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Vladimir Njegomir[1*]

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GLOBAL CLIMATE CHANGE: MACRO-ECONOMIC CHALLENGES

Abstract: The 20th century saw an unprecedented increase in global warming. Today there is little point in pondering whether global climate change is underway: the burning question is what its consequences for life on Earth, economy and human society are. The aim of the paper is to examine the impact of climate change trends and their challenges from a macroeconomic perspective. First, we examine the climate change trends in relation to economic development. In the sections that follow, we examine the impact of climate change on catastrophic damages and on national economies. Finally, we discuss economic approaches to mitigating climate change.

Key words: macroeconomic challenges, climate change, risk, economy

1. Introduction

Climate is defined as the average state of the atmosphere over a place or area in a certain period. In ancient times, it was believed that climate depends only on the inclination of the Sun's rays. In the 19th century, climate was defined as the average state of the atmosphere over a certain place or area. In modern times, climate is a statistical description of relevant meteorological conditions over a certain place or area of the Earth's surface, usually averaged at 30 years, considering the mean and variability of atmospheric conditions.

[1*] Full professor, Faculty of Law and Business Studies dr Lazar Vrkatić Novi Sad, email: vnjegomir@sbb.rs

Weather conditions cannot be described simply in terms of cause and effect. They are the outcome of complex systems in which many different factors influence each other, so that even the slightest variation in any factor can result in enormous consequences. Weather conditions are influenced by minor or major changes in shorter or longer periods in the atmosphere, biosphere, lithosphere, and hydrosphere. Consequently, it would be impossible to explain the change in weather conditions due to the variation of only one cause. Weather patterns also affect the changes in climate conditions. Therefore, it would be wrong to conclude that weather is under the influence of climate: rather it is the other way round. However, bearing in mind the evidence of climate change, which is defined as the long-term shift in the variability or average state of the atmosphere, it is possible to predict the trends of these changes in weather conditions.

Today there is little point in pondering whether global climate change is underway: the burning question is what its consequences for life on Earth, economy and human society are. On the one hand, global climate change will significantly affect the economies of certain countries, especially developing countries; on the other hand, economies can also provide a significant incentive to minimize the causes of climate change. Rising sea levels that affect islands and coastal cities, climate disturbances, extreme rainfall and droughts, uncertain harvests and other consequences of climate change will have a significant impact on the economy, but also on geopolitics, which will lead to rising migrations and public discontent. It is highly likely that climate change will permanently threaten the well-being of both present and future generations.

Understanding global climate change is necessary to gain insight into their potential effects, such as hurricanes, tsunamis, winter storms, or other natural disasters and their impact on the economy and decline in GDP and global well-being. Based on these insights, countries can make informed and timely decisions to minimize the factors that contribute to global warming, i.e., climate change. For any country, both future costs and its very survival may depend on the decisions that are made today. Therefore, climate change can serve as an example of a risk where long-term planning is of essential importance in order to avoid potentially catastrophic consequences. The purpose of this paper is to

examine the evident trends of climate change and their impact on the global economy, and to recommend change management options that would benefit economy in the future.

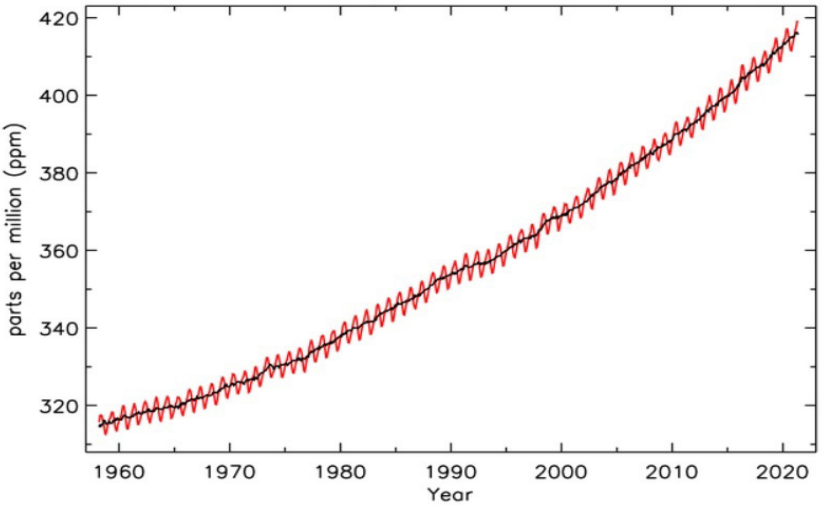
The aim of the paper is to examine the impact of climate change trends and their challenges from a macroeconomic perspective. First, we examine the climate change trends in relation to economic development. In the sections that follow, we examine the impact of climate change on catastrophic damages and on national economies. Finally, we discuss economic approaches to reducing the causes of climate change.

2. Climate change trends and economic development

The greenhouse effect was first proposed by the French scientist Jean-Baptiste Joseph Fourier in 1824. It was further investigated by the Swedish scientist Svante Arrhenius, who discovered that by absorbing solar radiation, the Earth's atmosphere allows the planet to warm up. The greenhouse effect is extremely important since the Earth would be much colder without it and could not sustain life. However, global economic activities and increases in gas emissions have caused an enhanced greenhouse effect, or global warming, which affects climate change.

Many studies have shown that climate change, or global warming, is a consequence of the increase in the carbon dioxide concentration in the atmosphere (CO2). Carbon dioxide is one of the basic elements capable of trapping solar radiation energy within a planet's atmosphere. It is clear why an increased concentration of this gas in the atmosphere results in an increased greenhouse effect. The increase in the concentration of carbon dioxide in the atmosphere in the period from 1957 to 2022 is shown in Graph 1.

Graph 1: Monthly mean atmospheric CO2 trends from 1957 to 2022, measured at Mauna Loa Observatory, Hawaii, USA



Source: GML (2022).

According to United Nations data, annual carbon dioxide emissions have increased by an average of 6.4 gigatons of carbon per year during the 1990s and to 7.2 gigatons per year from 2000 to 2005. This contributed to a 20percent increase in heat retention and re-radiation to the Earth between 1995 and 2005, the largest increase in the last 200 years. According to the fourth report of the Intergovernmental Panel on Climate Change (IPCC, 2007), an 80percent increase in carbon dioxide emissions was recorded from 1970 to 2004, which makes 77percent of the total emissions of greenhouse gases.

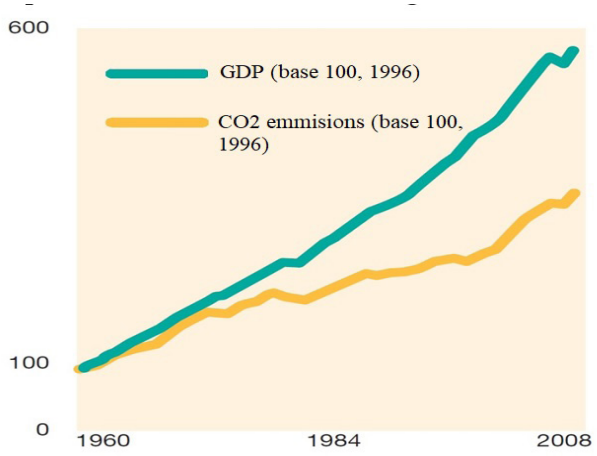
According to the fifth report of the IPCC (2014), if the emissions of greenhouse gases continue at the current rate, global mean temperature will rise between 3.7°C and 4.8°C by the end of the 21st century. The consequences may be disastrous: over 1.4 billion people could be exposed to water stress in Africa, the Middle East, and Southeast Asia.

In hindsight, it has become clear that it was the Industrial Revolution that kick-started climate change. Namely, data from the fourth report of the Intergovernmental Panel on Climate Change have shown that the concentration of atmospheric carbon dioxide before the Industrial Revolution was 280 parts per million (ppm), and that in 2005 it was 379 ppm. Also, the increase in the greenhouse effect in the industrial era is believed to be unprecedented in more than 10,000 years. If atmospheric CO_2 pollution were to continue by the current rate until 2050, the concentration of carbon dioxide would double in comparison to the pre-industrial period. Atmospheric C02 level would reach a critical 550 ppm, which would cause a temperature increase of 2 – 5 ^oC with a probability range of at least 77percent to as high as 99percent (Stern, 2006). The temperature increase would raise the risk of famine by 25 to 60percent, greatly threaten the availability of water, hasten a partial or complete decay of the Amazon rainforests, double the damage caused by hurricanes, and lead to the irreversible melting of the Greenland ice sheet.

Before the Fourth Report of the Intergovernmental Panel on Climate Change was published, there were different interpretations as to the causes of global warming and intensified greenhouse effect. However, the robust findings of the report have shown that the warming of the climate system is unequivocal, and that most of the global average warming over the past 50 years is very likely (greater than 90percent probability, based on expert judgement) due to human activities, i.e., industrialization. Without the increased CO2 emissions caused by human activity, and under the influence of only solar and volcanic energy, global cooling, not warming, would most likely occur.

Graph 2 shows the correlation between economic growth (global GDP) and CO2 emissions from 1960 to 2010.

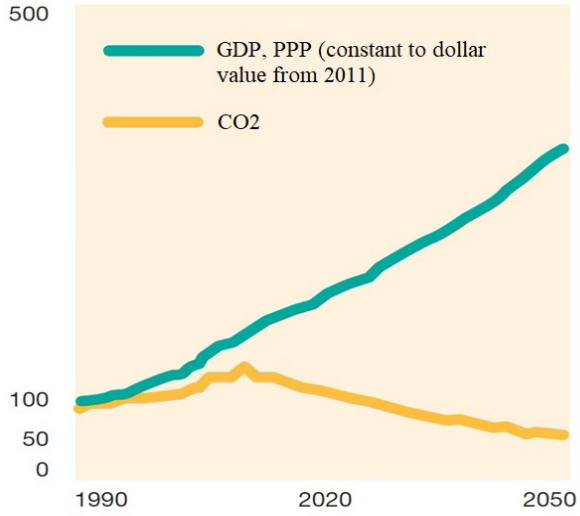
Graph 2: Global GDP and CO2 emissions between 1960 and 2010



Source: Canfin, P., Grandjean, A., Cochran, I., & Martini, M. (2015).

To keep the global average temperatures from rising by more than 2°C above pre-industrial levels, while at the same time achieving economic growth, means that GDP must no longer go together with the increase in greenhouse gas emissions. In essence, this means abandoning the use of fossil fuels to a significant extent. In 1960, the amount of CO2 per GDP unit produced was 1000g, adjusted for purchasing power parity. At the turn of the 21st century, it was 500g, and 400g of CO2 in 2010. To prevent the global temperature increase, the emissions must not exceed 60g of CO2 per GDP unit by 2050, as shown in Graph 3.

Graph 3: GDP and CO2 emissions projected growth by 2050, in case of global average temperature increase below 2°C



Source: Canfin, P. et al. (2015). *Note: PPP = purchasing power parity*

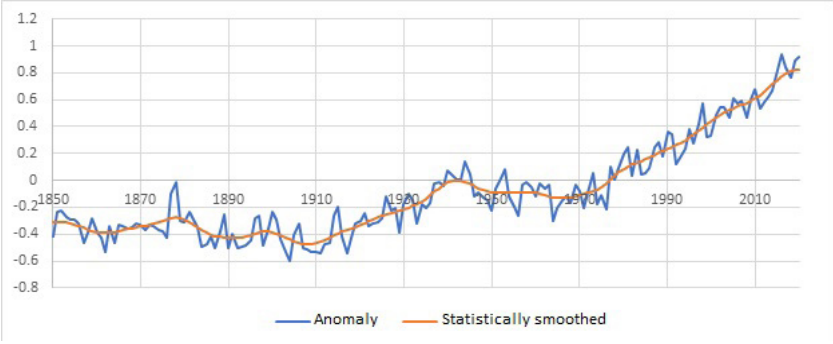
Graph 2 demonstrates how technological advancements brought about a decrease in CO2 per GDP unit emissions from 1960 to 2010. If we introduce a fundamental change to energy consumption, i.e., how we use energy for heating, construction, transport, manufacture, etc. (Tirol, 2019), CO2 per GDP unit emissions will drop further, and the global temperature increase will remain below 2°C (Graph 3).

3. Catastrophic damages caused by climate change

Climate change leads to an increase in global temperatures, sea levels and melting of the ice sheet, which causes a higher incidence and greater intensity of harmful consequences of catastrophic weather events.

The gradual increase in global average temperature over the last 170 years is shown in Graph 4.

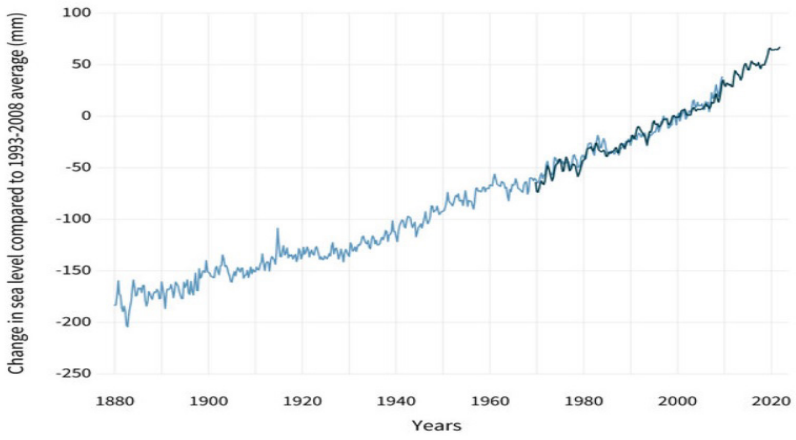
Graph 4: Gradual rise in global average temperature from 1850 to 2020



Source: CRS (2022)

From 1900 to 2014, the average global air temperature increased by +0.7°C. However, the rise was not continuous, but proceeded at an accelerated rate of +0.18°C per decade from 1976 onward. Between 2001 and 2010, the global temperature was higher by 0.27°C than the thirty-year mean temperature from 1961 to 1990, and by 0.22°C higher than from 1991 to 2000. The melting of the ice sheet in the Arctic and Greenland is evidence of the ongoing global warming. According to NASA, the ice surface in the Arctic is shrinking by an average of 9percent per decade. Besides the rise in temperature, evidence of the enhanced greenhouse effect are the melting of ice sheets and the rise of sea level (see Graph 5).

Graph 5: Sea level rise due to global warming



Source: NOAA (2022, February 22).

Graph 5 shows the average sea level rise recorded from 1880 to 1980. According to the United Nations Environment Programme analysis, the global average sea level during the 100 years shown has risen by 10 to 25 centimetres.

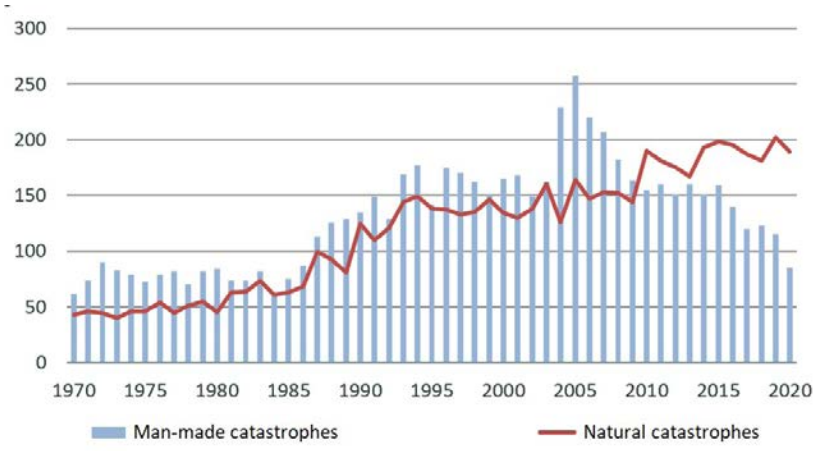
These trends have led to a higher incidence and greater extent of catastrophic damage. Catastrophic damage is defined as a simultaneous occurrence of one or more catastrophic events affecting a large number of structures or products and involving risk to lives and property (Marović & Žarković, 2007).

Insurance Information Institute defines a catastrophe as a natural or man-made event that causes USD 25 million or more in insured property losses, or 10 deaths; or 50 people injured; or 2,000 filed claims or homes and structures damaged (Insurance Information Institute, 2022, January 25).

Events such as hurricanes (especially the hurricane season of 2005), floods (e.g., the 2007 floods in the UK caused the greatest damage in the past 60 years), earthquakes (the 1994 Los Angeles earthquake, the 1995 Kobe earthquake and the 2008 earthquake in Sichuan Province, China), tsunamis (the 2004 Thailand tsunami and the 2008 Myanmar tsunami),

terrorist attacks (2001 World Trade Center) are happening with increasing incidence and with more harmful effects than ever before, both for the insurance market and for national economies, including the global economy. Graph 6 shows the increase in the number of catastrophic events worldwide from 1970 to 2020.

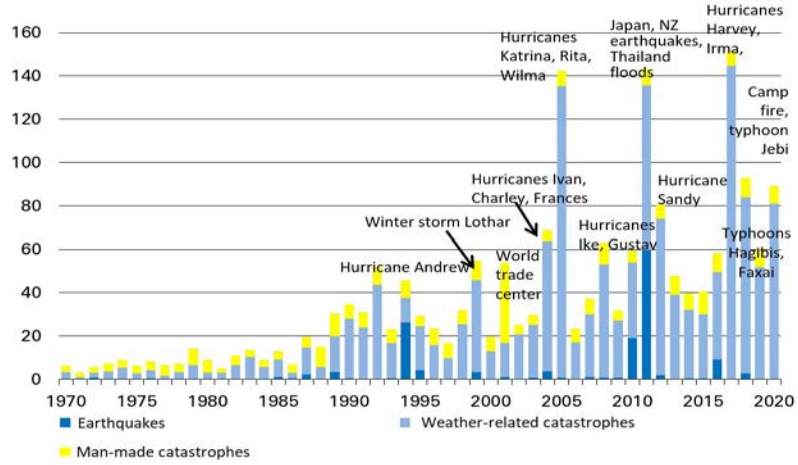
Graph 6: Natural and man-made catastrophes from 1970 do 2020



Source: Swiss Re (2021)

The density of people, facilities, and infrastructure per unit of land, combined with the population increase, property values, technological development and globalization effects, means that natural or man-made events can affect an increasing number of people and cause greater property damage than ever before. According to the OECD, a repeat of the 1923 Tokyo earthquake would result in USD 3000 billion or more in property losses, i.e., more than 75percent of Japan's GDP (OECD, 2003). Graph 7 shows the growing impact, in terms of the size of property losses, of natural catastrophes on the insurance market from 1970 to 2020.

Graph 7: Insured losses from natural catastrophes, 1970 – 2020 (USD billion)



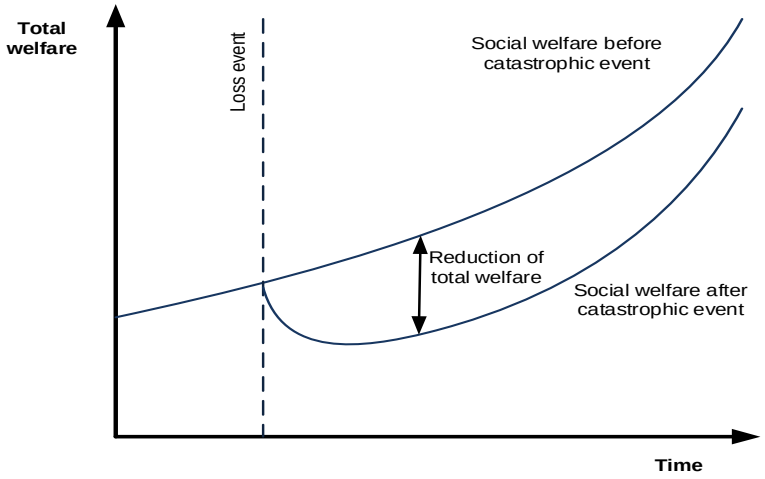
Source: Swiss Re (2021)

Graph 7 shows the continuous growth rate of losses due to higher incidence of natural and man-made catastrophes, especially from 2010 to 2020. It is evident that weather-related, or climate change-induced disasters are on the rise.

4. Impact of climate change on the economy

Graph 8 shows the impact of loss events, primarily catastrophes, on the economy.

Graph 8: Social welfare before and after catastrophic event



Source: Leonard & Howitt (2010).

Loss events cause a reduction in total welfare both due to the immediate harmful impact and the fact that social welfare cannot return to the pre-event level immediately afterwards. Graph 8 shows the trajectory of social welfare before and after a loss event. Immediately after a loss event, the trajectory of social welfare drops sharply since disasters cause loss of lives and property. After the destruction stops and recovery begins, the trajectory of social welfare begins to rise again, but at a lower level than before the loss event. However, if the overall risk management were satisfactory, social welfare should be able to not only reach the pre-event level, but to exceed it (e.g., old technology being destroyed and replaced by new, more efficient technology). Risk management is adequate if it ensures the reduction of risk costs: by influencing the nature of loss events, preventing, and reducing the incidence or intensity of adverse consequences, and by timely preparation for recovery and reconstruction after the loss event.

Climate change is a major cause of catastrophic events that threaten human lives and reduce the overall social welfare. Such events also cause

huge costs that affect the economy. Climate change presents a major risk to the global economy as it affects social wealth, resource availability, energy prices and company value. This phenomenon affects the availability of raw materials, the continuity of production and the damage and destruction of production facilities, which in turn cause stock prices fluctuations, affecting the capital markets.

Global warming is a major threat to industries, settlements and communities located in coastal areas and flooded river valleys, to areas dependent on resources sensitive to climate change, as well as to areas experiencing extreme weather and climate events and rapid urbanization. Climate change has a different impact on different sectors. In this context, the following social and economic impacts of climate change have been identified (McLean & McLean, 2001): enhanced loss of property and coastal habitats, increased risk of flooding and loss of human life, damage to coastal protection works and other infrastructure, loss of renewable and vital resources, loss of tourist, recreational and transport functions, loss of cultural resources and valuables, increase of risks in agricultural production, especially cultivation of aquatic organisms due to the decline of soil and water quality due to floods, droughts and other disasters.

Hurricanes that threaten the US coastal areas have had the greatest impact on global economy of all the catastrophic events caused by global warming. The economic costs incurred after the catastrophic 2005 hurricane season alone were estimated at more than USD 200 billion (CIER, 2007). In Europe, the most severe economic consequences of natural disasters caused by weather occur due to floods and winter storms. According to preliminary data from Swiss Re (2021), extreme weather events in 2021, including extreme winter conditions, floods, severe thunderstorms, heat waves and a major hurricane, led to estimated annual insured losses from natural disasters of USD 105 billion, the fourth largest amount since 1970. While Hurricane Ida was the costliest natural disaster in 2021, Winter Storm Uri and other secondary loss events caused more than half of the total damages.

Examining the impact of climate change on the economy, the costs incurred by preventative measures must be included. For instance, con-

sidering that there are about 20,000 kilometres of coastline and more than 32,000 kilometres of coastal areas exposed to frequent flooding in the USA, it is estimated that adapting to a sea level rise of one meter would require investments of about USD 156 billion. This amount pales in comparison to the total loss caused by natural disasters in 2021 which in the USA alone amounts to USD 169 billion (Insurance Information Institute, 2022, January 25). The costs of adapting to climate changes will put an enormous pressure on the economy of highly developed countries; therefore, the poor will be particularly vulnerable to climate change, especially those living in high-risk areas.

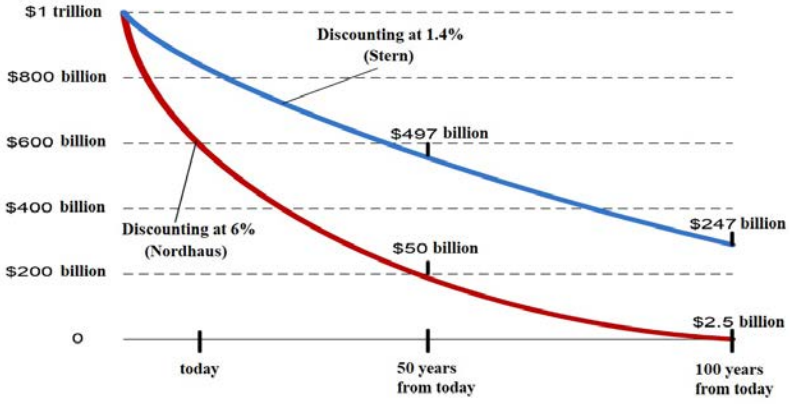
The causes of the higher economic costs of catastrophic events in recent times are not only climate changes, which bring about a higher incidence of loss events. In addition to climate change, significant factors that compound the economic consequences of natural disasters are the population and business growth, higher living standard and higher value of property exposed to catastrophic events, population density and economy in the areas affected by extreme weather conditions, sensitivity of modern societies and technologies to natural disasters, and other factors. It is estimated that in 15 years, even without the effects of climate change, a hurricane of the magnitude of the 1926 Miami hurricane could cause losses of USD 500 billion (Pielke, Gratz, Christopher, & Collins, 2008).

According to Stern's report (Stern, 2006) on the effects of climate change on the economy, extreme weather conditions could cause a drop in the total GDP by about 1percent, and a further temperature increase by two to three degrees could cause a reduction in the total global economic output by 3percent. Furthermore, if the temperature were to increase by five degrees Celsius, the global economic output could drop by about 10percent. According to the worst-case scenario, the total global consumption per capita could drop by 20percent, which would have far-reaching negative consequences. Also, the summary conclusion of Working Group 2, presented in the Fourth report (IPCC, 2006) of the Intergovernmental Panel on Climate Change, states that the costs and benefits of climate change will vary widely, depending on location, for individual industries, settlements, and population, but that the net effects will be mostly negative with the increase in the intensity of cli-

mate change, and that the economic costs of disasters caused by climate change will increase.

The two best-known reports of the climate change impact on the economy are those of Stern (2006) and Nordhaus (2007). These reports reached divergent conclusions about the future economic costs of climate change, due to applying different discount rates when determining the present value of future goods. The Stern review shows a greater economic impact of climate change on the economy because it uses a lower discount rate (1.4 percent) and has the ethical dimension, while the Nordhaus report uses a discount rate of 6 percent. In examining the climate change impact on the economy, it is necessary to consider the ethical dimension. This affects the results of modelling the economic implications of climate change. The lower the discount rate, the higher the present value of future goods, which justifies higher spending for mitigating the adverse effects of climate change today. Graph 9 shows the difference in the discount rates of the two reports.

Graph 9: Climate change impact on the economy based on the value of future goods (Stern vs. Nordhaus)



Source: Broome, J. (2008)

Graph 9 shows that Stern's 1.4 percent discount rate places a places a relatively high value on the well-being of future generations. A trillion dollars' worth of goods received in 100 years is valued at USD 247 billion today. Nordhaus's 6 percent discount rate places far less value than Stern's rate does on the well-being of future generations. A trillion dollars' worth of goods in 100 years is valued at only USD 2.5 billion today.

5. Mitigation of climate change

On a global level, there have been several attempts to mitigate the effects of climate change by slowing it down and reducing the rise in temperatures to pre-industrial levels, in order to ensure sustainable economic growth. The first and most famous international attempt was the 1997 Kyoto Protocol. The Kyoto Protocol was adopted on 11 December 1997. Owing to a complex ratification process, it entered into force on 16 February 2005, when it was ratified by Russia. It had to be ratified by at least 55 countries and 55 percent of major polluters. Serbia ratified the protocol in 2007. The Kyoto Protocol operationalizes the United Nations Framework Convention on Climate Change by committing industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets. The GHGs include: carbon dioxide, methane, nitrogen dioxide, hydrofluorocarbon, perfluorocarbon and sulphur hexafluoride. Involving almost all sectors of the economy, the Kyoto Protocol is a treaty with far-reaching effects on the environment and sustainable development. In its Annex B, the Kyoto Protocol sets binding emission reduction targets for 37 industrialized countries and economies in transition and the European Union. In 2012, however, the Kyoto Protocol covered less than 15percent of world emissions, since the US did not ratify it, and Canada, Russia and Japan withdrew from the treaty.

In 2000, the Millennium Declaration was adopted, with the goal to ensure environmental sustainability. At the 1992 Rio de Janeiro Earth Summit it was concluded that "today's development must not jeopardize the needs of present and future generations." Two important multilateral environmental agreements were adopted at this summit: the United

Nations (UN) Framework Convention on Climate Change and the Convention on Biological Diversity. It also laid the foundation for adopting the UN Convention to Combat Desertification (i.e., turning arable land into desert). World leaders agreed to move from the Millennium Development Goals to the Sustainable Development Goals. Unlike the Millennium Development Goals which mostly apply to poor countries while the rich countries act as donors, the Sustainable Development Goals are meant to be implemented worldwide.

The eighth goal of sustainable development defined at the Rio + 20 Summit is to limit anthropogenic factors as the cause of climate change. Based on this goal, the Paris Agreement was adopted at the International Climate Conference in Paris in December 2015.

The treaty was adopted after more than four years of international negotiations and two weeks of intensive talks in Paris and is considered a landmark in the multilateral climate change process. For the first time, a binding agreement brought all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects. Countries agreed on a series of measures that include joint action in the GHG emission reduction, improved transparency, adaptation, loss and damage recovery and support. The Paris Agreement aims to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. Many countries have their own plans to reduce the GHG emissions. By 2030, Serbia plans to reduce carbon monoxide emissions by 9.8 percent compared to 1990 by 2030.

The last agreement on reducing climate change is the 2021 Glasgow Climate Pact. For the first time, nations are called upon to phase down unabated coal power, as coal is the fossil fuel that contributes most to global warming. The treaty calls for countries to revise their climate plans and set more ambitious targets for reducing GHG emissions by 2030, and for rich countries to fulfil the pledge of providing 100 billion dollars annually from developed to developing countries, already suffering the effects of climate change.

Despite numerous treaties and their economic incentives, the data in this paper show that climate change and its effects are still on the rise. Although climate change agreements are widely covered in the media, few people are ready to give up the consumption habits that have led

to climate change and global warming. The problem is that countries do not internalize the benefits of their policies aimed at reducing emissions: these policies remain insufficient, emission rates remain high, while climate change becomes rampant (Tirol, 2019).

To mitigate the adverse climate change effects, all economic actors must accept their liability (Tirol, 2019), according to the EU Environmental Protection Directive (2004) and the principle that "the polluter pays". This approach involves giving subsidies for the use of "green energy" and equal carbon taxation worldwide to prevent industry relocation to other countries or decreased competitiveness of cost-burdened companies for carbon reduction.

Emission trading for carbon dioxide, or carbon trading, is a market mechanism that began to be used after the limitation of carbon dioxide emissions was stipulated by the Kyoto Protocol. This market mechanism regulates the atmospheric carbon dioxide pollution by providing economic incentives for fewer pollutant emissions. To reduce GHG emissions and to offset the social costs of climate change, countries can introduce taxes on carbon dioxide emissions or create market mechanisms. Emissions trading works by setting a quantitative total limit on the emissions produced by all participating emitters. Under emission trading, a polluter having more emissions than their quota has to purchase the right to emit more. The entity having fewer emissions sells the right to emit carbon to other entities. In this way, these entities are financially rewarded. The credits are usually bought by energy companies and various industries from developed countries and sold by the entities that manage forest farms or agricultural land, mostly from developing countries. These credits are traded on markets such as the Chicago Climate Exchange in the USA. In Phase I of the European Union Emission Trading Scheme (or EU-ETS) direct trading between economic entities is allowed, based on auctioning. The priority should be to establish a universal carbon price compatible with the proclaimed goal of reducing GHG emissions, with independent control system and economic incentives for developing countries. In the future, nations should strive to make this system more just, with developed countries pledging to provide "green" funds that would enable a more generous distribution of permits in favour of developing countries.

6. Conclusion

Climate change caused by industrialization is a reality for both macro- and microeconomic activities today. It severely affects global economy and society, most prominently by being the cause of natural disasters that lead to economic slumps and social welfare reduction. It is highly likely that this trend will continue in the future.

In the next few decades, the adverse anthropogenic effects of the GHG emissions will continue to rise. Even if atmospheric emissions stopped today, the GHGs would remain in the atmosphere for a long time, with continued adverse effects. However, if the GHG emissions were drastically reduced, the global climate might achieve an acceptable balance. This can be done by reductions in human emissions of GHGs as well as activities that reduce their concentration in the atmosphere. The most important challenge is to use a sustainable combination of energy sources and to stop burning coal, oil, and gas. Fossil fuels emit most carbon dioxide and greenhouse gas as a whole. Another challenge is to reconcile health and environmental issues with economic viability. There are three important factors that drive the search for a sustainable combination of energy sources: global warming, energy prices and political/military conflicts. Mitigation of climate change may also be achieved by reductions in dairy products and meat consumption (to reduce GHG emissions), transport, forest-management (reforestation and preservation), carbon trading, etc.

In the future, human society will have to face many new challenges. We will have to find ways to adapt our economies and technologies to global climate change and improve them so as to be able to anticipate climate changes. We will have to put a stop to further anthropogenic effects of enhanced GHG emissions which could slow down or ultimately prevent our gradual adaptation to new climate conditions.

References

Broome, J. (2008). *The Ethics of Climate Change*. Scientific American Inc.

Canfin, P., Grandjean, A., Cochran, I., & Martini, M. (2015). Mobilizing climate finance - A road-map to finance a low-carbon economy. Report of the Canfin-Grandjean Commission.

CIER (2007). *The US Economic Impacts of Climate Change and the Costs of Inaction.* A Review and Assessment by the Center for Integrative Environmental Research at the University of Maryland.

CRS (2022). Climatic Research Unit and the UK Met. Office Hadley Centre.

Directive (2004). Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage**,** *OJ L 143, 30.4.2004, p. 56–75*

GML (2022). *Atmospheric Carbon Dioxide and Carbon Isotope Records*. The Global Monitoring Laboratory of the National Oceanic and Atmospheric Administration.

Insurance Information Institute (2022, January 25). Facts + Statistics: U.S. catastrophes. https://www.iii.org/fact-statistic/facts-statistics-us-catastrophes#:~:text=Aonpercent20definespercent20apercent20catastrophepercent20as,orpercent20homespercent20andpercent20structurespercent20damaged.

IPCC (2007). *4th Assessment Report, Climate Change 2007: Synthesis Report*. Intergovernmental Panel on Climate Change.

IPCC (2014). *5th Assessment Report*. International Panel on Climate Change.

Leonard, H. B., & Howitt, A. M. (2010). Acting in Time Against Disasters: A Comprehensive Risk-Management Framework. H. Kunreuther, & Useem, M. (eds) *Learning from Catastrophes: Strategies for Reaction and Response*. Wharton School Publishing, Pearson Education, Inc.

Marović, B., & Žarković, N. (2007). *Leksikon osiguranja*. DDOR Novi Sad, AD.

McLean, G. N., & McLean, L. (2001). If we can't define HRD in one country, how can we define it in an international context? *Human Resource Development International*, 4(3), 313–326.

NOAA (2022, February 22). Climate.gov image based on analysis and data from Philip Thompson. University of Hawaii Sea Level Center Trends, https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

Nordhaus, W. (2007). A Review of the Stern Review on the Economics of Climate Change. *Journal of Economic Literature*, 45(3), 686–702.

OECD (2003). *Emerging Systemic Risks in the 21st Century: An Agenda for Action*, OECD.

Paris agreement (2015). Draft decision -/CP.21, Framework Convention on Climate Change, FCCC/CP/2015/L.9/Rev.1, United Nations.

Pielke, R. A. Jr., Gratz, J., Christopher, W. L., & Collins, D. (2008). Normalized Hurricane Damage in the United States: 1900–2005. *Natural Hazards Review*, 9(1), 29–42.

Stern, N. (2006). *The Economics of Climate Change*. Office of Climate Change.

Swiss Re (2021). *Secondary perils in the spotlight, but don't forget about primary-peril risks*. sigma 1/2021, Natural catastrophes in 2020, Swiss Re Institute.

Tirol, Ž. (2019). *Ekonomija za opšte dobro*. Akademska knjiga.