CHAPTER XIX

PANDEMICS AND CLIMATE CHANGE: CLIMATE BLACK SWANS

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ABSTRACT
Although there is no explicit confirmation that climate change is driving the spread of COVID-19, we know that it affects how humans interact with other species on the planet, which has implications on our health and infection risk. Therefore, one thing is certain – the risk of a pandemic is elevated by some of the core causes of climate change. This study aims to shed light on the links between climate change and pandemics. People are especially vulnerable to diseases and other post-catastrophic impacts. Therefore, the link between climate change and pandemics is significant. Before going deeper into the nexus between climate change and pandemics, we overview different Swan events, particularly Black and Climate Black (Green) Swan events. Then, we look into different interactions between the pandemics and environmental degradation, air pollution, climate/metrological factors, and temperature. Even though we still lack quantifiable information on the climate influence on pandemics, this issue requires interdisciplinary efforts because the probability of extreme and unusual events cannot be ignored, and understanding the deeper linkages between climate change and the pandemic is vital.

Keywords: *climate change, COVID-19, black swan, environmental.*

JEL Classification: *Q54, F64, O13, O44.*

1. INTRODUCTION

The outbreak of coronavirus disease (COVID-19) in 2020 has shut down the major economies (Parameswar et al., 2021), causing the deepest recession since World War II (World Bank, 2020) with varying degrees of stock market volatility (Uddin et al., 2021) and 114 million jobs lost worldwide (ILO, 2021). This event, or the so-called

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unprecedented global phenomenon (Congressional Research Service, 2021), was labeled a Black Swan (Deloitte, 2020) because it had devastating consequences in such a short time (Stavrova et al., 2020; Antipova, 2021).

Nassim Nicholas Taleb defined the term Black Swan, which "*illustrates a severe limitation to our learning from observations or experience and the fragility of our knowledge"* (2007, p.20). Events that include rarity, extreme impact, and retrospective predictability are considered Black Swans. Nonetheless, very soon after the global shock, in a news, article published by Avishai (2020) in the NewYorker, Taleb himself clarified that COVID-19 was not a Black Swan since, according to him, all the signs of a new dangerous pandemic were visible years before. In general, global pandemics have existed since 3000 B.C. (Halim, 2021), and it was only a matter of time before Disease X appeared (Huremović, 2019).

However, in this study, we do not take sides whether the COVID-19 is a Black Swan or not. Climate change raises the likelihood of pandemics, so this study examines the links between climate change and pandemics. The current COVID-19 crisis occurs when the world's population is 7.7 billion people, technology is advanced, and annual temperature records are on record highs, causing significant environmental damage (Hanić et al., 2021; VishnuRadhan et al., 2021). In this current consumer society and linear economic model based on the take-make-dispose concept (Ljumović et al., 2021), natural resources are overused, creating pressure on the environment and leading to pollution (especially GHG emissions) and deforestation. As a result of this excessive abuse of nature, we have climate change that causes global temperature extremes, heatwaves, floods, and earthquakes. Therefore, while discussing the present challenges facing our planet, climate change and global warming will almost certainly come up in almost every scientific discipline (Mitić et al., 2020).

The nexus between climate change and pandemics is significant since humans are highly vulnerable to diseases and other post-catastrophic effects (Khan et al., 2019) that VishnuRadhan et al. (2021) define as "envirodemics." But how can we understand and observe this nexus?

Taleb (2007) observes climate change as a Grey Swan event – an event that is not entirely impossible because the probability of its occurrence is known in advance. Mazarr (2016, p. 90) understands Grey Swans as *"an unlikely but fully conceivable risk that lies well within the bounds of experience and has been openly discussed, but becomes discounted and fails to generate mitigating actions."* In other words, *"a high-impact event that we might expect on the grounds of natural variability but outside the observational record"* (Horsburgh et al., 2021, p.716).

Aside from this depiction, we can find other metaphors in the literature that describe the issue of climate change. For instance, author Wucker (2016) uses a Grey Rhino to explain significant, prominent, and probable risks charging straight at us. Grey Rhino implies that we are aware of these events and the warning signs, but we disregard them until they become a surprise with significant effects. The author coined this metaphor in 2012 in the aftermath of the Greek Financial Crisis.

According to Wucker (2016), there is a five-stage framework for analyzing Grey Rhino events, and it includes:

- Denial (in COVID-19 case: "*It's just the flu*");
- Muddling – we recognize that there is a problem, but there is still no need to react (in COVID-19 case: "*It's far away in China*");
- Diagnosis (in COVID-19 case: "Test, test, and test on COVID-19");
- Panic (in COVID-19 case: "The virus is there but it's not dangerous") and
- Action (in COVID-19 case: "Testing, accurate information, transparency, treating").

This framework can be used to examine any crisis or incident that we are aware of, particularly climate change and its impact on the financial system. In that aspect, Bolton et al. (2020) emphasize the role of central banks, regulators, and supervisors and the importance of climate-related risk analysis by those institutions. Bolton et al. (2020) observe the effect of climate on financial stability as Green swans, or *"climate black swans,"* explaining potentially extremely financially disruptive events behind the next systemic financial crisis. In this context, this study aims to present the nexus between climate change and pandemics, considering the effect of Green Swans since the possibility of extreme values cannot be neglected. We focus on the theoretical background of this issue because the literature in this field is limited (Parameswar et al., 2021).

The remainder of this study is structured as follows. The deeper look into swan events refers to an analysis of Black Swans and other types of metaphors used to describe the issue of climate change. Then, in the third part, we analyze climate black swans or green swans, while in the fourth part, we focus on the nexus between climate change and pandemics. Finally, this study ends with a conclusion.

2. DEEPER LOOK INTO SWAN EVENTS

For an event to be a Black Swan, it needs to meet three criteria (Taleb, 2007, p.20):

- It is an outlier as it lies outside the realm of regular expectations;

- It carries extreme impact;
- Human nature makes us concoct explanations for its occurrence, after the fact, making it seem explainable and predictable.

Green (2011) observes Black Swan as *"unknown unknowns"* or unexpected and unknowable events. That ultimate uncertainty is an essential feature of Black Swans since other rare events are often compared to a Black Swan, like the *"perfect storm."* According to Pate-Cornell (2012), these metaphors explain rare events with different backgrounds and different types of uncertainties since "*perfect storm*" means a combination of rare but well-known events, unlike the Black Swan. The unexpectedness that characterizes a Black Swan includes national and international emergencies (Castles, 2010).

Some authors like Lindaas & Pettersen (2014) include *unknown knowns* into *unknown unknowns,* meaning that besides the sphere of knowledge, we involve the sphere of imagination in analyzing a Black Swan. This statement is consistent with Aven & Krohn (2014, p.9) since they classify the Black Swan into three types:

- unknown unknowns (completely unknown events);
- events that were not on the list of known events from the perspective of those who carried out a risk analysis; and
- events on the list of known events in the risk analysis but found to represent a negligible risk.

Before classifying an event as a Black Swan, it is essential to note that it has to be a *"game-changer"* event for those impacted by it (Hajikazemi et al., 2016). One of the examples often cited in the literature is the Fukushima nuclear disaster that happened in 2011. A devastating earthquake followed by a tsunami struck northeastern Japan, causing the meltdown of three reactors at the plant, resulting in one of the biggest nuclear disasters in history. The highest tsunami wave was 40 m high, while back in 2006, Japanese authorities estimated that in the event of a tsunami, the maximum wave height would be 6 m (Pate-Cornell, 2012). This event was classified as a Black Swan because we rarely experience nuclear-core meltdowns (Shrader-Frechette, 2011). In the case of Fukushima, there were no severe injuries reported due to radioactivity, while 19,500 people lost their lives by the tsunami (Safety of Nuclear Reactors - World Nuclear Association, 2021). More Black Swan events happened in the past, of which Table 1 highlights a handful.

Table 1. Some of Black Swan events in the past

Event	Year	Result / Consequence
Black Monday	1987	-28.5% drop of S&P
Gulf war	1991	-5,7% drop of S&P
Asian financial crisis	1997	International stocks tumbled 60%
Dot.com crash	2000	NASDAQ composite lost 78% of its value
9/11	2001	-11,6 % drop of S&P and -14% of Dow Jones
Global financial crisis	2008	Trillion USD wiped out in the global equity markets
Fukushima nuclear disaster	2011	Radiation levels in food, water, and the ocean have all increased.
Brexit	2016	-5,6% drop of S&P

Source: Ross, J. (2020, April 8). Black Swan Events: Short-term Crisis, Long-term Opportunity. Advisor Channel. https://advisor.visualcapitalist.com/black-swan-events/

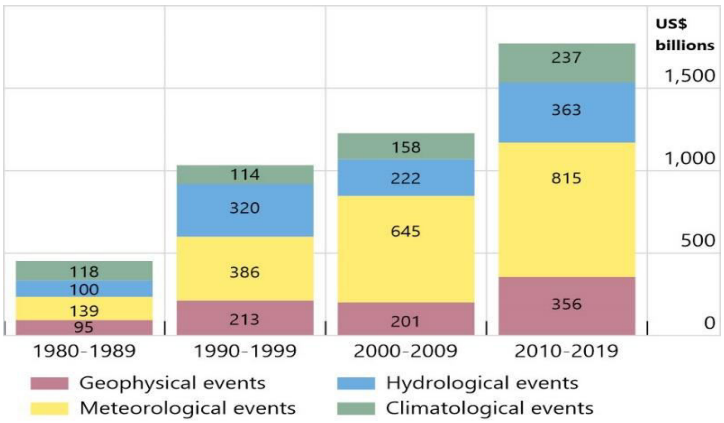
Overall, there are three types of Swans: White, Grey, and Black. Besides the fundamental elements that classify a Black Swan, Ale et al. (2020) emphasize the importance of knowledge about a particular event because White, Gray, and Black Swans vary in the context of their influence. Therefore, identifying a particular type of swan depends on its interpretation (Hanić, 2021). For instance, a White Swan has little effect and is specific to an individual or group. However, it can escalate to Grey (Manning et al., 2020), implying an event that people are aware of but do not take seriously enough, although its consequences can be devastating. Lin & Emmanuel (2016, p.1) state that Grey Swan events are "*high-consequence events that are unobserved and unanticipated [that] may nevertheless be predictable (although perhaps with large uncertainty).*" Therefore, Grey Swan occurrences require special attention because they are obvious risks that are often overlooked and can serve as warning indications for future Black Swan events. For example, in the abovementioned case of Fukushima, the climate-induced sea-level rise worsened tsunami impacts.

The specificity of climate change is that it is unavoidable. The strategy mentioned by Taleb (2007), the so-called Barbell Strategy, implies to "*play safe*," in terms of investing 85-90% in something safe while the remaining 10-15% in something very speculative. Barbell Strategy can not be applied in this case because there is no safe play when dealing with climate change. We can prepare better by analyzing the five stages regarding how the threat (grey rhino) moves, with what sources we welcome it, and its potential impact. We should not deny it and muddle it because climate experience is usually local. Understanding climate change as a single collective threat is complex and requires coordinated action among governments, financial institutions, corporate sectors, and individuals.

3. CLIMATE BLACK SWANS

Sir Nicolas Stern described climate change as *the greatest market failure the world has ever seen*. In that aspect, the potentially disruptive impacts on the financial system are becoming more apparent. As presented in Picture 1, it is evident that the world witnessed massive financial losses due to climate change, while predictions suggest that the global economy could lose 10% of its total economic value by 2050 (Swiss Re, 2021).

Picture 1. Estimated global economic loss from natural catastrophic events



Source*:* Climate-related risks. (2021b). Financial Stability Board. https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/climate-related-risks/

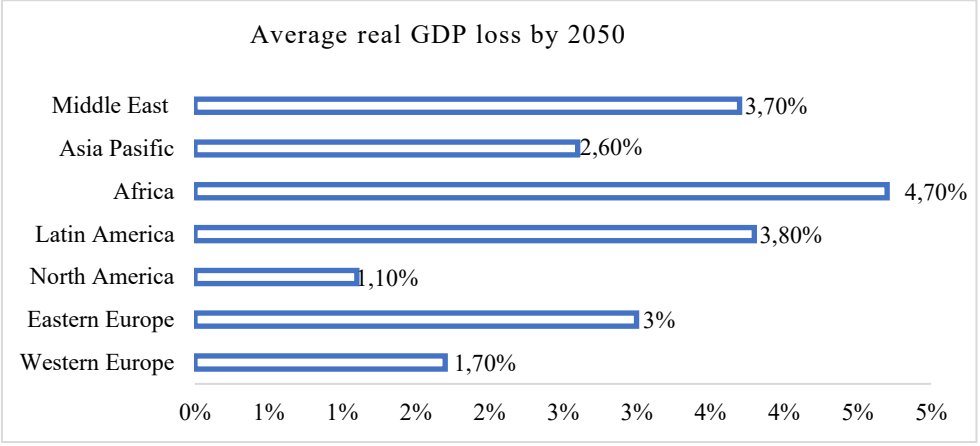
The Economist Intelligence Unit (2019) developed the Climate Change Resilience Index that forecasts the overall GDP loss of countries due to climate change out to 2050. The Index consists of eight indicators:

1) Loss of land/physical capital due to extreme climate/weather events.
2) Impact on public services, basic needs, and government expenditure.
3) Impact on the agricultural sector (Loss of Crop yields).
4) Loss of Labour productivity.
5) Tourism Loss.
6) Trade Loss.
7) Adaptation Costs.
8) Mitigation Costs.

According to this Index, the impact of climate change will not be equal because the developing economies will be affected more than the developed ones. Climate

change will least affect North America and Western Europe, as these regions have the financial and institutional quality to minimize the impact of climate change, as presented in Figure 1.

Figure 1. Economic impacts of climate change



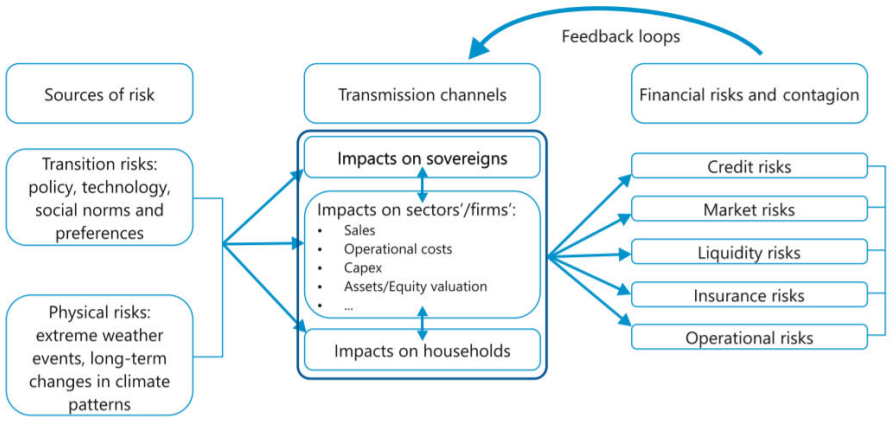
Source: Climate impacts "to cost world $7.9 trillion" by 2050. (2019, November 20). Physis.Org. https://phys.org/news/2019-11-climate-impacts-world-trillion.html

Two types of climate-related risks affect financial stability:

1. *Physical risks* – economic costs and financial losses happen due to climate-related weather changes. According to Woetzel et al. (2021), this type of risk is rising where the socio-economic impact of climate change will increase in a nonlinear way between 2 and 20 times by 2050 compared to today's level. There are two types of these risks: a) acute - related to extreme weather events or b) chronic risks with gradual shifts in climate. According to Campiglio et al. (2019), physical risks decrease the payoffs of equities and increase the proportion of non-performing loans (NPLs).
2. *Transition risks* – societal changes that arise due to a transition to a low-carbon economy and include policy changes, shifts in market preferences and social norms, and the use of green and digital technologies. Transition risks make some fossil-fuel-intensive technologies unprofitable. In that aspect, these types of costs can affect payoffs such as research and development regarding new and alternative (green) technology.

The physical and transition risks can impact business costs, revenues, and supply chains. At the same time, they can affect the financial risk (credit, market, liquidity, insurance, and operational) in five main ways, as presented in the picture below.

Picture 2: The effect of physical and transition risks on financial risks



Source: Bolton et al., (2020).

Considering the effects of climate change on financial stability, Bolton et al. (2020) use the term Green Swan or Climate Black Swan to explain potentially extremely financially disruptive events behind the next systemic financial crisis. Climate Black Swans have a basis in climate-related risks where physical and transition risks have similar characteristics as any other Black Swan event. However, at the same time, a Green Swan is different from a Black one for several reasons:

- climate change is a certainty, not a rare event since it is already happening, meaning that physical and transition risks will interact in the future;
- the effect of climate change is more devastating than systemic financial crises since Green Swan entails a chain reaction of numerous events and crises (there are estimations that global financial crisis led to a global loss of more than $2 trillion while global natural disasters, between 1980 and 2018, resulted in losses of around $5.2 trillion, according to Munich Re, 2020);
- the complexity related to climate change is higher than for Black Swan events.

Besides this concept based on the effect of climate change on financial stability, in the book called *"Green Swans: The Coming Boom in Regenerative Capitalism,"* Elkington (2020) also uses the term Green Swan, but it considers a system change in terms of serving people, planet, and prosperity; or applying business practices to restore and build rather than exploit and destroy. In practice, it is about embracing innovations to move towards green capitalism. Elkington (2020) defines a Green Swan as *"a profound market shift, generally catalyzed by some combination of Black or Gray Swan challenges and changing paradigms, values, mindsets, politics,*

policies, technologies, business models and other key factors. A Green Swan delivers exponential progress in the form of economic, social and environmental wealth creation". But Green Swans are extraordinary in terms of progress based on the positive solutions. In other words, *"like a phoenix that has risen out of the ashes left by Black Swans"* (van der Molen, 2020).

4. NEXUS BETWEEN CLIMATE CHANGE AND PANDEMICS

Pandemics occur when viruses find a way to spread swiftly among humans. Either existing viruses mutate and become more infectious, or humans come in close contact with a wild animal as a transmitter. The contact occurs due to animal migration because humans disrupted the natural cycle between animals and their natural habitat since 32% of the world's forest has been destroyed thus far (Global Assessment Report on Biodiversity and Ecosystem Services, 2019). The current global COVID-19 pandemic is possibly a consequence of the anthropogenic biodiversity crisis (Lorentzen et al., 2020).

At the same time, higher emissions of GHG weaken humans' immune systems making them less resistant to the emergence of new viruses and bacteria. To better understand the nexus between climate change and pandemics, we will analyze it through 4 clusters identified in the literature review done by Shakil et al. (2020), which includes:

1) pandemics and environmental degradation,
2) pandemics and air pollution,
3) pandemics and climate/metrological factors and
4) pandemics and temperature.

4.1. Pandemics and environmental degradation

Decomposition, or a severe reduction or deterioration of environmental quality, occurs due to consumption, use, and contamination of air, water, and land. Degradation of the environment also refers to damaging the natural environment and the extinction of plant and animal species.

An increasing population, constant increases in monetary wealth and the use of technology that depletes and pollutes nature are all elements that might contribute to a reduction in environmental quality. When a country's natural resources deplete and the environment suffers due to threats to biodiversity, air, water, and soil pollution, environmental pollution occurs (Fisher, Hill, & Feinman, 2009).

Furthermore, environmental degradation is primarily, but not exclusively, caused by anthropogenic activities that deplete natural resources by using them faster than they can be replenished. Natural occurrences such as landslides and earthquakes can disrupt the natural balance and cause environmental degradation. Biodiversity, natural resources, and habitats can all be harmed by continued environmental degradation (Mitić, 2020).

As a result, environmental degradation is a broad term encompassing many issues, including deforestation, biodiversity loss, desertification, and global warming. In other words, the long-term harmful effect of environmental degradation is evident, which may produce destructive effects on human welfare and the economy, thus leading to increases in social welfare and healthcare expenses (Petrović-Ranđelović et al., 2020). So, we can assert that environmental degradation influenced the acceleration of climate change and its social and economic consequences. In the literature, this phenomenon is called the Great Acceleration, which implies an increase in the intensity of human activities with a highly destructive impact on the environment.

Such an influence led to Earth entering a new geological epoch, which geologists defined as the Anthropocene or “The Age of Men”. In this new epoch, which began in the 1950s with the intensive development of industry, man dominates the environment negatively, resulting in pandemics' increasing occurrence (Hanić & Mitić, 2020; Chin et al., 2020a). Table 2 lists some of the past outbreaks of infectious diseases.

Besides health, pandemics shape human civilization's economic, political, and social aspects (Huremović, 2019). In the case of COVID-19, the first months of global lockdown caused a change of behavior, emphasizing the importance of considering the current social, moral, and environmental patterns and their order (Hanić and Mitić, 2020; Videnović et al., 2021). At the same time, there was a reduction in environmental noise and GHG emissions across the globe, leading to a short-term cooling of our planet (Forster et al., 2020). As a result, global CO_2 emissions in 2020 were reduced by 5.4% (Emissions Gap Report, 2021), as presented in Picture 3, while in countries like China, Italy, France, Spain, and the USA, there was a 20-30% reduction in NO_2 emission (Bhat et al., 2020).

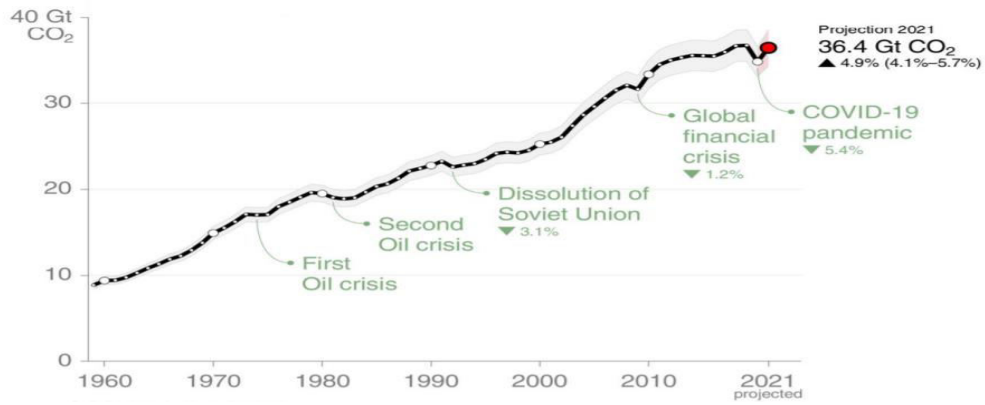
Table 2 The outbreaks of infectious diseases throughout the history

Year	Name	Deaths	Comments
430 BCE	"Plague of Athens"	~100,000	First identified trans-regional pandemic
541	Justinian plague (*Yersinia pestis*)	30–50 million	Pandemic; killed half of world population
The 1340s	"Black Death" (*Yersinia pestis*)	~50 million	Pandemic; killed at least a quarter of world population
1494	Syphilis (*Treponema pallidum*)	>50,000	Pandemic brought to Europe from the Americas
c. 1500	Tuberculosis	High millions	Ancient disease; became pandemic in Middle Ages
1793–1798	"The American plague"	~25,000	Yellow fever in colonial America
1918	"Spanish" influenza	~50 million	Led to additional pandemics in 1957, 1968, 2009
1976–2020	Ebola	15,258	First recognized in 1976; 29 regional epidemics to 2020
1981	Acute hemorrhagic conjunctivitis	rare deaths	First recognized in 1969; pandemic in 1981
1981	HIV/AIDS	~37 million	First recognized 1981; ongoing pandemic
2002	SARS	813	Near-pandemic
2009	H1N1 "swine flu"	284,000	5th influenza pandemic of the century
2015	Zika	~1,000?±	Pandemic, mosquito-borne

Source: Morens and Fauci (2020).

Apart from the positive effect on the environment, due to the reduction of CO_2, measured by the Social Cost of Carbon (SCC), the global economy benefitted 648 billion USD for the first half of 2020 (Syed and Ullah, 2021). In general, SCC is used to estimate in USD the economic damage resulting from emitting one ton of carbon dioxide into the atmosphere.

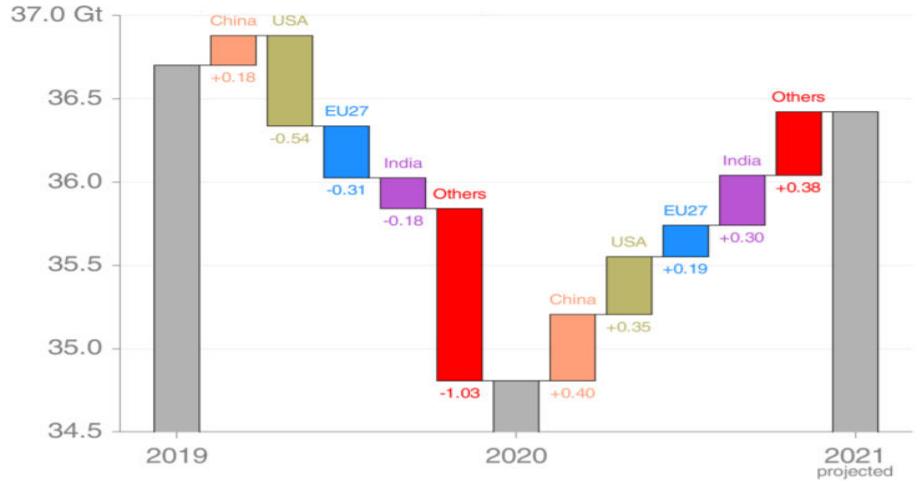
Picture 3: Global fossil CO_2 emissions



Source: Data Supplement to the Global Carbon Budget 2021 (2021)

Nevertheless, as the economy is returning to business as usual, the destruction of the environment will probably return to the pre-pandemic state. According to Adler (2021), in 2021, emissions were just 0.8% below the record of 36.7 billion mt in 2019, and nearly a 5% rise from 2020's level. Moreover, projections say the most robust growth will be in the case of the biggest polluters (Picture 4). At the same time, the COVID 19 pandemic resulted in a considerable amount of medical waste (masks, glows, plastic visors), causing the degradation to continue.

Picture 4: Pandemic rebound in emissions



Source: Canadell et al. (2021)

4.2. Pandemics and air pollution

Air pollution is a significant environmental problem humans face. Many air pollutants have common characteristics, and in that interaction, they affect ecosystems. One such example is the forest, where this interaction changes the soil processes, tree growth, composition, and distribution (Bytnerowicz et al., 2007). As a result, erosion occurs because of deforestation, landslides, and organic matter reduction.

Air pollution happens when dangerous or excessive volumes of gases, particles, and biological molecules are released into the atmosphere. Air pollution can result in various illnesses, allergies, and even death. Industry, energy, transportation, and agricultural activities are the primary sources of air pollution. Furthermore, some domestic activities, such as heating, can result in significant air pollution. However, this is primarily a concern in impoverished and undeveloped nations (Kojić et al., 2021).

One of the primary air pollutants is CO_2, which generates the greenhouse effect and makes the Earth warmer, leading to global warming and climate change. All living things emit CO_2 during respiration; however, it is considered life-threatening if it is emitted in large amounts. Other gases contribute significantly to air pollution, such as chlorofluorocarbons, methane, sulfur oxides, nitrogen oxides, and particulate matter.

Particulate matter are fine solid or liquid particles suspended in a gas. Particles that can reach the tiniest alveoli in the lungs are especially significant. The diameter of these particles is less than 10 μm. The EPA divides these particles into two categories: PM_{10} and $PM_{2.5}$ (EPA, 2018). Volcanic eruptions, dust storms, and wildfires can naturally produce these particles. Nevertheless, particulate matter is predominantly produced by human activities such as the combustion of fossil fuels in vehicles, power plants, and numerous industrial processes (Mitić, 2020).

Increased PM levels have been linked to health problems such as heart disease, deteriorated lung function, and lung cancer. The particles are linked to respiratory illnesses, and they can be especially dangerous for people who already have asthma or other chronic respiratory problems.

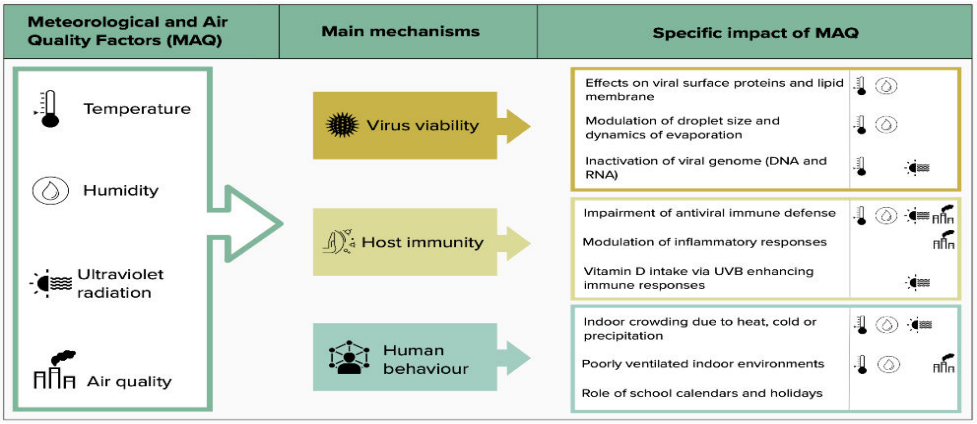
According to Malo (2018), air pollution affects global life expectancy by an average of 1.8 years per person, making it the world's leading cause of death. PM from polluted air shortens life more than smoking, drinking and drug usage, wars, and HIV/AIDS.

One of the major problems is the air pollution in urban areas, especially in big and capital cities. In the literature, it is called urban air contamination. In general, 54% of the world's population lives in urban areas, and by 2050 that number will probably increase to 66% (World urbanization prospects: the 2014 revision, 2015). Air quality in cities results from a complex interaction between natural and anthropogenic environmental conditions (Mayer, 1999). According to the WHO (2016), ambient air pollution caused 4,2 million deaths worldwide. The link between pandemics and air pollution was not apparent at first, but research shows that air pollution intensifies the mortality rate (Karan et al., 2020). Exposure to polluted air may weaken immunity and worsen the health consequences, which increases the risk of death. For instance, Travaglio et al. (2021) explored potential links between major fossil fuel-related air pollutants and COVID-19 mortality in England. The authors found statistically significant evidence that a slight increase in air pollution leads to a significant increase in the COVID-19 infectivity and mortality rate. Wu et al. (2020) came to similar conclusions regarding an association between long-term exposure to air pollution and higher COVID-19 mortality rates.

4.3. Pandemics and climate/metrological factors

The world has witnessed the five warmest years since 2015, while nine of the 10 warmest years have occurred since 2005 (Assessing the Global Climate in 2019, 2020). According to Wang et al. (2020), the transmission of viruses can be affected by climate conditions, population density, and medical care quality (Picture 5).

Picture 5: The effect of meteorological and air quality factors on respiratory viral infections



Source: WMO. (2020). Review on Meteorological and Air Quality Factors Affecting the COVID-19 Pandemic

This question has been the subject of several research studies like Ahmadi et al. (2021), who investigated the relationship between the geographical features of Iran and the transmission of COVID-19. The result showed that wind speed values, humidity, and exposure to solar radiation affect the virus's survival.

Damette et al. (2020) came to a similar conclusion, which reassessed the impact of weather factors on COVID-19 daily cases in a panel of advanced and emerging countries between 1st January and 28th May 2020. The authors used a dynamic panel model to capture the impact of climate on social distancing and thus on COVID-19 outcomes. The model in question included direct/physical factors related to the virus's survival and durability dynamics on surfaces and outdoors, and an indirect factor through human behaviors and individual mobility (walking or driving outdoors). The findings show that temperatures and solar radiation are critical climatic drivers in the COVID-19 outbreak. In addition, human behavior interrelationships between climatic variables and people mobility are significantly positive and should be taken into account when assessing the effects of climatic factors.

4.4. Pandemics and temperature

Global warming increases the average temperature of the Earth's atmosphere and its oceans. In other words, it is a long-term increase in the average temperature of the entire Earth's climate system. In the modern context, the terms "global warming" and "climate change" are frequently interchanged (Shaftel, 2021). However, climate change is a more encompassing word that includes global warming and its consequences, such as melting glaciers, heavier rainstorms, and more frequent droughts. Global warming is one of the symptoms of a much more severe problem: human-caused climate change (Kennedy and Lindsey, 2021).

Several issues stand out when looking into the causes of global warming. Forests generate the oxygen required for life on Earth and absorb a considerable quantity of damaging carbon from the atmosphere, so deforestation is a significant problem. Deforestation increases carbon emissions, which contributes directly to rising global temperatures. Another aspect is the greenhouse effect, which occurs when greenhouse gases (GHGs) reflect the Earth's radiation and prevent it from exiting the atmosphere. The Earth would be too cold to support life if greenhouse gases were not present.

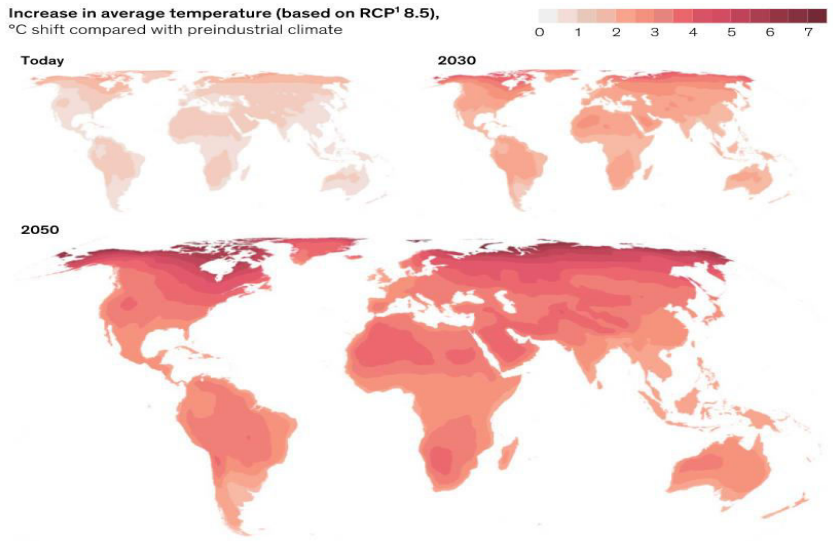
On the other hand, human activities artificially contribute significant amounts of these gases into the atmosphere, resulting in rising temperatures. As previously stated, CO_2 emitted by burning fossil fuels such as oil, coal, and natural gas, is the

most critical gas that human activities emit into the atmosphere. In addition, rearing livestock and other animals releases methane into the atmosphere. Mining, for example, is a part of the extraction of fossil fuels since it releases stored carbon from the Earth into the atmosphere, contributing to rising temperatures (Mitić, 2020).

Furthermore, after examining the causes of global warming, it is necessary to establish its most significant repercussions, including increasing glacier melting, rising sea levels, desertification, hurricanes and cyclones, and disease transmission. (Stern, 2007).

Therefore, climate factors affect the geographical and seasonal occurrence of infectious diseases (Wu et al., 2016), while weather conditions affect the time and intensity of disease outbreaks (Wu et al., 2013), including pandemics. One of the factors that also significantly impact infectious diseases is temperature. According to Sloan et al. (2011), the temperature is the primary predictor of the geographical distribution of disease rates at different times of the year. The picture below shows that global average temperatures will increase between 1.5 and 5 °C by 2050.

Picture 6: Global average temperatures rise by 2050



Source: Woetzel et al. (2021)

In the case of COVID-19, there was a debate whether the number of patients would be lower during the summer. In research done by To et al. (2021), on a sample of over 77,700 COVID-19 cases from four Canadian provinces, authors conclude that higher temperatures do not reduce the transmission of COVID-19. At the same time,

Chin et al. (2020) note that the virus is highly stable at 4 °C, but sensitive to heat, while Xie and Zhu (2020) conclude that the relationship between mean temperature and COVID-19 confirmed cases was approximately linear in the range of <3 °C and became flat above 3 °C. In practice, results are mixed, and the debate is still ongoing.

5. CONCLUSION

The COVID-19 pandemic has led to global economic disruption. Although the world is currently slowly recovering and returning to its pre-pandemic state, the consequences of this pandemic will be present for a long time, especially in the context of the socio-economic paradigm. In response to the initial shock that followed the spread of the virus from China, the world's reaction to it was an event known in the literature as the Black Swan. Taleb developed this metaphor to explain how limited human knowledge is. Historically, the event is related to Australia when the black swan was first recorded in 1697. Until then, there was a firm belief that all swans are white and that this is the undeniable truth.

The specificity of this pandemic is that many, including Taleb himself, refuse to call it the Black Swan but rather observe it as a White Swan since pandemics happen all the time. For this specific one, however, we were not prepared. Some authors give this pandemic the prefix of a perfect storm, another metaphor used to describe a rare but predictable event. On the other hand, authors like Michele Wucker view the COVID-19 pandemic as a Gray Rhino, with significant, noticeable, and probable risks approaching us, but we refuse to act. Gray Rhino is precisely how people's attitudes toward the severe problems of climate change are viewed. Climate change is already changing economic trends and traditional economic models, requiring the application of a new approach that would begin to view the environment and the concept of sustainability as a starting point and not as a goal to be pursued in the future. Such an approach is advocated by one of the leading experts in understanding social responsibility and sustainable development, John Elkington, which defines the Green Swan metaphor. Elkington observes Green Swan as a new way of making capitalism green.

However, given that climate change has a powerful effect on socio-economic trends, some authors advocate the impact of climate change on central banks' financial flows and activities worldwide, viewing it as climate Black Swan. The COVID-19 pandemic is just one of the consequences of the current unsustainable attitude of the human population towards the environment, as there has been an interaction between humans and animals that would not otherwise exist if their natural habitats had not been disturbed. Therefore, understanding the nexus between climate change and the

pandemic is essential for analysis because the possibility of extreme and rare events cannot be neglected.

ACKNOWLEDGEMENTS

This research has been funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia

REFERENCES

1) Adler, K. (2021, November 4). Global CO_2 emissions to rise by 4.9% in 2021: Global Carbon Project. IHS Markit. https://cleanenergynews.ihsmarkit.com/research-analysis/global-co2-emissions-to-rise-by-49-in-2021-global-carbon-proje.html
2) Ahmadi, M., Sharifi, A., Dorosti, S., Jafarzadeh Ghoushchi, S., & Ghanbari, N. (2020). Investigation of effective climatology parameters on COVID-19 outbreak in Iran. Science of The Total Environment, 729, 138705. https://doi.org/10.1016/j.scitotenv.2020.138705
3) Ale, B. J., Hartford, D. N., & Slater, D. H. (2020). Dragons, black swans and decisions. Environmental Research, 183, 109127. https://doi.org/10.1016/j.envres.2020.109127
4) Antipova, T. (2020). Coronavirus Pandemic as Black Swan Event. Integrated Science in Digital Age 2020, 356–366. https://doi.org/10.1007/978-3-030-49264-9_32
5) Assessing the Global Climate in 2019. (2020, January 15). National Centers for Environmental Information (NCEI). https://www.ncei.noaa.gov/news/global-climate-201912
6) Aven, T., & Krohn, B. S. (2014). A new perspective on how to understand, assess and manage risk and the unforeseen. Reliability Engineering & System Safety, 121, 1–10. https://doi.org/10.1016/j.ress.2013.07.005
7) Avishai, B. (2020, April 21). The pandemic Isn't a Black Swan but a Portent of a More Fragile Global System. The New Yorker. https://www.newyorker.com/news/daily-comment/the-pandemic-isnt-a-black-swan-but-a-portent-of-a-more-fragile-global-system
8) Bhat, S. A., Bashir, O., Bilal, M., Ishaq, A., Din Dar, M. U., Kumar, R., Bhat, R. A., & Sher, F. (2021). Impact of COVID-related lockdowns on environmental and climate change scenarios. Environmental Research, 195, 110839. https://doi.org/10.1016/j.envres.2021.110839
9) Bolton, Patrick, Despres, M., Pereira da Silva, L.A., Samama, F., & Svartzman, R. (2020). The green swan: central banking and financial stability in the age of climate change. Bank for International Settlements.

10) Bytnerowicz, A., Omasa, K., & Paoletti, E. (2007). Integrated effects of air pollution and climate change on forests: A northern hemisphere perspective. Environmental Pollution, 147(3), 438–445. https://doi.org/10.1016/j.envpol.2006.08.028
11) Canadell, P., Quéré, C. L., Peters, G., Friedlingstein, P., Andrew, R., & Jackson, R. (2021, November 4). Global emissions almost back to pre-pandemic levels after unprecedented drop in 2020, new analysis shows. The Conversation. https://theconversation.com/global-emissions-almost-back-to-pre-pandemic-levels-after-unprecedented-drop-in-2020-new-analysis-shows-170866
12) Castles, F. G. (2010). Black swans and elephants on the move: the impact of emergencies on the welfare state. Journal of European Social Policy, 20(2), 91–101. https://doi.org/10.1177/0958928709358793
13) Chin, A. W. H., & Poon, L. L. M. (2020). Stability of SARS-CoV-2 in different environmental conditions – Authors' reply. The Lancet Microbe, 1(4), e146. https://doi.org/10.1016/s2666-5247(20)30095-1
14) Chin, A., Simon, G. L., Anthamatten, P., Kelsey, K. C., Crawford, B. R., & Weaver, A. J. (2020a). Pandemics and the future of human-landscape interactions. Anthropocene, 31, 100256. https://doi.org/10.1016/j.ancene.2020.100256
15) Climate-related risks. (2021). Financial Stability Board. https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/climate-related-risks/
16) Climate-related risks. (2021b). Financial Stability Board. https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/climate-related-risks/
17) Congressional Research Service. (2021). Global Economic Effects of COVID-19.
18) Damette, O., Mathonnat, C., & Goutte, S. (2021). Meteorological factors against COVID-19 and the role of human mobility. PLOS ONE, 16(6), e0252405. https://doi.org/10.1371/journal.pone.0252405
19) Data supplement to the Global Carbon Budget 2021. (2021). ICOS. https://www.icos-cp.eu/science-and-impact/global-carbon-budget/2021
20) Deloitte. (2020). Managing supply chain risk and disruption. Canada
21) Elkington, J. (2020). Green Swans: The Coming Boom in Regenerative Capitalism. Fast Company Pr.
22) Emissions Gap Report 2021. (2021). UNEP - U.N. Environment Programme. https://www.unep.org/resources/emissions-gap-report-2021
23) Fisher, C. T., Hill, J. B., & Feinman, G. M. (Eds.). (2009). The archaeology of environmental change: socionatural legacies of degradation and resilience. University of Arizona Press.

24) Forster, P. M., Forster, H. I., Evans, M. J., Gidden, M. J., Jones, C. D., Keller, C. A., Lamboll, R. D., Quéré, C. L., Rogelj, J., Rosen, D., Schleussner, C. F., Richardson, T. B., Smith, C. J., & Turnock, S. T. (2020). Current and future global climate impacts resulting from COVID-19. Nature Climate Change, 10(10), 913–919. https://doi.org/10.1038/s41558-020-0883-0
25) Global Assessment Report on Biodiversity and Ecosystem Services. (2019, November 10). IPBES Secretariat. https://www.ipbes.net/global-assessment
26) Global Greenhouse Gas Emissions Data. (2021, October 26). US EPA. https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#:%7E:text=Global%20carbon%20emissions%20from%20fossil,increase%20from%201970%20to%202011.
27) Green, N. (2011), Keys to success in managing a black swan event [White ,], AON Corporation, Retrieved from http://www.aon.com/attachments/risk-services/Manage_Black_Swan_Even_White,_31811.pdf
28) Hajikazemi, S., Ekambaram, A., Andersen, B., & Zidane, Y. J. T. (2016). The Black Swan – Knowing the Unknown in Projects. Procedia - Social and Behavioral Sciences, 226, 184–192. https://doi.org/10.1016/j.sbspro.2016.06.178
29) Halim, M. (2021). Building Policies for Climate Changes: Lessons from COVID-19. Journal of Clinical and Medical Research. https://doi.org/10.37191/mapsci-2582-4333-3(2)-065
30) Hanić, A. (2020). Crni labud u svetskoj ekonomiji In Mitić, P., Marjanović, D.. (Eds). Black Swan in the World Economy. Institute of Economic Sciences
31) Hanić, A., & Mitić, P. (2020). Uticaj COVID-19 na životnu sredinu i energetski sektor. In Mitić, P., Marjanović, D.. (Eds). Black swan in the world economy 2020. Institute of Economic Sciences, Belgrade, pp. 141-157.
32) Hanić, A., Jovanović, O., & Stevanović, S. (2021). Environmental disclosure practice in the Serbian banking sector. Management, 26(2), 115–144. https://doi.org/10.30924/mjcmi.26.2.7
33) Horsburgh, K., Haigh, I. D., Williams, J., de Dominicis, M., Wolf, J., Inayatillah, A., & Byrne, D. (2021). "Grey swan" storm surges pose a greater coastal flood hazard than climate change. Ocean Dynamics, 71(6–7), 715–730. https://doi.org/10.1007/s10236-021-01453-0
34) Huremović, D. (2019). Brief History of Pandemics (Pandemics Throughout History). In Huremović (eds) Psychiatry of Pandemics: A Mental Health Response to Infection Outbreak. Springer
35) International Labour Organization (2021). ILO Monitor: COVID-19 and the world of work. Seventh edition
36) Karan, A., Ali, K., Teelucksingh, S., & Sakhamuri, S. (2020). The impact of air pollution on the incidence and mortality of COVID-19. Global Health Research and Policy, 5(1). https://doi.org/10.1186/s41256-020-00167-y

37) Kennedy, C., & Lindsey, R. (2021, September 27). What's the difference between global warming and climate change? | NOAA Climate.gov. Retrieved January 14, 2022, from https://www.climate.gov/news-features/climate-qa/whats-difference-between-global-warming-and-climate-change
38) Khan, M. D., Thi Vu, H. H., Lai, Q. T., & Ahn, J. W. (2019). Aggravation of Human Diseases and Climate Change Nexus. International Journal of Environmental Research and Public Health, 16(15), 2799. https://doi.org/10.3390/ijerph16152799
39) Kojić, M., Mitić, P., Dimovski, M., & Minović, J. (2021). Multivariate Multifractal Detrending Moving Average Analysis of Air Pollutants. Mathematics, 9(7), 711. https://doi.org/10.3390/math9070711
40) Lancet. (2018). The Lancet. https://secure.jbs.elsevierhealth.com/action/cookieAbsent?code=lancet-site
41) Lin, N., & Emanuel, K. (2015). Grey swan tropical cyclones. Nature Climate Change, 6(1), 106–111. https://doi.org/10.1038/nclimate2777
42) Lindaas, O. A., & Pettersen, K. A. (2016). Risk analysis and Black Swans: two strategies for de-blackening. Journal of Risk Research, 19(10), 1231–1245. https://doi.org/10.1080/13669877.2016.1153499
43) Ljumović, I., Hanić, A., & Kovačević, V. (2021). The role of reward-based crowdfunding in farm financing: What characterises successful campaign? Ekonomika Poljoprivrede, 68(3), 773–788. https://doi.org/10.5937/ekopolj2103773l
44) Lorentzen, H.F, Benfield, T., Stisen, S., Rahbek, C. (2020). COVID-19 is possibly a consequence of the anthropogenic biodiversity crisis and climate changes. Dan Med J., 67(5), 1-5.
45) Malo, S. (19.11.2018). Deadly air pollution shortens lives by nearly 2 years - researchers. Available at https://in.reuters.com/article/global-pollution-health-idINL2N1XU12C
46) Manning, L., Birchmore, I., & Morris, W. (2020). Swans and elephants: A typology to capture the challenges of food supply chain risk assessment. Trends in Food Science & Technology, 106, 288–297. https://doi.org/10.1016/j.tifs.2020.10.007
47) Mayer, H. (1999). Air pollution in cities. Atmospheric Environment, 33(24–25), 4029–4037. https://doi.org/10.1016/s1352-2310(99)00144-2
48) Mazarr, M. J. (2016). Rethinking Risk in National Security: Lessons of the Financial Crisis for Risk Management (1st ed. 2016 ed.). Palgrave Macmillan.
49) Mitić, P. (2020). Interdependence between economic growth and environmental pollution in Southeastern European countries [Doctoral thesis, The University of Niš]. http://ebooks.ien.bg.ac.rs/1466/1/Doktorska%20disertacija%20Petar%20Mitic.pdf

50) Mitić, P., Kostić, A., Petrović, E., & Cvetanovic, S. (2020). The relationship between CO_2 emissions, industry, services and gross fixed capital formation in the Balkan countries. Engineering Economics, 31(4), 425-436. https://doi.org/10.5755/j01.ee.31.4.24833
51) Morens, D. M., & Fauci, A. S. (2020). Emerging Pandemic Diseases: How We Got to COVID-19. Cell, 183(3), 837. https://doi.org/10.1016/j.cell.2020.10.022
52) Natural disaster risks: Losses are trending upwards | Munich Re. (2020). Munichre. https://www.munichre.com/en/risks/natural-disasters-losses-are-trending-upwards.html
53) Parameswar, N., Chaubey, A., & Dhir, S. (2021). Black swan: bibliometric analysis and development of research agenda. Benchmarking: An International Journal, 28(7), 2259–2279. https://doi.org/10.1108/bij-08-2020-0443
54) Paté-Cornell, E. (2012). On "Black Swans" and "Perfect Storms": Risk Analysis and Management When Statistics Are Not Enough. Risk Analysis, 32(11), 1823–1833. https://doi.org/10.1111/j.1539-6924.2011.01787.x
55) Petrović-Ranđelović, M., Mitić, P., Zdravković, A., Cvetanović, D., & Cvetanović, S. (2020). Economic growth and carbon emissions: evidence from CIVETS countries. Applied Economics, 52(16), 1806-1815. https://doi.org/10.1080/00036846.2019.1679343
56) Ross, J. (2020, April 8). Black Swan Events: Short-term Crisis, Long-term Opportunity. Advisor Channel. https://advisor.visualcapitalist.com/black-swan-events/
57) Safety of Nuclear Reactors - World Nuclear Association. (2021). World Nuclear Association. http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx#:%7E:text=The%20risk%20of%20accidents%20in,radioactive%20releases%20can%20be%20avoided.
58) Shaftel, H. (2021). Overview: Weather, Global Warming and Climate Change. Climate Change: Vital Signs of the Planet. Retrieved January 11, 2022, from https://climate.nasa.gov/resources/global-warming-vs-climate-change/
59) Shakil, M. H., Munim, Z. H., Tasnia, M., & Sarowar, S. (2020). COVID-19 and the environment: A critical review and research agenda. Science of The Total Environment, 745, 141022. https://doi.org/10.1016/j.scitotenv.2020.141022
60) Shrader-Frechette, K. (2011). Fukushima, Flawed Epistemology, and Black-Swan Events. Ethics, Policy & Environment, 14(3), 267–272. https://doi.org/10.1080/21550085.2011.605851
61) Sloan, C., Moore, M. L., & Hartert, T. (2011). Impact of Pollution, Climate, and Sociodemographic Factors on Spatiotemporal Dynamics of Seasonal Respiratory Viruses. Clinical and Translational Science, 4(1), 48–54. https://doi.org/10.1111/j.1752-8062.2010.00257.x

62) Stavrova, E., Paskaleva, M. & and Stoykova, A. (2020). Empirical Analysis Of "Black Swan Effect": Evidence Of China. Economic Science, education and the real economy: Development and interactions in the digital age, Publishing house Science and Economics Varna, 1, pp. 129-146.
63) Stern, N. (2007). The economics of climate change: The Stern review. Cambridge University press.
64) Syed, F., & Ullah, A. (2021). Estimation of economic benefits associated with the reduction in the CO_2 emission due to COVID-19. Environmental Challenges, 3, 100069. https://doi.org/10.1016/j.envc.2021.100069
65) Taleb, N. N. (2007). The Black Swan: The Impact of the Highly Improbable.
66) The Economist Inteligence Unit. (2019). Industries in 2019.
67) To, T., Zhang, K., Maguire, B., Terebessy, E., Fong, I., Parikh, S., & Zhu, J. (2021). Correlation of ambient temperature and COVID-19 incidence in Canada. Science of The Total Environment, 750, 141484. https://doi.org/10.1016/j.scitotenv.2020.141484
68) Travaglio, M., Yu, Y., Popovic, R., Selley, L., Leal, N. S., & Martins, L. M. (2021). Links between air pollution and COVID-19 in England. Environmental Pollution, 268, 115859. https://doi.org/10.1016/j.envpol.2020.115859
69) Trends in Global CO_2 and Total Greenhouse Gas Emissions; 2020 Report. (2020, December 21). PBL Netherlands Environmental Assessment Agency. https://www.pbl.nl/en/publications/trends-in-global-co2-and-total-greenhouse-gas-emissions-2020-report
70) Uddin, M., Chowdhury, A., Anderson, K. and Chaudhuri, K. (2021), "The effect of COVID – 19 pandemic on global stock market volatility: can economic strength help to manage the uncertainty?", Journal of Business Research, 128, 31-44.
71) United Nations Department of Economic and Social Affairs. (2014). UN.Org. https://www.un.org/en/development/desa/publications/2014-revision-world-urbanization-prospects.html#:%7E:text=The%202014%20revision%20of%20the,population%20between%202014%20and%202050.
72) van der Molen, F. (2020b, January 21). John Elkington: "How Do You Define A Green Swan?" Duurzaam Ondernemen. https://www.duurzaam-ondernemen.nl/john-elkington-how-do-you-define-a-green-swan/
73) Videnović, S., Hanić, A., & Sućeska, A. (2021). Ethically relevant values and behavior of employees in Serbia during the COVID-19. Teme, XLV(3), 821−842.
74) VishnuRadhan, R., Thresyamma, D. D., Eldho, T. I., Dhiman, R., & Bhavan, S. G. (2021). On the emergence of a health-pollutant-climate nexus in the wake of a global pandemic. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-021-16392-y

75) Wang, M., Jiang, A., Gong, L., Lu, L., Guo, W., Li, C., Zheng, J., Li, C., Yang B., Zeng, J., Chen, Y., Zheng, K., Li h.,2020. Temperature significant change COVID-19 transmission in 429 cities. MedRxiv. doi: https://doi.org/10.1101/2020.02.22.20025791
76) Woetzel, J., Pinner, D., Samandari, H., Engel, H., Krishnan, M., Boland, B., & Powis, C. (2021, January 27). Climate risk and response: Physical hazards and socio-economic impacts. McKinsey & Company. https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-response-physical-hazards-and-socioeconomic-impacts#:%7E:text=Physical%20climate%20risk%20is%3A,by%202050%20versus%20today's%20levels.
77) World Bank. (2020). Global Economic Prospects. USA
78) World Health Organization. (2016). Ambient air pollution: a global assessment of exposure and burden of disease. World Health Organization.
79) Wu, X., Lu, Y., Zhou, S., Chen, L., & Xu, B. (2016). Impact of climate change on human infectious diseases: Empirical evidence and human adaptation. Environment International, 86, 14–23. https://doi.org/10.1016/j.envint.2015.09.007
80) Wu, X., Nethery, R. C., Sabath, M. B., Braun, D., & Dominici, F. (2020). Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis. Science Advances, 6(45). https://doi.org/10.1126/sciadv.abd4049
81) Wu, X., Tian, H., Zhou, S., Chen, L., & Xu, B. (2013). Impact of global change on transmission of human infectious diseases. Science China Earth Sciences, 57(2), 189–203. https://doi.org/10.1007/s11430-013-4635-0
82) Wucker, M. (2016). The Gray Rhino: How to Recognize and Act on the Obvious Dangers We Ignore. St. Martin's Press.