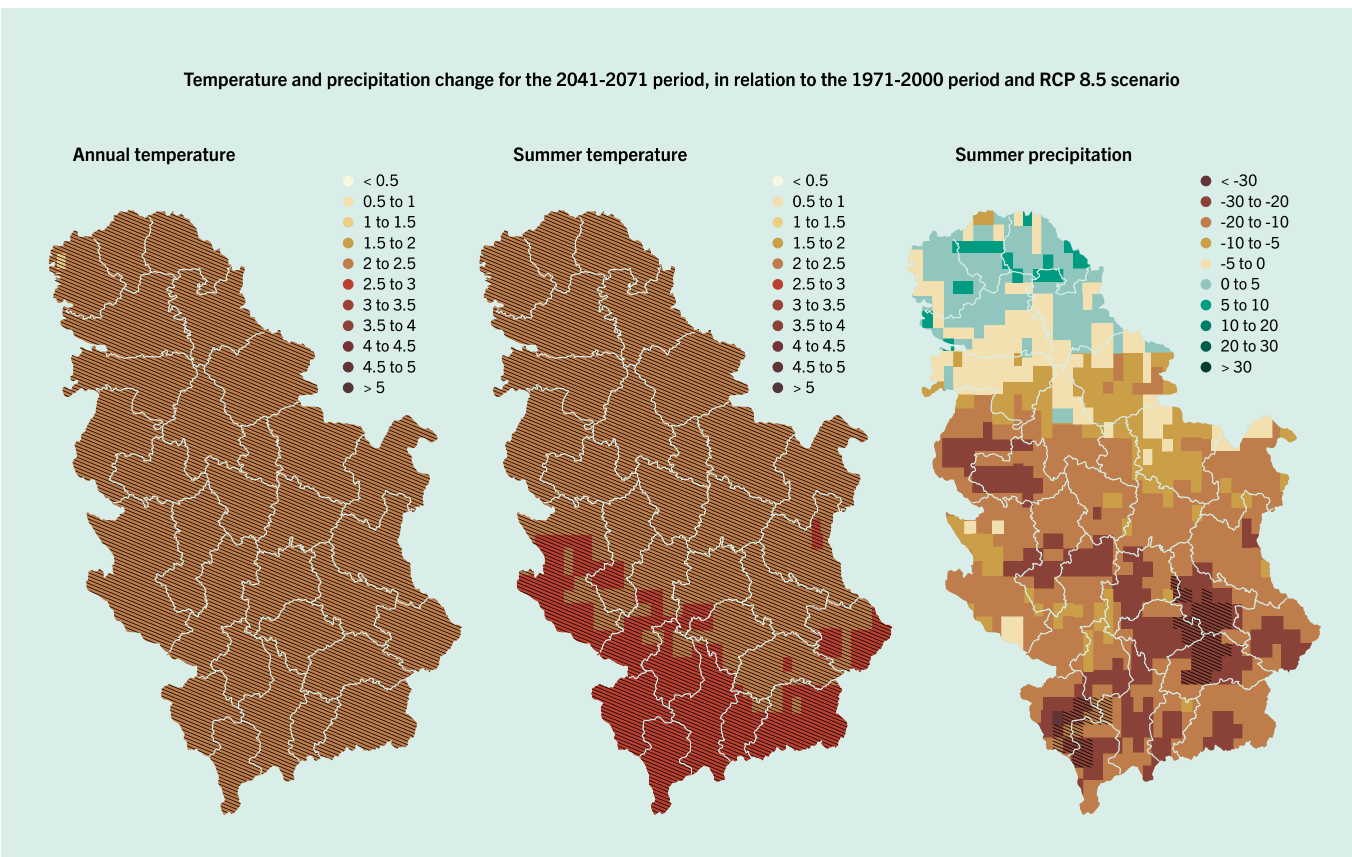


Figure 4. Future projections in temperature and precipitation change for for the mid-21st century depicting main changes in climate conditions in Serbia

** Hatched areas are with statistically significant change.*

line, particularly in terms of average temperature levels. The change is toward warmer conditions and intensification of different weather and climate extremes, such as heat-waves, extreme precipitation, prolonged dry periods etc. (Đurđević et al., 2018). Since the 1960's there has been a positive increase in temperature of 0.36 °C per decade, while climate change scenarios predict an overall increase between 2°C and 4.3°C until 2100, compared to the period 1986-2005. A change in the annual precipitation cycle has been observed, with less precipitation during summer, and a slight increase during other seasons. Moreover, extreme precipitation episodes have become more frequent (Draft Climate Strategy and Action Plan RS, 2019; Janković et al., 2019: 352).

Following the results from the climate change projections, the observed trends will continue in the future (Vukovic et al., 2018). The IPCC intermediate climate scenario RCP4.5[216] in Serbia envisages an increase in temperature of about 0.5°C in the period 2016-2035; about 1.5°C for the period 2046-2065 and about 2°C in the period 2081-2100, compared to the reference period (1986-2005) (Draft Climate Strategy and Action Plan RS, 2019: 43-44). According to the worse-case scenario[217] (RCP8.5[218]), for the period 2041-2070 the expected annual temperature increase will be 2.0 – 2.5°C and expected increase in summer temperatures 2.5 – 3.0 °C in comparison to the period 1971-2000 (Figure 4).

As presented in the figure 4, increases are expected in annual temperature (left) and summer temperature (centre), together with a decrease in summer precipitation in most regions in the country (right).[219] Vulnerable areas in Serbia cover around 57% percent of territory which is prone to heatwaves, drought, floods, landslide hazards, forest fires and erosion (Dragicevic et al., 2011). A greater increase in average temperature is expected in southern Serbia in comparison to the northern parts of the country.[220] In addition to changes in the mean annual and mean seasonal values of the essential climate variables, temperature and precipitation, changes of the different extremes are also projected (Vukovic et al., 2018; Djurdjevic et al., 2018). The number of hot and tropical days will continue to increase, and heat waves will become more intense and more frequent in the future. Extreme heat waves, which were rare during the reference period, will occur on average at least 2-3 times a year by the middle of the twenty-first century. The changes in precipitation extremes indicate a further intensification of the processes already observed.[221]

The impact of climate change on various aspects of life in Serbia is already visible. In the period 2000-2015 alone, material damage caused by extreme climatic and weather events amounted to over 5 billion euros[222] (Božanić & Mitrović, 2019; UNFCC, 2021; VRS, 2020) and in-

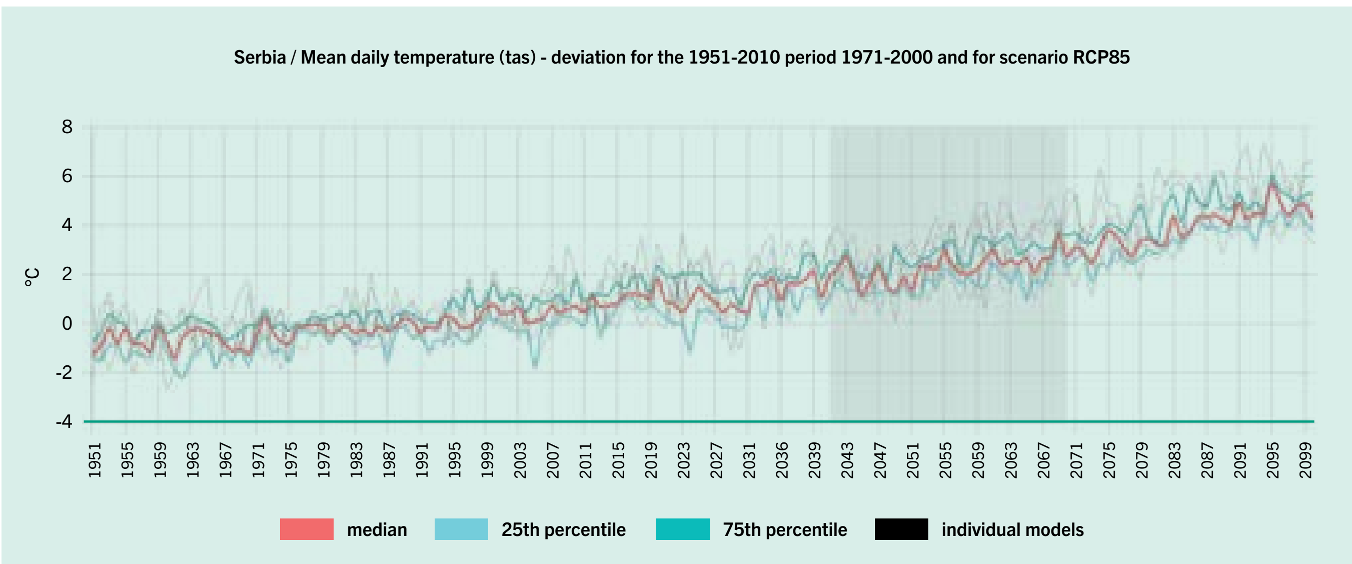


Figure 5. Mean annual temperature change (average over Serbia) up to 2100, following RCP8.5 scenario.

Source: Digital platform developed within the project project "Improving mid-term and long-term planning of adaptation measures to changed climate conditions in the Republic of Serbia", funded by the Green Climate Fund, the Ministry of Agriculture, Forestry and Water Management and the Ministry of Environmental Protection of Serbia

[216] Representative Concentration Pathway (RCP) 4.5 is a scenario of long-term, global emissions of greenhouse gases, short-lived species, and land-use-land-cover which stabilizes radiative forcing at 4.5 Watts per meter squared in the year 2100. RCP 4.5 is described by the IPCC as an intermediate scenario.

[217] For the next 30 years the choice of scenario is not crucial for the assessment of the temperature and precipitation change signals, given that emission scenarios (and GHG concentrations) are not significantly different in this time frame. The differences between scenarios are more visible for the last decades of the 21st century.

[218] RCP8.5 is generally taken as the basis for worst-case climate change scenarios.

[219] It is expected that there will be no significant changes in total amount of annual precipitation, but according to the projections, changes in the annual cycle will intensify and become more visible in comparison with currently observed trends.

[220] In the north regions of the country a slight increase in summer precipitation of about 5% can be expected, and in the central and southern regions a decrease in summer precipitation ranging from -5 to -30% (Figure 4, right panel).

[221] In the future the changes in precipitation distribution intensity towards more frequent heavy precipitation events and higher precipitation accumulations during intense precipitation events are expected.

[222] See also: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Serbia%20First/Republic_of_Serbia.pdf (accessed 10/02/2022).

The Case of Exceeding Levels of Aflatoxin in Milk and Climate Change in Serbia

An illustrative example of the socio-economic and political consequences of climate change is the case of the excess concentration of aflatoxin M1 in milk. Due to a severe drought that hit Serbia in the summer of 2012 (which can be attributed to climate change), maize yields were significantly lower, and in addition became contaminated with alfatoxins (Milićević et al., 2019). Since dairy herds were fed with the lower quality grain, the toxin was transferred to the cow's milk. Finally, milk with an increased concentration of aflatoxins reached the market. Scared and confused, consumers reacted by decreasing their consumption of milk and dairy products. The milk supply chain was seriously shaken and a mini-political crisis emerged (Popović et al., 2016; Nešić i Zorić, 2013).

creased by an additional 1.8 billion euros[223] in the period 2015-2020. The impact of climate change endangers public infrastructure, agricultural productivity, water availability and public health. The most vulnerable sectors are agriculture, forestry, hydrology and water resources (Draft Climate Strategy and Action Plan RS, 2019: 10). When it comes to the health of the population, heat stress is considered to be one of the most harmful consequences of climate change leading to increased mortality and the prevalence of various diseases (respiratory, cardiovascular, etc.), especially among old persons. Chronic patients (diabetics, kidney patients, etc.) are at a highest risk of heat stress, but also residents of cities where green areas are scarce (Bogdanović et al., 2013).

The unfavourable consequences of climate change especially affect the poorest, rural areas in Serbia, which accelerates the depopulation processes (MUP, 2017). This is especially the case with the least developed region of Southern and Eastern Serbia, covering a third of the country's territory and facing pronounced depopulation trends. Agriculture is at particular risk, mostly from droughts, high temperatures and storms. It is estimated that losses in agriculture (mostly from decreased maize yields) amount to 2.2 billion dollars (Djurdjević, 2019; Stričević et al., 2020). Decreases in agriculture yield destabilise the local economy and can trigger migration as working-age people move in search of employment. With depopulation, rural areas are left inhabited predominantly by an elderly population which poses serious challenges to rural development (Igić, 2020: 2-3).

Urban environments are also at risk, especially those prone to floods and extreme temperatures (Bogdanović et al., 2013; Radulovic et al., 2015). For instance, extreme weather events in Belgrade have become more frequent, causing serious and sometimes catastrophic consequences. The urban core of Belgrade is particularly at risk of heat waves, due to the lack of vegetation, asphalt and concrete coverage and limited air movement. That said, it should be mentioned that a recent study warned that Belgrade urgently needed a heat health warning system

Climate-related threats to public health in Belgrade

The risk of the abovementioned climate-related threats to public health in Belgrade is estimated as high (heat waves, extreme cold temperatures, floods) or medium high (droughts, storms). The negative consequences of the extreme weather events are the following:

(1) in heat waves: death, mainly due to cardiovascular diseases, cerebrovascular and respiratory system diseases; expanding infectious diseases; modified allergic patterns; heat stress;

(2) in extreme cold: increased traumatism, circulation disorders, with a possible fatal outcome;

(3) In extreme precipitation and floods: traumatism and deaths; expanding infections, mainly due to polluted water (Đokić & Grujuć, 2015: 17).

People who reside and work in vulnerable areas, especially the extremely poor, elderly, infants and children, people with disabilities, chronic patients, and women are at highest risk (Đokić & Grujuć, 2015: 17; MacDonald, 2021: 31-32).

(Stanojević et al., 2014). Other research also demonstrates the importance of digital systems in detecting environmental hazards (via state owned and community sensors), making them immediately available via networks during environmental crisis (Stupar & Mihajlov, 2016).

In addition to their vulnerability to heath waves, parts of Belgrade near the Sava River are at a high risk of flooding, which was especially visible during the 2014 floods. Another example is the Zemun municipality located in the northern part of Belgrade, that has experienced a number of landslides in the last three decades, jeopardizing buildings and roads, as well as the livelihoods of the local population, particularly in the case of the 2010/2011 landslides. It is expected that without adequate adaptive measures this "hidden risk" will become more visible and dangerous in the future (Lukić et al., 2018).

One recent research paper conducted in Belgrade has shown that 88% of respondents are to some degree aware of the climate risks, and about 70% think that climate change has a negative impact on their every-day functioning (Cvetković et al., 2019). However, despite the awareness of climate related risks, existing research shows that there are many challenges to decarbonisation in Serbia, both on local and on national level, and among different stakeholders (Bajić Brković et al., 2012).

In the boxes we offer two illustrative examples of the negative impact of climate change in Serbia: the 2007 summer heat wave and 2014 floods (Milutinović, 2018: 12). Moreover, one should keep in mind the dangers of climate change related compound extreme weather events that can seriously jeopardize the normal functioning of a society. For example, in the summer of 2010, Russia was struck by an unprecedent-

[223] https://www.klimatskepromene.rs/wp-content/uploads/2020/10/CCA-revizija-NDCs-NACRT-oktobar-2020.pdf, p. 22 (accessed 10/02/2022).

2007 Summer Heat Wave

In July 2007, over almost the entire territory of the country, maximum daily temperatures exceeded 35°C on nine consecutive days between 16th and 24th July. Serbia's highest ever temperature of 44.9°C was recorded in the District of Smederevska Palanka and Podunavlje District on 24th July. During this heatwave there were a total of 167 excess deaths in Serbia. People aged 75 years and older accounted for 151 (90%) of all excess deaths. The increase in mortality among older persons was 76% in comparison to the base- line mortality. Excess female mortality was over two times higher than excess male mortality. The biggest increase in mortality was from diabetes mellitus, chronic kidney disease, respiratory system diseases, and nervous system diseases. Cardiovascular and malignant neoplasms mortality accounted for the highest absolute numbers of excess deaths (Bogdanović et al., 2013: 140).

ed heatwave combined with a prolonged drought. The extremely dry and hot conditions led to wildfires, which damaged crops and caused many casualties. The wildfires also induced extreme levels of air pollution in cities such as Moscow, adding to the total number of deaths caused by the heatwave (Zscheischler et al., 2018). Similarly, last year in the midst of the covid-19 pandemic, Northern Macedonia had to face huge problems in the energy system as a result first of extreme flooding and then droughts (BGEN, 2020). The probability of such events in Serbia is high, and mitigation and adaptation policies should take into account the potentially devastating effects of compound negative climatic events on the socio-economic functioning of the society.

Climate change is also one of the triggers of migration. In Serbia, migrations from rural to urban areas are resulting in an unfavourable social structure both in urban and rural areas. The unfavourable existing age and gender structure of the remaining population, together with negative demographic growth represents a threat to rural development and makes climate change adaptation more difficult (Igić et al., 2020: 2). Changes in the ability to perform agricultural work and reduced agricultural yields (and thus household income) as a result of droughts, fires or reduced rainfall due to climate change, can be one of the drivers of migration from rural to urban areas and thus contribute to depopulation of these areas.

However, the opposite trend of migration from urban to rural areas could also be expected in the future, as the ecological migrations of middle classes are becoming more frequent. In addition to proactive strategies, such as participation in environmental actions, one of the strategies of the wealthier and more educated part of the population in the future might be migration in areas that are more environmentally friendly (so-called lifestyle migrations, already practiced in developed countries) (Benson & O'Riley, 2016)

It is clear that the already observed and projected changes due to the altering climate will affect virtually all aspects of life in Serbia.

2014 Floods

When cyclone Tamara struck, Serbia was unprepared. As a consequence of heavy rains in May 2014 (nearly 50% of the May 1950–2013 climatological precipitation fell in only 48 hours) there was a significant increase in water levels in a short period of time on many rivers (especially the Sava, Tamnava, Kolubara). The catastrophic floods hit 38 towns and municipalities in central and western Serbia and around 20% of the population, while over 30,000 people were displaced (among whom almost 25,000 from Obrenovac). The floods resulted in 51 fatalities, of which 23 were from drowning. The economic damage was estimated at €1.7 billion, causing economic recession (Đokić & Grujuć, 2015; Crnčević & Orlović Lovren, 2017; Stadtherr et al., 2016). The May 2014 flood showed the significant unpreparedness of Serbia for extreme weather events. It revealed all the consequences of three decades of poor maintenance, an outdated planning and information system, inefficient implementation and unsustainable management, lack of technology and infrastructure (Trgovčević et a., 2020). This event also exposed alarming levels of gender inequality and the pronounced climate vulnerability of women in Serbia. During the imminent danger, men (especially older men who had completed their National Service) were at an advantage because they owned boats and possessed basic knowledge of rescue procedures. Consequently, single women and single mothers were at greater risk than those with male household members and much more dependent on both organized assistance and informal support (Baćanović, 2014: 29-30).

It will have significant effects on overall health and quality of life, which will impact the health system, and almost all sectors of the economy will experience challenges of some kind; people will be pushed to migrate from areas particularly affected by climate change (for example, due to loss of agricultural opportunities, economic decline, frequent floods, landslides, droughts, fires, etc.). Having this in mind, it is obvious that future population policies will have to take into account the effects of climate change and environmental disturbances that adversely affect all three components of depopulation: fertility, mortality and migration. In this sense, the next chapter will consider the relationship between climate change and population dynamics in Serbia.

Based on the case studies discussed so far, we have had the opportunity to see that climate change is already adversely affecting the population of Serbia, primarily through increased morbidity and mortality, but also through forced migration. Unfortunately, studies examining the impact of climate change and pollution on fertility have not been conducted, while research examining the specific impact of climate and environmental factors on migration is scarce. What we know from the existing studies on migration in Serbia (see chapter on migrations) is that, for now, economic reasons are the

Lifestyle migrations in Serbia

Lifestyle migrations of the upper-middle classes can be expected in Serbia in the future, but mostly in the form of "secondary homes" in environmentally attractive areas, in addition to primary homes located mostly in the urban centres.

One of the examples is Fruška Gora. The eastern part of Fruška Gora, which is in the vicinity of the Belgrade – Novi-Sad highway, has always been an attractive location for country houses. However, for some years now, and especially with the COVID 19 pandemic, this has expanded to the whole mountain (especially in Vrdnik, which was in significant demographic decline). This trend can also be observed on Mt. Kosmaj, in Veliko Gradište, Golubac, and in the area between Užice and Zlatibor.

However, it is doubtful whether these processes actually add to the repopulation of existing villages, since lifestyle migrants usually opt for new houses built in new settlements, sometimes in former agricultural or even forest land, avoiding empty houses in the nearby villages.

main incentive for migration. However, the global trend of increasing ecological refugees and lifestyle migration indicate that in Serbia, too, an increase in this form of spatial movement can be expected in the near future. Of course, it should be borne in mind that climate and environmental migration can be mediated by economic factors. As said, the decrease of income from agriculture due to climate change can encourage a number of people to leave rural areas in search of better living conditions. On the other hand, environmental and climatic factors, such as extreme weather events, can directly affect temporary or permanent relocation, as was the case with Obrenovac residents after the 2014 floods. It is important to emphasize here that without very detailed and focused research, it is impossible to separate the influences of climatic and environmental factors from the influence of socio-economic and political factors, and changes in (perception) of quality of life on migration decisions. Similarly, without focused research, it is not possible to determine the isolated impact of climate and environmental factors on the other two components of (de) population – mortality and fertility, because they are mediated by a complex set of socio-economic factors (e.g. lack of a developed healthcare system and the system that informs citizens about environmental risks and prevention measures; lack of technological and infrastructural preparedness of the state for extreme weather events, etc.), as we have seen in the presented case studies.

In the next section, we shift our attention from the observed effects of climate change to projections of future climate effects on population dynamics in Serbia.

2.2 Population Dynamics and Climate Change in Serbia

Connecting population dynamics and climate change is a complex and often controversial task. It is important that any discussion of the links between the two takes into consideration both the size of the population and its structure, as well as consumption patterns. It is much fairer to say that consumers, rather than people, contribute to climate change; and important to recognize that there is a significant variation in contribution to climate change between developed countries (with intense consumption and low fertility rates) and developing countries (with negligible consumption and high fertility rates).[224] It should also be clear that socio-demographic factors (e.g. growth rates, composition, spatial distribution and education levels) affect the adaptive and mitigation potential of populations. Last but not least, migration should be regarded as a crucial aspect linking population and climatic change (Stephenson et al., 2010).

One of the analytical tools used to better understand the interplay between population growth and composition, climate change and socio-economic development, is the concept of Shared Socio-economic Pathways (SSPs) has been introduced (KC & Lutz, 2017). SSPs are scenarios of projected socioeconomic and climatic global changes up to 2100[225] based on five narratives describing alternative socio-economic and climate developments (Riahi et al., 2017). Up until recently, climate models have included only very rough estimates of future population changes. However, SSPs scenarios take into consideration multiple population characteristics (Lutz & Striessnig, 2015). The basic ideas behind the SSPs storylines are presented in the box and summarized in Figure 6 (for an extended description of the SSP storylines, see: O'Neill et al., 2014; O'Neill et al., 2015; Fricko et al., 2016). In a nutshell, these narratives describe the alternative paths of future society. SSP1 and SSP5 scenarios predict relatively optimistic future human development, with significant investments in education and health, fast economic growth and well-functioning institutions. They are different in the sense that SSP 5 assumes this will be driven by an energy-intensive economy based on fossil fuels, while in SSP1 there is a growing shift towards a more sustainable society. SSP3 and SSP4 are more pessimistic regarding future economic and social development, with little investment in education or health in poorer countries, coupled with rapid population growth and growing inequalities. SSP2 is a "middle of the road" scenario with historical patterns of development that continue throughout the 21st century.[226]

Table 1 shows the correlation of key components of population change with the SSP models. The yellow colour in the table indicates the group of countries with low fertility to which Serbia belongs. In this part of the research, the method of multi-dimensional mathematical demography was used to project the Serbian population based on alter- native assumptions on future fertility, mortality, migration and educational transitions that correspond to the five shared socioeconomic pathways (SSP) storylines (for more details, see: KC & Lutz, 2017).

[224] Of course, one should be aware of the cases of China and India (the world's two largest countries, by population) that combine population growth with already globally significant levels of greenhouse gas emissions.

[225] https://unece.org/fileadmin/DAM/energy/se/pdfs/CSE/PATHWAYS/2019/ws_Consult_14_15.May.2019/supp_doc/SSP2_Overview.pdf (Accessed 05/10/21).

[226] https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change (Accessed 05/10/21).

Shared Socio-economic Pathways

SSP1 Sustainability (Taking the Green Road) (small challenges for mitigation and adaptation to climate change). This scenario assumes moving toward a more sustainable future characterised by better management of global common goods, emphasis on human well-being, health and education instead of economic growth, which, on the other hand, accelerates demographic transition to a relatively low world population (KC & Lutz, 2017; Riah et al., 2017). This scenario corresponds to the previously more frequently used IPPC RCP2.6 (significant mitigation)[227] scenario, which is considered to be a stabilization scenario and rather optimistic, envisioning the stabilization of CO2 emissions from 2040 onwards. In demographic terms, this path leads to lower mortality and higher education in all countries. In rich OECD countries, it is expected that the emphasis on quality of life will make it easier for women to combine work and family, preventing further fertility decline. For this reason, for this group of countries, the medium fertility assumption was chosen in the prediction model developed by KC and Lutz. For all other countries, the assumption of low fertility was anticipated, stemming from the assumption of the rapid continuation of demographic transition. Migration levels were anticipated to be at a medium level for all countries (KC & Lutz, 2014, 2017).

SSP2 Middle of the Road (medium challenges for mitigation and adaptation to climate changes). In this scenario, the world does not shift considerably from the present-day trajectory, with the continuation of the observed social, economic, and technological trends. Development and income growth proceeds unevenly, and the global efforts toward achieving sustainable development are relaxed. This scenario corresponds to the RCP4.5 climate scenario (moderate mitigation). Environmental systems still experience degradation and the environmental challenges remain, al- though there are some improvements in resource consumption. Global population growth is moderate (Riah et al., 2017; Fricko et al., 2016).[228] All countries are ex- pected to have medium fertility with medium mortality and medium migration (KC & Lutz, 2014, 2017; for more details see: KC and Lutz, 2017 and Dellink et al., 2017).

SSP3 Regional Rivalry (great challenges for mitigation and adaptation to climate changes). This scenario refers to a fragmented world with an emphasis on national sovereignty and security at the expense of international development. A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic issues. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or even increase over time. A low international priority given to environmental concerns leads to strong environmental degradation in some regions. The international movement of people is controlled and restricted. It presumes high mortality and low education for all countries. Fertility is assumed to be low in the rich OECD countries and high in the rest of the world. Due to the emphasis on security and barriers to international exchange, migration is expected to be low for all countries (KC & Lutz, 2017; Fujimori et al., 2017).

SSP4 Inequality (A road of divisions) (low challenges for mitigation, high challenges for adaptation). This scenario refers to a world characterised by high inequalities. Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, the gap widens between an internationally-connected society that contributes to knowledge and the capital-intensive sectors of the global economy, and a fragmented collection of lower-income, poorly educated societies that work in a labour-intensive economy. In terms of fertility, this scenario implies continued high fertility in today's high fertility countries and continued low fertility in other countries. The high fertility countries are expected to suffer from high levels of mortality, whereas the others have medium mortality. Migration is expected to be at a medium level for all countries (Calvin et al., 2017; KC & Lutz, 2014, 2017).

SSP5 Development based on fossil fuel (great challenges for mitigation, low challenges for adaptation). This scenario refers to a world that underlines technological progress and where economic growth is fostered by strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of fossil fuel resources and the adoption of a lifestyle that implies consumption of resources and energy around the world. All these factors combined lead to fast growth of the global economy. This scenario corresponds with the RCP8.5 climate scenario with no mitigation of usual emissions. In demographic terms, it is assumed that all this will be reflected in high education and low mortality in all countries. The fertility pattern is strongly differentiated, with relatively high fertility anticipated for the rich OECD countries, and low fertility for all other countries. The emphasis on market solutions and globalization implies high levels of migration for all countries (KC & Lutz, 2017: 184; Kriegler et al., 2017).

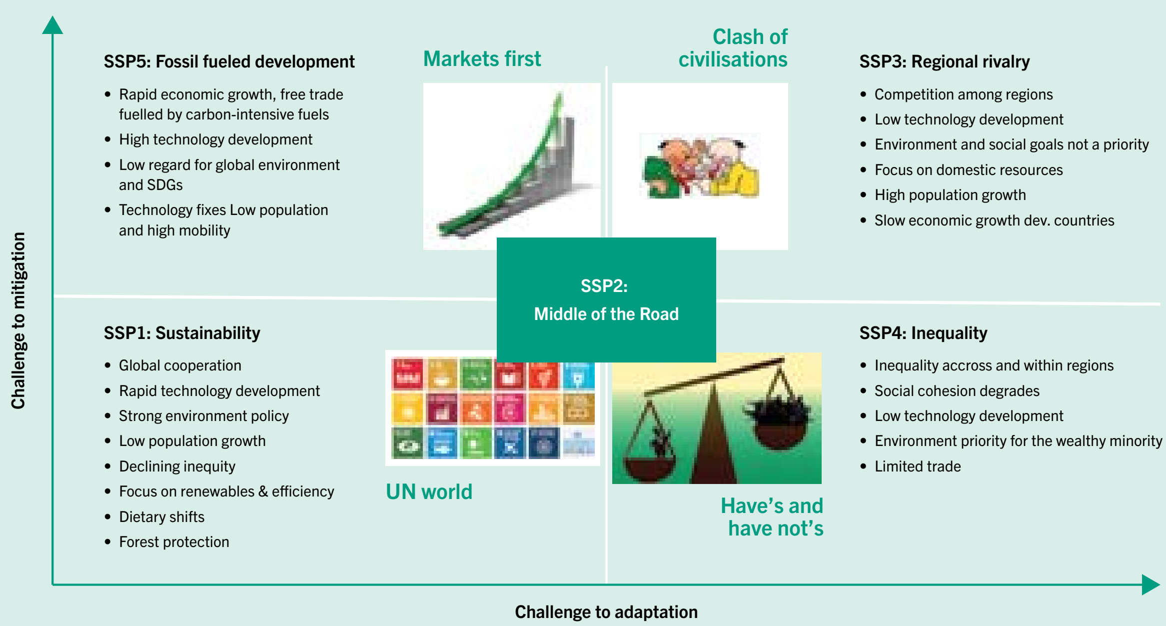


Figure 6. Shared Socio-economic Pathways

Source: https://unece.org/fileadmin/DAM/energy/se/pdfs/CSE/PATHWAYS/2019/ws_Consult_14_15.May.2019/supp_doc/SSP2_Overview.pdf (accessed 14/11/21)

[227] RCP stands for Representative Concentration Pathways

[228] https://unece.org/fileadmin/DAM/energy/se/pdfs/CSE/PATHWAYS/2019/ws_Consult_14_15.May.2019/supp_doc/SSP2_Overview.pdf (Accessed 05/10/21)

	Country groupings	Fertility	Mortality	Migration
SSP1	High fertility group	Low	Low	Medium
	Low fertility group	Low	Low	Medium
	Rich - OECD	Medium	Low	Medium
SSP2	High fertility group	Medium	Medium	Medium
	Low fertility group	Medium	Medium	Medium
	Rich - OECD	Medium	Medium	Medium
SSP3	High fertility group	High	High	Low
	Low fertility group	High	High	Low
	Rich - OECD	Low	High	Low
SSP4	High fertility group	High	High	Medium
	Low fertility group	Low	Medium	Medium
	Rich - OECD	Low	Medium	Medium
SSP5	High fertility group	Low	Low	High
	Low fertility group	Low	Low	High
	Rich - OECD	High	Low	High

Table 1. Demographic Components with Regard to Shared Socio-economic Pathways Scenarios

Adapted from: KC & Lutz, 2017: 184

Within the framework developed by KC and Lutz (2017), Serbia belongs to the Low Fertility group (Table 1).

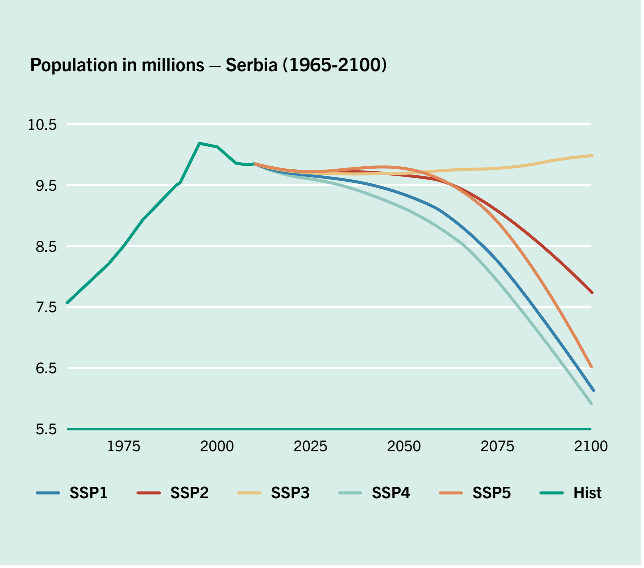
In population projections the starting point and the most important piece of information is the total size of the population (Graph 1). Four out of five projections envision a significant population decline in Serbia by the end of the century. The only exception is the SSP3 scenario (regional rivalry) characterised by high fertility and significantly restricted movement of the people.

In the SSP1 scenario in which the sustainability path is selected, the population of Serbia (with Kosovo[229] and Metohija) will start to decline sharply after 2050, reaching the level of around 6 million at the end of the century. SSP1 envisions low fertility and mortality rates combined with medium migrations, which means that the migration component will be the leading factor of the depopulation process in Serbia.

The "Middle of the road", SSP2 scenario predicts population decline after 2060, but not as sharp as in the previous case, whereby the population Will number close to 7.7 million at the end of the century.

The SSP2 scenario Provides for medium levels of fertility, mortality and migration in Serbia, keeping the total number of people more stable than in the SSP1 scenario.

In the SSP3 scenario, characterised by rising nationalism, closing of borders and competition between the nations, migrations are project-



Graph 1. Population Change According to SSP Scenarios

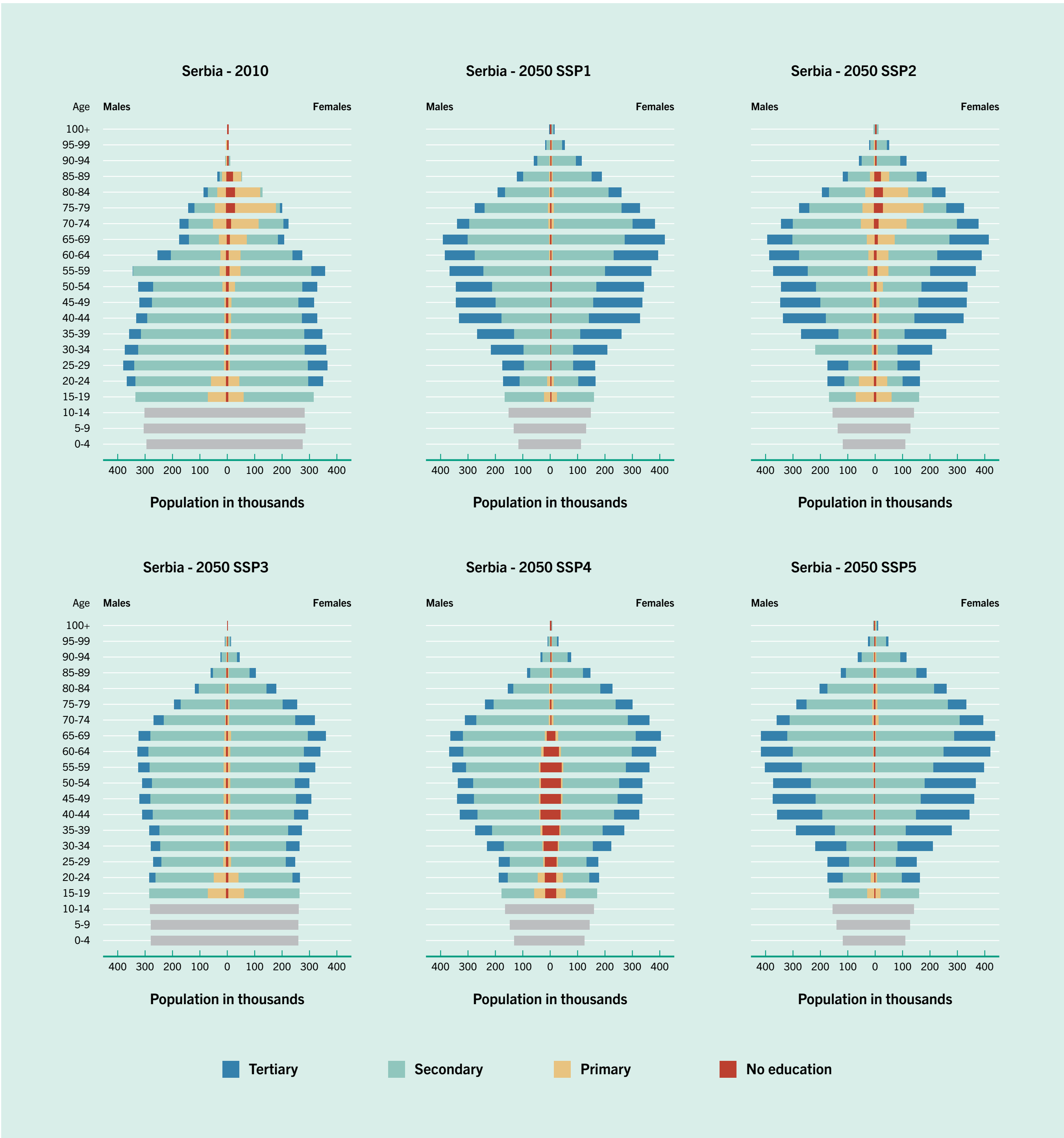
Source: https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=30 (accessed 14/11/21)

[229] References to Kosovo shall be understood to be in the context of Security Council resolution 1244 (1999).

ed as low (combined with a rather high level of fertility and mortality), which will lead to a slight increase in the population to around 10.1 million. However, the increase in the number of people is due to their limited movement and comes about in the unfavourable context of a high mortality rate and international rivalry and conflicts.

The SSP4 model predicts the sharpest decline in the total number of people in Serbia (less than 6 million in 2100). This will be the result of low fertility and medium mortality and migration. The entire context will be characterised by pronounced social inequalities, low social cohesion, low technological development, and the neglect of the environment.

Finally, the SSP5 scenario, which is the most pessimistic in terms of climate, envisions a population decline to the level of approximately 6.5 million. Such an outcome is the result of a combination of high migrations and low fertility and mortality rates.



Figures 7.1–7.6 Population pyramid projections in accordance to the SSP scenarios, Serbia 2010 - 2050

Source: https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=30 (accessed 14/11/21)

Although important, the total size of the population does not give the entire picture of future demographic trends. Therefore, population projections need to go beyond the consideration of population size alone. This is important because human populations are not homogeneous and this heterogeneity greatly matters for the future growth of the population. Populations that have only a small proportion of women or with more older people are likely to have lower birth rates than populations of comparable size, but with a larger proportion of women in reproductive age. In this sense, future population growth is a direct function of the age- and sex-structure of the population, and for this reason it is important that population projections explicitly incorporate these two sources of population heterogeneity and define their assumptions in the form of a specific fertility, mortality and rate of migration for various age categories. The age- and sex-composition of the population is also of interest in its own right. Population aging is considered a highly important socio-economic issue, which can only be quantitatively addressed if the age-structure of a population is explicitly incorporated in the projection model (KC & Lutz, 2017).

Figures 7.1-7.6 give sex-, age- and education-pyramids as projected for Serbia under the five scenarios, with the year 2010 as the starting year. Given that most of the assumptions integrated into the SSP scenarios (with the exception of mortality) mostly affect the younger population, and the time horizon is only 40 years, the five pyramids (7.2-7.6) are quite similar to one another regarding the older population but differ for the younger cohorts. Population aging is evident in all scenarios with reverse pyramid trends (narrowing of the base of the age pyramid) in all cases, with the exception of the SSP3 scenario. The overall education of the population is expected to improve in the next four decades, but some scenarios are worse than others regarding population educational levels. For instance, the SSP4 (inequality) scenario envisions a considerable share of young people without formal education.

This section was intended to point out the connectedness between climate change and demographic movements. While the previous section showed the reader how climate change is already affecting the population, this section examined possible futures. Of course, climate models and demographic projections do not provide an unambiguous answer to the question of what the future will look like, but they clearly show that climate change significantly affects demographic trends, both globally and locally, and that decision-makers at all levels must take this factor into account in formulating population policy. In other words, it is necessary to understand that, in a certain sense, climate policy is at the same time demographic policy, albeit that the opposite is also true, as if these were two sides of the same coin. Climate changes adversely affect population size and structure, as well as the quality of life. Likewise, population growth coupled with unsustainable consumer styles has the effect of increasing climate risks. The most important message of this section is that population policy must take climate change into account, both the changes already observed, and also future projections.

3 Air Pollution and the Depopulation Processes in Serbia

3.1 Air pollution in Serbia

In addition to climate change, air pollution is one of the biggest environmental challenges in Serbia. Air pollution is measured by the concentration of particulate matters (PM) and the size of the particles is directly linked to their potential for causing health problems. Small particles (less than 10 micrometres in diameter) pose the greatest problems, because they can reach deep into the lungs, and some (less than 2.5 micrometres in diameter) may even reach the bloodstream. Exposure to such particles can affect both the lungs and the heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including: premature death in people with heart or lung disease, non-fatal heart attacks, irregular heartbeat, aggravated asthma, reduced lung function, increased respiratory symptoms, (such as irritation of the airways, coughing or laboured breathing. The latest WHO report estimates that the annual mean PM2.5 concentration in the country reaches 19.4 μg/m^3, with somewhat higher mean levels in urban zones (21.0 μg/m^3) compared to rural areas (19.4 μg/m^3). These figures are significantly higher than the average annual mean PM2.5 concentration in Europe as a whole (14.0 μg/m^3) and the WHO recommended value (10μg/m^3) (WHO, 2019).

The main sources of air pollution in Serbia are the following: 1. the energy sector (thermal power plants, district heating plants and individual household heating); 2. the transport sector (an old vehicle fleet); 3. waste dump sites; 4. manufacturing activities (oil refineries, the chemical industry, mining and metal processing and the construction industry). The most important individual contributors to air pollution include the petrochemical industry complexes in Pančevo and Novi Sad; cement factories in Popovac, Kosjerić and Beočin; chemical plants and metallurgical complexes in Smederevo, Sevojno and Bor; thermal power plants in Obrenovac, Lazarevac and Kostolac (WHO, 2019).

One of the factors that contributes to air pollution is the use of coal for electricity generation and individual household heating. In Serbia, the level of pollution is particularly high as 72.4% of electric energy is produced from coal, usually of a very low quality. As much as

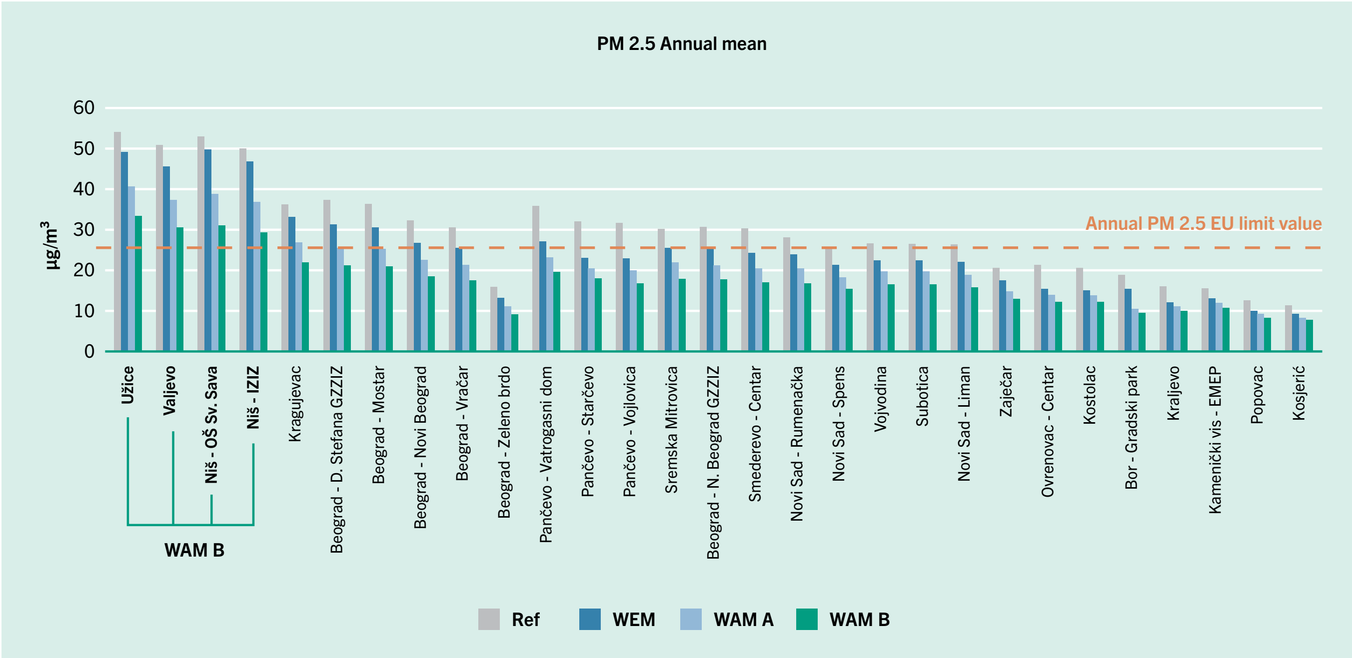


Figure 8. Annual mean concentrations of PM 2.5 according to different scenarios WEM, WEM A, WEM B

Source: Real, 2021

32 million tons of that coal are burned annually in Serbia (Carvalho, 2019). Recent information suggests that the increased use of tailings for heating (instead of coal) additionally increases the already high levels of pollution in Serbia (BGEN, 2020b). It also should be noted that the emissions Western Balkans are almost as high as from the 296 existing coal plants in the EU-28. Coal power plants in the Western Balkans emit 13 times more SO2 and 30 times more PM2.5 per installed megawatt than the average European plant. From the 1st January 2018, the countries of the Western Balkans have been expected to start reducing their emissions for large combustion plants and align national laws and regulations with those of EU ones. This process stems from the Energy Community rules, which require coal plants currently operating in the Western Balkans to cut their emissions gradually until the end of 2027. However, it is already becoming clear that operators are struggling to keep to the limit values for emissions (Matkovic Puljic et al., 2018).

Cities with exceeding levels of PM2.5 in Serbia are: Užice, Valjevo, Niš, Kragujevac, Beograd, Pančevo, Novi Sad, Sremska Mitrovica, Smederevo, and Subotica (figure 8) where approximately 2,7 million people or about 40% of total population live. Even with significant improvements, the annual levels of PM2.5 will still be above the EU limits (25 μg/m^3)[230] and far above the WHO recommended value (5 μg/m^3) in Užice, Valjevo and Niš (Figure 8).

According to the 2021 Annual progress reports of the European Commission for Serbia in the field of air quality, Serbia has attained a good level of alignment with the EU acquis. However, Serbia has to speed up implementation of the existing laws including air quality plans, and further improve its air quality monitoring system. Adopting the EU air quality index is stressed as a key recommendation. The unfavourable situation with the air pollution in Serbia has prompted certain policy initiatives in this area, such as the development of the Air Protection Program (WHO, 2019). However, this is only the initial phase.

3.2 Impact of air pollution on public health, morbidity and mortality in Serbia[231]

Exposure to air pollution, especially airborne particulate matter (PM), is associated with increased mortality and morbidity, mostly from cardiovascular and respiratory diseases. The World Health Organization (WHO) estimated that exposure to ambient air pollution accounted for 4.2 million premature deaths globally in 2016, including half a million in the WHO's European region (WHO, 2019). These particles have been recognized as the main risk factor associated with air pollution. Around 83% of all deaths related to air pollution in Europe in 2015 can be attributed to PM2.5, particles, 14% to NO2[232], and the remaining deaths are attributed to ozone (Carvalho, 2019).

An analysis of the countries and territories with multiple deaths attributed to air pollution, reveals that the region of Eastern and South-

[230] https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health(accessed 10/02/2022)

[231] Although there is not enough space in this chapter to deal with the other sources of pollution in Serbia, one should keep in mind that they also have a certain negative impact on the overall health and livelihoods of people (for more information see: Environmental Report, 2019).

[232] Nitrogen dioxide

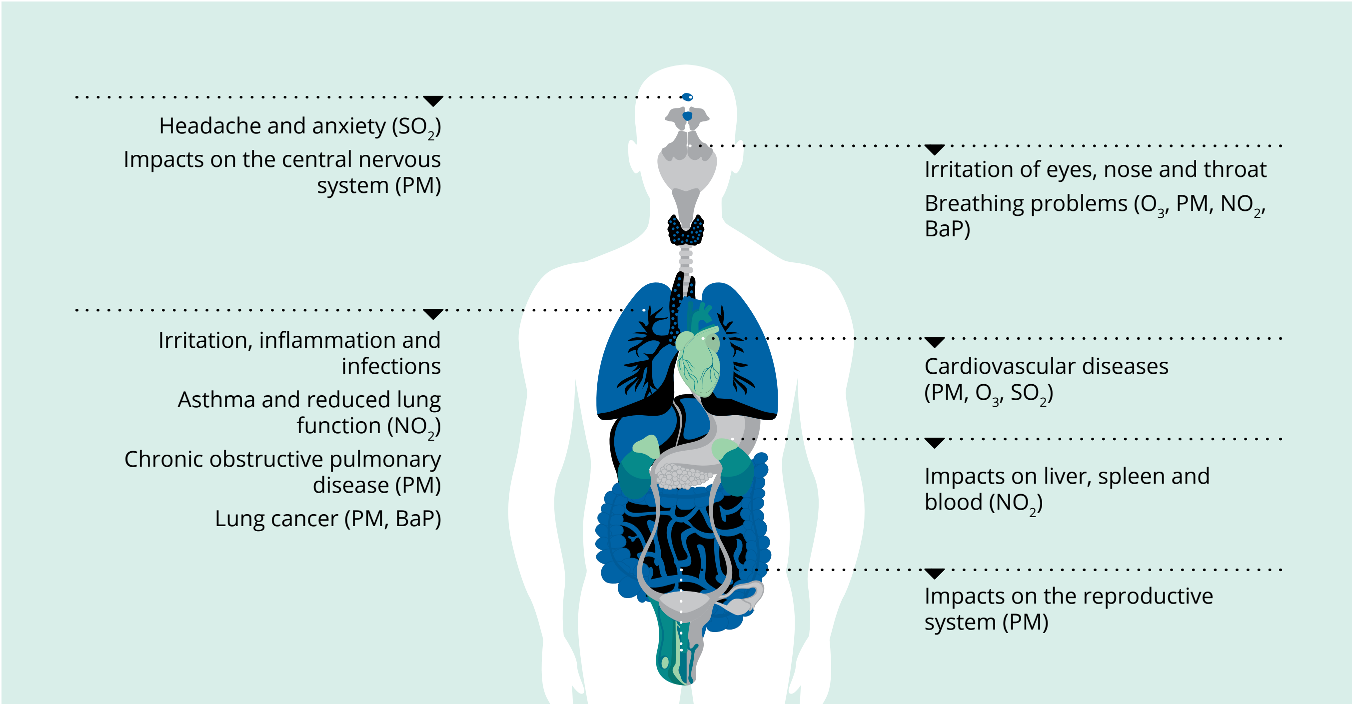


Figure 9. Health impacts of air pollution

Source: EEA, Healthy environment, healthy lives, 2019.

ern Europe has the lead, with Kosovo, Bulgaria, Serbia, Macedonia and Hungary at the very top of the list (Table 2).

The annual mean PM2.5 levels for most of the countries and territories with an increased mortality rate are four times higher than the WHO recommended level of 5 μg/m³.

According to the 2020 Report on Air quality in Europe (EEA, 2020: 158), it is estimated that over 16,000 people die prematurely in Serbia due to the level of air pollutants being exceeded. Other sources estimate the number of premature deaths due to air pollution to 6,592 (WHO, 2019) and 9,773 (Air Protection Programme in the Republic of Serbia with an action plan[234]). Although estimates differ, it is clear that the situation is far from ideal, as every year the population of a small town disappears.

Estimations of premature deaths attributable to excessive levels of PM2.5 (WHO air quality guideline of 10 μg/m³) are summarized in table 3. As estimated by WHO, 3,585 premature deaths in the 11 cities can be attributed to exposure to high levels of PM2.5. The estimated proportion of all deaths attributable to PM2.5 is highest Užice and Valjevo (almost 19%) where mean concentrations of PM2.5 are four times higher than recommended. In absolute terms, air pollution has by far the highest impact in Belgrade. However, when estimated per 100,000 inhabitants, the existing concentration of PM2.5 is associated with the highest relative impact on health, in Valjevo and Užice (WHO, 2019:14).

Rank	Country/ territory	Deaths by 100.000 inhabitants	Annual mean PM 2.5 μg/m³	% Energy produced from coal
1	Kosovo[233]	215.5	26.4	97.5
2	Bulgaria	210.9	24.1	46.2
3	Serbia	200.7	23.3	72.4
4	Macedonia	154.7	28.7	58.4
5	Hungary	148.4	18.9	19.5
6	Italy	138.7	18.5	16.7
7	Greece	137.3	19.1	42.7
8	Romania	137.3	18.1	27.6
9	Poland	125.0	21.6	80.9
10	Croatia	122.1	17.4	20.6
11	Montenegro	110.9	18.5	50.3
12	BH	105.1	18.9	64.0
13	Czech Republic	104.9	17	54.0
14	Slovenia	99.9	17.4	29.6
15	Slovakia	99.8	19.1	11.9

Table 2. European countries and territories with higher death rates attributed to air pollution, Air Quality Report 2018

Source: Carvalho, 2019.

[233] All references to Kosovo shall be interpreted in accordance with Security Council Resolution 1244 (1999).
[234] https://eas3.euzatebe.rs/rs/o-projektu (accessed 14/11/21)

City	Mean concentration (µg/m³)	Total population	Population aged ≥ 30 years	Estimated attributable deaths		Estimated attributable proportion	
				No.	CI	%	% (95% CI)
Beočin	22.2	15 304	10 183	14	9-18	7.1	4.68 - 9.29
Belgrade	29.2	1 364 453	937 461	1796	1194 - 2337	10.9	7.25 - 14.19
Old Belgrade	29.4	932 813	640 819	1259	838 - 1639	11.0	7.34 - 14.37
New Belgrade	28.7	431 640	296 642	539	358 - 702	10.7	7.08 - 13.87
Kosjerić	31.1	11 341	8 234	25	17 - 33	11.9	7.93 - 15.46
Kragujevac	30.5	178 610	122 020	250	166 - 324	11.6	7.74 - 15.11
Lazarevac	34.2	57 735	37 999	104	69 - 135	13.5	9.05 - 17.54
Niš	29.2	257 883	176 513	354	236 - 461	10.9	7.27-14.23
Novi Sad	22.8	350 930	231 604	280	185 - 367	7.4	4.90 - 9.72
Obrenovac	31.9	72 323	48 594	117	78 - 152	12.3	8.24-16.04
Smederevo	39.3	105 774	70 221	223	150 - 287	16.2	10.87 - 20.85
Užice	44.4	75 805	52 856	180	121 - 231	18.7	12.62 - 23.98
Valjevo	44.6	87 944	61 802	242	164 - 311	18.8	12.69 - 24.1
All		2 578 102	2 694 948	3 585			

Table 3. Total long-term mortality due to PM2.5 in 11 Serbian cities

Source: WHO, 2019: 12

In the continuation of this section of the report, we rely on the data gathered through the project "Air Protection Programme in the Republic of Serbia with an action plan". Within the project, four scenarios of air pollution in Serbia until 2030 were made (WEM, WAM-A, WAM-B, WAM-C). The analysis of the impact of air pollution on population health, morbidity and mortality is based on information on the levels of primary air pollution emissions from a number of scenarios: the reference scenario from 2015 (REF), which is the baseline scenario compared to a projected scenario for 2030 which assumes the application of existing regulations (WEM 2030), and three mitigating scenarios: WAM A, WAM B and WAM C (Šuht, 2021: 1). Each scenario implies additional efforts (with additional measures) compared to the preceding one.

- WEM: with existing measures. The scenario includes policies and measures adopted and implemented by January 1, 2019.
- WAM A: with additional measures A. Relevant EU directives and regulations are not yet fully transposed and implemented;
- WAM B: with additional measures B. More intensive control than in the case of WAM A. In addition to WAM A measures, stricter emission limits are introduced in some sectors and measures are set for national financial and fiscal measures for key categories of emission sources;
- WAM C: with additional measures C. Complete control scenario. In addition to WAM B measures, new measures are introduced,

Scenario	REF	WEM	WAM A	WAM B	WAM C
Year	2015	2030	2030	2030	2030
PM 2.5 (µg/m³)	17.4	13.9	12.5	10.8	10.2
SOMO35 (ppb,dana)[235]	3,036	2,559	2,512	2,469	2,466
NO_2 (µg/m³)	9.1	6.5	5.9	5.3	5.2
Population size 2015: **7 108 454**					

Table 4. Average annual exposure of the population in relation to the scenarios

Source: Šuht, 2021: 12

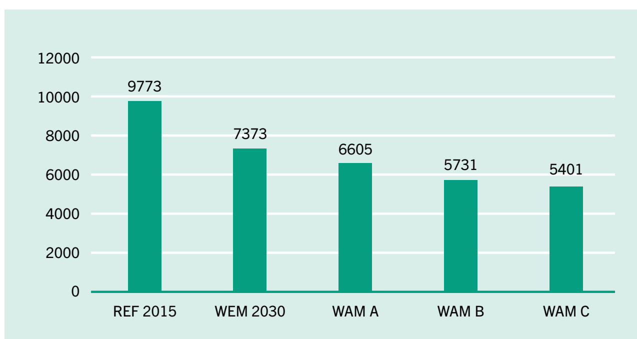


Figure 10. Number of annual premature deaths in Serbia caused by air pollution

Source: Šuht, 2021: 15

[235] SOMO35 means the sum of mean ozone values greater than 35, and it is an indicator for health impact assessment recommended by the WHO. It is defined as the annual sum of daily maximums of 8 hours on average for more than 35 ppb (https://www.emep.int/mscw/definitions.pdf).

including site-specific measures (e.g. incentives, restrictions and prohibitions) aimed at ensuring compliance with air quality limit values in certain cities (Directive 2008/50/EC, in particular for suspended PM10 and PM2.5 particles).

The impact of the implemented measures on the concentration of air pollutants are represented in Table 4. With the implementation of the two more ambitious scenarios WAM B and WAM C, Serbia would practically meet the WHO recommendations regarding the levels of PM 2.5.

Figure 10 represents a drop in the number of premature deaths in Serbia in accordance with the implementation of different scenarios. With the implementation of the least ambitious scenario WEM, which practically means compliance with the existing laws on air protection, including the National Emission Reduction Plan, 2,400 lives would be saved per year. This scenario envisages desulphurization in state-owned thermal power plants (interventions regarding individual household heating and transportation are not included), which should be managed by the state authorities. If the WEM C scenario (the most restrictive) was applied, compared to the current situation (REF 2015), the number of premature deaths from air pollution would be almost halved and reduced to 5,041 people per year. In other words, with the implementation of the WAM C scenario, it is estimated that 4,382 lives per year would be saved. Estimated negative health impacts which would be avoided in 2030 thanks to the implementation of the mitigation scenarios (WAM A - WAM C), comparison to WEM are further elaborated in Table 5.

In terms of money, according to international standards, every avoided case of premature death or any other impact on health (hospital admission due to respiratory or cardiovascular disorders, bronchitis, days of reduced working capacity, days of absence from work etc.), is an economic benefit for the whole of society. The net benefits are equal to the annual avoided health care costs (health benefits) minus the additional annual investments and operating costs (for the implementation of measures), according to mitigation scenarios and compared to WEM 2030 (Cavalhiero, 2021: 8). Additional measures (WAM A, WAM B, WAM C) to reduce emissions could save up to 3 billion euros in health care costs up to 2030. This can be seen from the graph in Figure 10, which shows the avoided health damage (= benefits), compared to the basic WEM 2030 scenario. The lower estimated benefit for this scenario, which relies on the mortality rate according to VOLY[236], is € 800 million (Šuht, 2021). On the other hand, VSL[237] methodology estimates the negative health impact of air pollution at 15,6 billion euros (4.6 billion euros VOLY) for REF year 2015, compared to the most optimistic scenario WEM C – 8.6 billion euros VSL (value of statistical life) (2.3 billion euros VOLY) annually (see figure 11). What is indicative is that with the implementation of measures envisioned by the existing legislation (REF 2015 - WEM) alone, somewhere between 1.5 billion (VOLY) and 4 billion euros (VSL) of health costs could be saved. However, it should be taken into consideration that different scenarios demand different levels of investment. For example, it is estimated that the implementation of WAM A will cost around 1 billion euros, while WAM B and WAM C will cost 2.8 and 2.9 billion euros respectively.[238]

Scenario / indicator	WAM A in comparison to WEM 2030	WAM B 2030 in comparison to WAM A 2030	WAM C 2030 in comparison to WAM B 2030
Cases of premature death of PM2.5, per year	768	1,642	1,972
Lost years of life cause by PM2.5, per year	6,289	13,446	16,142

Table 5. Negative health impacts that were avoided in 2030 as a result of implementation of mitigation scenarios, in comparison to WEM

Source: Šuht, 2021: 14

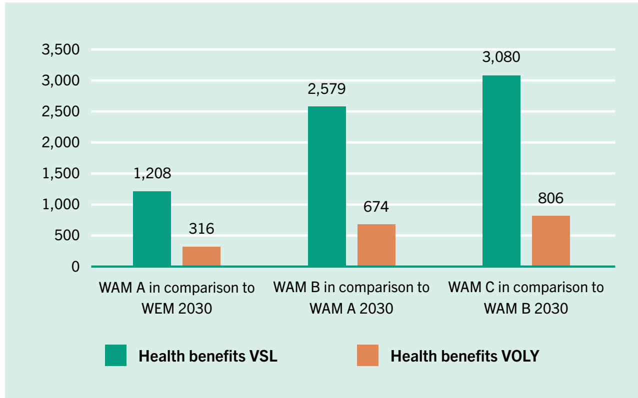


Figure 11. Benefits to health in comparison with WEM 2030 in millions of euro

Source: Šuht, 2021

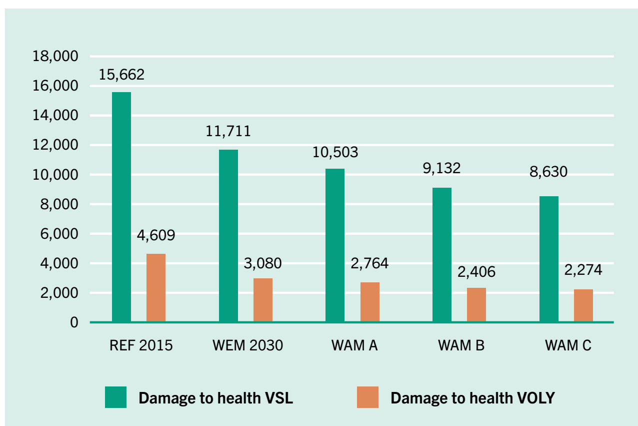


Figure 12. Total annual damage to health in millions of euro

Source: Šuht, 2021

[236] VOLY stands for value of a life year.
[237] VSL stands for value of statistical life.
[238] https://drive.google.com/file/d/1uf1aNcO4uayRqEKagZtEe6nPXmp6aFyY/view (Accessed 14/11/21)

To conclude, the presented data show that every year a population of the size of a smaller town disappears in Serbia as a result of air pollution with the health cost that amounts up to 15.6 billion euros annually. This puts Serbia at the very top of the list of the European countries with regards to air pollution. The largest part of the air pollution is attributable to the state-owned thermal power plants and district heating plants, which means that the improvements in this sector largely depend on the willingness of the government to tackle this issue. It should also be noted that most of the European laws regarding air protection have been transposed into domestic legislation and that their implementation would save 2,400 lives every year as well as up to 4 billion euros (in healthcare costs) annually. Therefore, the first step would be to implement the existing laws.

4 Recommended measures

The general recommendation is that climate change and environmental degradation should be taken as an important factor of (future) depopulation in Serbia - either through a direct impact on the quality of life, mortality, birth rates and migration, or indirectly through economic decline and a loss of vitally important natural resources. Therefore, improvements in terms of mitigation and adaptation to climate change and reduction of pollution should have multiple positive effects on all three aspects of population change: fertility, mortality and migration.

The implementation of existing measures in line with European environmental legislation would result in significant progress in reducing morbidity and mortality due to air pollution and climate change. For example, the new Law on Climate Change[239] adequately regulates this area, however it is necessary to develop bylaws and to work on their implementation. Bylaws should be developed having in mind the adverse effects of climate change on the population and human development, as well as the need to promptly act on reversing observed trends.

Reducing the levels of air pollution in accordance with the WAM scenarios is complex and involves significant technological advances, policy measures and their implementation, as well as campaigns to raise public awareness. However, it is clear that implementing stricter regulations would significantly reduce the number of premature deaths and improve the overall public health. Controlling the air pollution from the coal power plants presents a huge opportunity to save lives and millions of euros in healthcare costs in the next decade.

Additional intervention directly aimed at reducing air pollution could be: 1.) reducing the use of low-quality coal and solid fuels in the energy sector; 2.) increasing the use of low-emission fuels and renewable power sources; 3.) reducing emissions from industrial sites by implementing new technologies; 4.) increasing the energy efficiency of buildings; 5.) stimulating sustainable urban mobility; 6.) upgrading the air quality monitoring system in order to make pollution data more accurate, accessible, personalized and applicable for citizens; 7.) improving general awareness of the health risks of air pollution.

The isolated impact of environmental factors on fertility have not yet been researched in Serbia, and it is recommended that a research study exploring the links between pollution and male and female infertility be conducted.

[239] http://www.parlament.gov.rs/upload/archive/files/cir/pdf/zakoni/2021/337-21.pdf (accessed 14/11/21)