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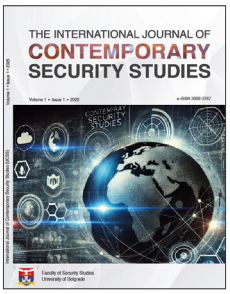

Climate Change as a Security Challenge, Risk and Threat of the 21st Century and Its Consequences on Critical Infrastructure

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ABSTRACT

In recent decades, we have increasingly witnessed frequent climate changes. Climate change is one of the significant problems facing modern society, negatively affecting the environment, economy, infrastructure, and the health and safety of people. However, the effects of climate change during the 21st century have endangered both transport and telecommunications infrastructure. Research into climate change presents one of the most significant challenges facing the Planet in the 21st century. Considering that most social communities have rarely experienced protection from the numerous effects of natural and technological disasters, such complexity has emphasised the need for more detailed research. Namely, although climate change is one of the biggest global challenges, the world has long faced many issues it brings, and some research indicates that its impact will become increasingly frequent. This paper primarily highlights the complexity of this issue. One of the paper's goals is to realistically assess the situation and explore the potential for improving the activities of numerous institutions, experts, and scientists. The first chapter defines the concept of climate change and its classification, while the second chapter defines the concept of critical infrastructure and the problems that may arise. The third part of the paper will present the importance of ensuring the sustainability of critical infrastructure and the measures to address these issues. Climate change is our reality. We deal with the consequences, not the cause.

KEYWORDS

Climate change, consequences of climate change, protection of critical infrastructure, essential sustainability of infrastructure.

1. Introduction

Climate change represents the reality of modern life and business conditions (Cvetković & Grbić, 2021; Cvetković et al., 2019). As a consequence of climate change, large-scale catastrophic events, such as floods, fires, tsunamis, and hurricanes, often occur, greatly endangering individuals, the economy, and society as a whole (Iftikhar & Iqbal, 2024; Aktar et al., 2021; Chakma et al., 2020). In today's world, the question is no longer whether global climate change exists but rather how evident climate changes are and how they will be reflected, as well as the challenges they pose to life on Earth and the economy (Njegomir, 2017). Therefore, events in Serbia, such as the significantly cold February days during the winter period in 2012, the May floods in 2014, tornadoes in Vojvodina, freezing rain in Majdanpek, as well as significantly high temperatures measured in Belgrade and our other cities, drew the public's attention to actions that cause climate change. Climate change never ceases

to surprise us with its actions and phenomena, which at times are so striking that we think the end of the world is imminent (Luković & Djordjević, 2015). It is often noted that climate change primarily refers to alterations in climate factors resulting from natural influences or anthropogenic actions, which are the effects of human activity on the environment.

In contrast, global warming refers to an increase in average temperature. Namely, climate changes related to global warming are increasingly becoming a serious problem for both nature and society. Accordingly, temperatures are increasing, and the ice is melting at certain poles. In some cases, the increased temperature can lead to heat strokes, the spread of infectious diseases, and similar health risks, all of which can endanger people's health. Namely, global warming contributes to the increase in droughts, which in turn leads to soil erosion and a lack of water. Consequently, population migrations from areas of high risk, conflicts, and wars often occur. When it comes to climate change and increased temperatures, research on the percentage of high temperatures has shown that in some parts of the country, temperatures have been significantly high. For example, in January 2018, parts of Sydney experienced a temperature of over 47 degrees Celsius, the highest since 1939, while in the summer of 2018, California's temperatures reached over 48 degrees Celsius. What is particularly interesting, considering that we are in the year 2025 and that some scientists talked much earlier about the year 2025, is that when it comes to the weakening of the Gulf Stream that moves through the Atlantic has led to a change in the climate and that to the appearance of harsher winters and colder summers. Meanwhile, another group of scientists believes that the Gulf Stream could disappear between 2025 and the end of the 21st century.

There are numerous estimates regarding global warming itself, with projections that by 2050, sea levels will rise by approximately 20 centimetres, and by 2100, they will rise by over 200 centimetres. If it were to happen, such consequences would significantly affect both the flora and fauna, as well as many lives, in these parts of the country. History shows that many cultures and civilisations have disappeared due to the constant impact of natural disasters (Kovačević & Kovačević, 2018). However, when we discuss critical infrastructure, we must consider that it is a complex system that necessitates a holistic approach to its operation. According to some authors, critical infrastructure encompasses a set of essential goods and infrastructure elements that are crucial for the functioning of society, the safety and health of people, and other vital aspects. However, for the critical infrastructure to be effective, it largely depends on the success of the company and its cooperation with other countries. Namely, the term critical infrastructure originated in the United States of America.

The term is used to emphasise that it is a system of special importance for the well-being of society and the community. As many as eight infrastructures are identified in the documents of the United States. These include, primarily, telecommunications, energy systems required for the exploitation and production of electricity, natural gas and oil, finance and banking, traffic and transport, water supply systems, state services, and emergency services. Of particular importance is the Act known as the Patriot Act, passed in 2001. We are talking about an act that was passed in response to a major terrorist act on the Twin Towers, and within that act, there is an act on the protection of critical infrastructure. He defines critical infrastructure as a set of values, systems, and networks that are of great importance to the United States. If their destruction and weakening were to occur, national security and economic security would be compromised. That is why it is imperative to strive for the protection of critical infrastructure, which represents a new concept in modern society that is still in development (Keković & Ninković, 2020).

2. Definition of climate changes

Defining the term 'disaster' itself has always attracted attention and is one of the most interesting questions for many scientists in disaster research (Cvetkovic, 2020). They represent a relatively new term in both theoretical and practical terms. Namely, two disasters that are very often mentioned are the industrial disaster in Bhopal and the nuclear catastrophe in the Soviet Union during the eighties. We are referring to disasters that had a significantly greater impact on the environment. Therefore, natural disasters increasingly threaten people and their goods every day, and in most cases, they primarily affect poor countries, posing a significant threat to the entire world. According to conducted research, on average, 50% of disasters are meteorological, 30% technological, 12% geological, and 8% are biological. However, among the most devastating disasters that have hit China are earthquakes, droughts, floods, and similar events. In contrast, in parts of Latin America, disasters such as volcanic eruptions, avalanches, and landslides have been recorded. In contrast, the most significant geological disaster in the Indian Ocean was recorded, followed by a tsunami (Cvetković, 2017).

Namely, many problems related to food and food production are closely linked to climate change, including droughts, floods, and other extreme weather events. Most crops, such as wheat, rice, and corn, are increasingly affected by changes in annual temperatures. Areas prone to urbanisation are most vulnerable to the negative consequences of climate change, including landslides, water shortages, and other related issues. Only those urban areas that lack basic infrastructure and services and are therefore not prepared to respond in emergencies are more susceptible to these risks, as well as those with poorer quality housing facilities. When it comes to the loss of means of living due to limited access to drinking water, irrigation, and reduction in agricultural production, one of the reasons is that farmers and shepherds who have such means are most exposed to it. In most cases, climate change will also affect the shortening of the heating season (Doljak & Petrović, 2015).

Although climate change can be categorised as a combination of climatological and meteorological studies, in the broadest sense, it is characterised by an increase in temperature, precipitation, and similar phenomena. Their influence is felt everywhere and can harm the environment and agriculture and contribute to sea level rise. Therefore, climate change affects the whole of Europe, but its impact is not uniform everywhere, and it will have varying effects on parts of southern, southeastern, and western Europe. Most research has shown that Serbia will be significantly affected by climate change in the future, including increased occurrences of heavy rains, prolonged periods without precipitation, and days marked by intense droughts and heatwaves (Raković, Jocković, Pujević, & Obradović, 2023). In essence, the changes caused by climate change are related to the greenhouse effect, which occurs due to an increase in the concentration of harmful gas emissions in the atmosphere.

Among them are four groups of harmful gases such as methane, carbon dioxide, and chlorofluorocarbons, and the last among them is nitrogen suboxide). The danger that the planet Earth faces, which is also exacerbated by substantial climate change, is global warming, including extreme weather events such as droughts and cold spells. For example, one of the warmest years mentioned more and more often as an example of its importance, is 2019. However, the range from 2015 to 2019 increased the level of the greenhouse effect and a higher percentage of carbon dioxide in almost the entire world. This research suggests that by the year 2100, the greenhouse effect is expected to increase by an average of 3%. In this case, we should strive for an urgent reduction in carbon dioxide emissions to avoid an extreme catastrophe. Therefore, natural disasters encompass both natural and human-caused events that negatively impact most countries and populations, resulting in severe economic, social, and environmental consequences. However, over the last few years, their destructive influence has increased, resulting in a rise in the number of victims and economic losses, both material and non-material (Cvetković, 2014).

3. Escalation of social conflicts and wars as a consequence of climate change

Thus, an increase in temperature growth may tend to increase the risk of escalating violent conflicts due to the worsening of poverty-related problems. However, climate change can also be a potential and significant cause of social conflicts and wars. First of all, wars are often related to basic resources, and above all, water is one of the most essential resources for life and survival. Namely, there is a cause-and-effect relationship between climate change, resource scarcity, and conflicts. In essence, climate change can significantly reduce the availability of essential resources, including food and water. In such a situation, the population would immediately start fighting for the remaining necessary resources if it is threatened. As one example, the civil war in Syria caused by social, political, economic, and environmental factors is often mentioned.

Climate change, such as the 2006 drought, was a potential indicator of conflict, while increased temperatures had serious consequences for agriculture, as grain yields declined rapidly as a result. Most of the vast number of agricultural producers were left without their products and had to leave their places. In that period, the influx of refugees, estimated at over one million from Iraq, began in Syria. All of this led to an increase in the demographic population and higher unemployment in cities, resulting in increased crime and social unrest, rebellion, and eventually civil war. The conflict in Darfur is often mentioned as the first climate war. The reason for this kind of conflict is long-term droughts, which are linked to global warming and have ultimately become one of the significant causes of the conflict. Namely, the conflict in Darfur initially arose as an environmental crisis exacerbated by climate change. Thus, the case of Darfur demonstrated how environmental factors, in this instance drought, can degrade society and the state (Kovačević & Kovačević, 2018). Many negative consequenc-

es of climate change affect most sectors, and according to World Bank estimates, natural disasters incur annual costs of billions of dollars (Petrović, 2020).

In general, climate change, with its varied effects, can lead to the extinction of both plant and animal species. Namely, global warming is closely related to the appearance of the greenhouse effect. Research indicates that the number of cold days has decreased significantly, resulting in an increase in high temperatures during the 21st century. It is expected that by the end of the 21st century, there will be more high temperatures and fewer cold days, but precipitation is expected to become more intense. The rise in high temperatures will also affect the way of life of many people. For example, one of the stories is related to the town of Coober Pedy, situated in the heart of the Australian desert. It is a mining town located over 800 km from Adelaide, with a population of approximately 3,500. It is a city where the rainfall is minimal, and the temperatures are so high that people are forced to live underground. For these reasons, the majority of the population has failed to change their lifestyle despite the stated goal of addressing global warming.

Due to the high temperatures, some residents of Paris resorted to using cold islands to cool off and improve their living conditions. Many natural disasters have large-scale consequences, so in 2018, fires engulfed the Californian part of Shasta, creating fiery tornadoes that destroyed trees and cars, even in the face of strong winds. In such a situation, a considerable number of the population was forced to evacuate. The consequences were such that a considerable number of people died, and over 500 buildings and houses were destroyed. Large-scale fires also affected the United States of America in the same year, with an estimated number of over 100 fires per year. Sweden was also affected by fires in the same year, which destroyed over 20,000 hectares of land. However, the actual number is much higher, and the fires also impacted Italy, Portugal, and Spain, destroying approximately 800,000 hectares of land.

The consequences of the fire were also recorded in Greece, where a large part of the population lost their lives while another part of the population suffered the effects of burns from the fire. It must not be forgotten that Japan was also affected by the consequences of natural disasters, including rainfall, floods, landslides, and high temperatures. As a result of such disasters, the number of plant and animal species decreased. Some research indicates that by 2050, there will be 15% fewer plants and animals than there are currently. In Asia, it is predicted that by 2048, there will be no fish left for fishing. However, according to some research, Africa may have the most significant tendency to lose birds and mammals by the year 2100, while particular species will be significantly endangered. Based on everything so far, we see that, indeed, climate change leads to the appeasement and disappearance of many plant and animal species. Due to the effects of global warming, rivers and lakes are experiencing the process of evaporation and water loss. Without water, plant and animal species will not be able to survive, and this is particularly true for the Caspian Lake, the largest lake on the planet. Although it is surrounded by Kazakhstan, Russia, Azerbaijan, Turkmenistan, and Iran, it gradually evaporates, reducing the water level by seven centimetres per year.

Climate change affects people's health through its actions but also contributes to the spread of viruses and bacteria. Diseases such as bronchitis, influenza, and pneumonia are expected to become more frequent precisely because of the effects of climate change. People will die from high temperatures, heatstroke, UV radiation, sunstroke, dehydration, blood pressure and more. In France in 2003, as many as 15,000 people lost their lives due to a heat wave, and some studies point out that by 2080, mortality will increase in some parts of the world due to the increase in heat waves. Heat waves will become more frequent. It will last longer and increase the mortality of a vast number of people. Although it is said that the northern part of China is the most densely populated part of the planet, the problem lies in the occurrence of infectious diseases transmitted through contaminated water. There is also a view that by the end of the 21st century, it will become the hottest part of the country. Due to contaminated water, air, and soil, the occurrence of infectious diseases is expected to increase, leading to a higher prevalence of malaria in areas where it was previously absent.

The temperature rise will also lead to the spread of ticks and tiger mosquitoes, as well as other carriers of infectious diseases that can cause illnesses such as West Nile virus and dengue fever. Due to rising temperatures, the number of people infected, ill and dead from West Nile fever in Europe is also increasing. Namely, the West Nile virus is spreading in Europe, so since the beginning of 2018, more than 400 people have fallen ill, while over 400 people have been registered in Serbia. Due to the effects of climate change, infections and pandemics are likely to emerge, endangering the health of a large number of people. In that case, it is noted that global warming is expected to cause a significant number of deaths worldwide by 2050. Therefore, research indicates that by the end of the 21st century, due to the adverse effects of climate change and the greenhouse effect, cli-

mate change will be the primary cause of the deaths of a large number of people (Kovačević & Kovačević, 2018). In general, many climate changes affect ecosystems, causing numerous negative consequences. In the worst case, they can leave a large part of the population without sufficient food production, resulting in food shortages, malnutrition, and similar issues. Therefore, malnutrition carries an increased risk of infectious diseases and respiratory tract diseases, all of which can occur due to contamination of water and air (Milotijević & Ilić Krstić, 2020).

Depending on the nature of the process of occurrence, natural disasters can be classified into three categories: geophysical, which includes volcanoes, earthquakes, storms, landslides, and similar events; biological, which includes epidemics and insect infestations; and extraterrestrial, which includes meteor impacts. When it comes to the place of occurrence, natural disasters can be divided into atmospheric, which includes tornadoes, cyclones, and similar phenomena; lithospheric, which encompasses volcanic eruptions; and natural disasters originating from the biosphere, such as forest fires, bacteria, and others. When it comes to origin, they can be divided into endogenous, such as earthquakes and volcanic eruptions, and exogenous, such as floods and droughts, as well as anthropogenic, which is caused by human action, including floods resulting from the collapse of dams (Cvetković, 2014). In our current era, one of the most significant security challenges is the protection of critical infrastructure, as the functioning of most states heavily depends on the practical safeguarding of key infrastructure facilities. Infrastructures essential for the production of food, water, energy, transportation, and healthcare provide the basic conditions for human life and the uninterrupted operation of states. However, the destruction of any of these infrastructure systems can cause extensive damage to both states and organisations. In such cases, the protection of critical infrastructure becomes particularly important and represents a matter of utmost national security.

Events such as the 2001 terrorist attacks in the United States elevated the level of critical infrastructure protection, while attacks in London, Paris, Moscow, Brussels, and Barcelona further highlighted the importance of investing in infrastructure resilience. When it comes to critical infrastructure protection, the primary goal pursued by all states, including the Republic of Serbia, is to establish an effective mechanism that can prevent conditions leading to infrastructure failure due to disasters (Trbojević, 2018).

In the Republic of Serbia, the number of natural disasters has increased over the past two decades, resulting in the destruction of vast areas of land. Until 2014, little attention was paid to preventive measures—until Cyclone Tamara raised numerous concerns among international organisations. This cyclone struck parts of the Western Balkans in 2014, leaving behind severe consequences. The outcomes included overflowing rivers, extreme precipitation across much of Serbia, and subsequent flooding, landslides, and soil erosion.

Research showed that Serbia was unprepared to cope with the consequences of the cyclone. Precisely for these reasons, and in light of climate change, all affected populations must be ready to respond and contribute to reducing the risk of devastating consequences (Đorđević, Vukašinović, Cvetković, & Pejić, 2016).

4. Definition of critical infrastructure and the impact of climate changes on critical infrastructure

One understanding of the term' critical infrastructure' is that it encompasses networks, systems, facilities, and assets that ensure the smooth functioning of the state and the provision of basic needs to the population. Therefore, it represents a vital backbone of every society, ensuring both prosperity and security. Due to the importance of the role it plays in maintaining the smooth functioning, integrity, and security of urban areas, it can be considered a vital link in urban security. Many social processes have led to changes in the organisational, technical, and operational segments of critical infrastructure. The interconnectedness, complexity, and dependence of these infrastructures have led to an increase in risk. In the times we live in today, critical infrastructure is vulnerable to various types of threats, natural disasters, cyber-attacks and acts of terrorism.

Being so vulnerable simultaneously affects the vulnerability of society and represents a significant risk to overall security, including the security of urban areas. However, one of the important segments of critical infrastructure protection is its resilience. Essentially, resilience represents the ability of a system, network, object, or other element of critical infrastructure to mitigate negative impacts and adapt to them in the most acceptable period, thereby returning to a state of normal and improved functioning. Therefore, by strengthening the resil-

ience of critical infrastructure, it is possible to enhance the resilience of the environment in which it is located, and this is precisely how it contributes to the overall resilience of society. The private security sector plays the primary role in protecting critical infrastructure. Precisely, the private security industry, as it has been referred to over the last few years, is a significant entity in the provision of security services. In contrast, critical infrastructure refers to the objects that it protects. Therefore, the non-state security sector, or the sector of the private security industry, is increasingly a part of everyday life, signifying the bearer of certain security functions. Private security companies, as part of this sector, are increasingly involved in the realisation and maintenance of public security, which includes the protection of critical infrastructure, a task that poses a serious challenge for the entire security sector (Marković, 2024). In increasing cases, the negative impacts of climate change, such as floods, landslides, and droughts, are becoming more significant, and they mainly affect traffic infrastructure, leading to traffic interruptions.

Natural disasters caused by climate change can have an eminent impact on infrastructure. Although the infrastructure is designed to last for years, its longevity largely depends on the influence of the climate itself and the effects of climate change. Of all the mentioned climate changes, precipitation such as snow, the appearance of fog, and the like have the most significant impact on infrastructure, leaving behind destroyed bridges and other structures. Namely, cities such as those in France, Italy, and Switzerland were the most affected by floods in 2020, and their infrastructure was impacted. What is more, a part of Western Europe faced floods in 2021 that killed a massive number of people, including an incredible 184 deaths. Destroying and leaving consequences on the traffic infrastructure; the consequences in the surrounding towns were such that many roads remained closed, and the population was limited in their ability to evacuate and leave their homes. Climate change also affected the United States of America and, more specifically, in 2021, in Canada.

One of these consequences is the increase in temperature, which has led to extreme effects, including impacts on infrastructure, roads, and the closure of schools, among many other effects. At the same time, the population of England in 2020 faced the natural disaster of storm Dennis and so much damage and consequences to the same population; the infrastructure amounted to several million pounds, and due to the necessary renewal of the infrastructure, money will be needed twice as much in order to return to pre-storm Dennis conditions. This storm also affected rail, road, and air traffic; however, a substantial amount of money will be required to rebuild the road infrastructure. Namely, if we look back at our country, Serbia also faced the consequences of critical infrastructure damage due to the May 2014 floods. Some research has presented data indicating that in May 2014, the infrastructure destroyed in Serbia due to floods totalled an incredible 945 km, including 307 bridges and 147 landslides. Namely, in some cities in Serbia, such as Kragujevac, Kraljevo, Knić, Tutin, and many other cities, landslides were triggered by flooding, which also destroyed many roads and railways. In Kraljevo, the overflow of the Ibra River resulted in significant consequences and damage to the population, agriculture, numerous residential buildings, and infrastructure (Mošić & Traffic, 2022).

As already mentioned, climate change and increasing infrastructural works contribute to specific areas that are otherwise susceptible to disasters in the future becoming even more targets for extreme weather conditions and natural disasters, the consequences of which can be in the form of a vast number of dead and injured victims (Cvejić, Tutundzič, Bobić & Radulović, 2016). Namely, the effects of climate changes, such as floods, droughts, storms, and forest fires, can vary, and their impact extends beyond transportation to affect the energy and water supply. The question is often asked: How exactly does climate change, such as flooding, affect infrastructure? One of the answers is undoubtedly that they can cause interruptions in the supply of electricity, transportation, and water. At the same time, they have the potential to create losses in many businesses. Due to the drastic increase in temperature, the consequences are such that the use of air conditioners puts a strain on energy networks. Meanwhile, due to the increased amount of precipitation, the quality of water can drastically decrease, prevent the availability of water and affect the water supply. As already mentioned in the text, to adequately respond to the challenges faced by critical infrastructure, it is necessary to implement new standards for the construction of infrastructure systems that are resistant to climate change. It is also crucial to invest in technological development to enhance system efficiency and mitigate greenhouse gas emissions. Of course, the cooperation of many experts and the population is also crucial, which entails developing risk management plans and preventing possible disasters. What most affect infrastructure systems are certainly technological threats, and critical infrastructure, such as energy networks, telecommunications systems, financial systems, healthcare, and others, may be subject to an increasing risk of cyber threats and attacks. Such attacks are increasingly affecting sensitive information and can lead to the disabling of important systems. For example, hacking poses

a serious threat with severe consequences, including the loss of electricity, interruptions in telecommunication systems, and similar disruptions.

Namely, to mitigate the impact of cyber attacks and intrusions on the telecommunications system, it is essential to implement protective measures promptly and establish a system for safeguarding against cyber intrusions, thereby preserving the viability of critical infrastructure (Komazec & Janković, 2023). As already mentioned, natural disasters leave a destructive and devastating effect on the entire community of society. For these reasons, it is essential to pay close attention to such phenomena and strive to find effective ways to address them. Namely, the interruption of telecommunications infrastructure is occurring more frequently due to the effects of climate change and natural disasters. Floods, like all other natural disasters, occur suddenly and unexpectedly. Most research indicates that the number of disasters worldwide is increasing annually and that the damage caused by disasters affects both human lives and material goods. For such reasons, the impact of floods on the telecommunications infrastructure is so vulnerable, especially its network elements and the overall functioning of the system. For example, countries like Japan, due to their frequent natural disasters, are an example of where operators take care to calculate the possibility of natural disasters in advance, even during the planning phase of telecommunications infrastructure.

That is why it is essential to examine the state of the telecommunications network from four key dimensions. These are the conditions immediately before the flood, which implies that the social community and the population should be informed promptly about the possibility of an impending disaster through an alarm and warning system that will save the lives of a vast number of people. For example, let us think of a disaster like the tsunami of 2004 in the Indian Ocean when a large number of people lost their lives, and all of them could have been saved if the notification and warning system had been properly used. The second phase of the four is the shortest but also the most critical. She discusses the fact that during the flood, many infrastructures were severely damaged, and systems that were still operational were overwhelmed. In the third phase, emergency response is particularly crucial, ensuring the normalisation of the device's power supply. At the same time, the fourth phase can last several months. He also points out that investing in telecommunications infrastructure can be pretty expensive, and such an investment process can be long-lasting.

For example, in 2004, the four major hurricanes, Charley, Frances, Ivan, and Jeanne, in the United States of America caused a system interruption in fixed telephony for millions of users, while the rest of the territory was left without a telephone network and signal. However, among the most powerful hurricanes to hit the United States in the 21st century was Hurricane Katrina, which affected the Florida and New Orleans areas. The aftermath of this hurricane revealed that the weakest point was the communication infrastructure. Many telephone lines remained without service, while a large number of buildings were destroyed. Then, the 2011 tsunami that hit eastern Japan destroyed over a hundred buildings and left most of the population without telecommunications. Additionally, the floods that hit the city of Doboj in Bosnia and Herzegovina affected the telecommunications centre, which was surrounded by water. Although several workers in the facility stayed for three days, they still managed to keep the system functioning as much as possible. However, due to the influx of water, the facility was left without a commercial power supply (Popović & Djukanović, 2015). Thus, from its inception to the present day, telecommunications has been one of the economic branches that generates substantial profits (Cvetković & Tintor, 2019). Telecommunication networks are considered an inseparable part of social interaction; however, protecting these networks from various attacks and natural disasters, which can lead to the unavailability and interruption of network services, is a crucial aspect that must not be overlooked.

There are many definitions of infrastructure. For example, in the United States of America, it is defined as a term that encompasses a set of different assets and resources needed for the daily functioning of social, economic, political, and cultural systems. It is also noted that any interruption in these systems can cause significant problems. The definition of critical infrastructure in Australia encompasses physical objects, information technologies, and communication networks that, if destroyed, can impact both social and economic systems. Therefore, the telecommunications infrastructure of a country represents a complex set of systems that includes various technologies and services, which are owned by multiple entities, including states, companies, and others (Gospić, Murić & Bogojević, 2012). Many natural disasters have consequences that affect people, their material possessions, and critical infrastructures, and these consequences can be either primary or secondary. The consequences of a primary character can be manifested in the form of ground shaking, leading to the collapse of all infrastructural objects. In contrast, the consequences of a secondary character are represented by the occurrence of landslides, tsunamis, and fires. The consequences can be both physical and material, such as destroyed

or damaged housing and other critical infrastructure, as well as human casualties. Social consequences include demographic, economic, political, institutional, psychological, and health consequences (Cvetković, 2014).

5. The impact of flooding as one of climate changes on critical infrastructure

Damage caused by floods, a type of climate change, is a global risk, and damage to infrastructure is among the most expensive (Fekete, 2019). Namely, the increasingly frequent and severe floods are expected to increase in many countries, while in others, they are expected to decrease. Among the thirty member states that participated in the scenarios, ten believed that floods could certainly affect critical infrastructure. Over the last few years, flood-related losses have increased significantly. In essence, the power grid is susceptible to flooding, and as a result, power outages are becoming more frequent (Pant, Thacker, Hall, Alderson, & Barr, 2018). Extreme weather events pose serious risks to critical national infrastructure in the UK. That is why floods stood out among them as the most significant risk for Great Britain and are a threat both now and in the future. In England and Wales, it occupies thousands of hectares of land, making it a target for floods and the effects of climate change. However, the number is expected to be significantly higher by 2080 (Karagiannis et al., 2019).

Infrastructure is seen as a basic object, service and institution needed for the smooth functioning of the community and society, which includes transport and communication systems, public institutions, schools and others. That is why infrastructure plays a crucial role in everyday life and is essential for the community, enabling better responses to natural disasters. It consists of physical and information technology objects, networks and services, the destruction of which can have serious consequences for the health and safety of the majority of society and the population. However, floods as natural disasters increasingly destroy property and critical infrastructure, so in the United States, early attention was primarily focused on protecting critical infrastructure from threats of military attacks, energy crises, and terrorist attacks. In this regard, the fact that natural disasters are increasingly viewed as a threat with serious consequences for the country, resulting in significant losses and an increased number of victims, is highlighted. Thus, many natural disasters can physically destroy and damage critical infrastructure objects. For example, Hurricane Sandy in 2012 caused a power outage that affected millions of people, with the failure being so severe that it had a significant impact on the information infrastructure, as well as transportation, and prevented the provision of medical services (Qiang, 2019). Namely, critical transport infrastructure refers to such infrastructure that, due to the destruction of one of the natural disasters, could affect the maintenance of important daily functions. It is essential that the quality performance of transport services would not be possible without key elements of transport, such as means of transport and transport infrastructure.

Therefore, emergencies significantly alter the state of the social community due to natural disasters or other natural and technological catastrophes. Therefore, each country or organisation is obligated to define and classify its infrastructure and identify which infrastructure is critical. However, after defining the critical infrastructure and determining its basic elements, one can visualise its comprehensive critical infrastructure network and define the measures and approach to protect it in the event of collapse. In the last ten years, the Republic of Serbia has been affected by more than 150,000 fires. Additionally, the floods that had consequences for the Republic of Serbia were the May 2014 floods and the 2009 earthquake in the city of Kraljevo. Accordingly, due to such events, the Republic of Serbia has invested considerable effort in creating a protection and rescue system to respond in the best possible way to conditions that threaten critical resources. When we discuss traffic infrastructure, it is essential to emphasise that transportation also plays a crucial role in the functioning of everyday human activities and enables the smooth operation of other important functions. However, for it to function, a transport system is necessary, which is one of the most important logistics activities. It belongs to very complex systems and includes facilities, transportation means, and transportation relations within its group.

Transport is of great importance for the exchange and supply of goods on the market, increasing the ratio of producers and consumers. One of the primary functions of the transportation system is precisely what was mentioned in the previous sentence: it effectively represents the relationship between buying and selling, providing the best service delivery and ensuring customer satisfaction. Therefore, it follows that the national transport infrastructure represents a pillar in the supply of material goods and services. The quality and efficiency of this infrastructure, which provides people with access to services and resources, significantly impact the quality of life and economic growth. That is why it is crucial to define critical infrastructure in transport, as it holds

particular importance for the state. The disruption of one of the critical elements of transport infrastructure will significantly impact the functioning of the entire transport system. The consequences of transport infrastructure can be so severe that they are challenging to eliminate (Košanin, 2019). Thus, critical infrastructure, as a vital segment of modern society, provides a wide range of essential services that form the backbone of the European economy.

However, the environment in which critical infrastructure has operated over the last twenty years has also undergone significant changes. For example, many climate change events, such as floods and storms, significantly increase their hydrometeorological hazards through their actions and thus influence the priority to focus on the resilience of critical infrastructure. For example, one case study presented its study on climate change adaptation that relied on the resilience of critical infrastructure. However, the purpose and goal of this study was to present a methodology for investigating the impact of climate change on flood risk to critical infrastructure. This study was conducted in an urban centre in Western Europe, emphasising the impact of flooding on critical infrastructure as a result of climate change. It also describes the recurrence frequency of the flood scenario and the estimated losses incurred by critical infrastructure. Such research was conducted by the Joint Research Center of the European Commission (Karagiannis, Turksezer, Alfieri, Feyen & Krausmann, 2017). In essence, floods that cause significant damage to the power grid typically result in power outages. In one study, as many as twenty floods caused by heavy rains and hurricanes resulted in significant electricity loss, which took a long time to restore, with the loss lasting from twenty-four hours to one week (Karagiannis et al., 2017).

6. Sustainability and review of critical infrastructure resilience measures and critical infrastructure protection

Therefore, critical infrastructure plays a crucial role in maintaining the functioning of not only society but also the economy, serving as the fundamental pillar of social and economic development. However, given that society faces global challenges such as climate change, urbanisation, and technological development, it is necessary to ensure that critical infrastructure is developed sustainably. Therefore, the sustainability of critical infrastructure is of paramount importance. As we have already mentioned, critical infrastructure is affected by many climate change impacts, and a significant problem is the lack of funds for sustainable development and infrastructure improvement. However, although there are challenges that disrupt most infrastructures, there are still many ways to solve such problems. For these reasons, establishing a resilient infrastructure is crucial, representing a vital goal for sustainable development. Therefore, critical infrastructure encompasses important systems, facilities, and services of considerable importance for the smooth functioning of society and the development of the economic system (Komazec & Janković, 2023).

To achieve successful resistance of infrastructure to climate change, most institutions have begun to specify their guidelines precisely for those infrastructures that are resistant to climate change and have started to evaluate guidelines for mitigating the risk of potential natural disasters, such as storms, floods, earthquakes, and the like. Certain studies indicate that most of Europe will be affected by extreme climate changes, including floods. For these reasons, it is crucial to ensure the resilience of infrastructure facilities to such disasters, thereby minimising the need for significant financial resources over the period from 2040 to 2100. For example, Japan was one of the first to increase its capacity for assessing the temperature on railway tracks from 60°C to 65 °C in order to improve investments and prevent the possibility of bending railway tracks. The measures for such improvements can be grouped into planning measures, that is, measures that are applied at the moment when it is necessary to make decisions about the construction of a specific object, and construction measures that indicate the relocation of roads, the construction of new bridges in order to better respond to floods and rising water levels (Mošić & Traffic, 2022).

The protection of critical infrastructure is of particular importance for the well-being of many social communities, both due to direct threats and the interdependence of critical infrastructure at the national, international, and global levels. Namely there are several types of such interdependence, and one of them is cyber interdependence, which is defined as the dependence of infrastructure on information that is mutually exchanged and further transmitted by the information sector. This is a relatively new concept that was created as a result of the computerisation and automation of infrastructure. Therefore, if the work and function of the infrastructure sector cease, a problem of eminent proportions arises, and the adverse effect also affects road traffic, i.e., traffic

infrastructure, as well as energy systems (Miletić, 2022). Namely, as already mentioned, natural disasters, such as floods, storms, droughts, and landslides, indicate the degree of warning and the need for a quick response from all institutions to take appropriate measures that will be applied to all critical infrastructures and their adaptation to climate change. Therefore, bearing in mind the increasing frequency of natural disasters that lead to the interruption of traffic and the destruction of traffic infrastructure, the losses caused by them and how they can be avoided by building an infrastructure that would be resistant to climate change and thus bring eminent quality and duration and resistance of traffic infrastructure to climate change. In that case, a special place should be given to the planning and design of the infrastructure, and above all, the emphasis should be placed on the current and future impacts of all climate change.

Therefore, investments in critical infrastructure that is resistant to climate change can significantly reduce the financial costs of reconstruction (Mošić & Traffic, 2022). Protection encompasses all capabilities and functions that contribute to reducing risk, increasing resilience, and ensuring the functioning of key systems, services, and functions. In essence, adversaries continue to devise new methods to attack, disrupt, and render critical infrastructure non-functional despite the implementation of numerous protection measures that are continually improved and enhanced (Todorović, 2018). Therefore, measures to protect critical infrastructure from numerous threats are becoming increasingly important for safeguarding it against these threats. It is of particular importance because it protects against all potential damage and consequences. In such cases, the protection of critical infrastructure can be viewed as a process that enables a response to emergencies (Košanin, 2019).

Namely, the critical infrastructures as we know them today were developed over the past decades and centuries. From small and independent technologies, infrastructures emerged in the sense that when one technological system dominates others or when independent systems develop into a network. One definition of critical infrastructure is that it refers to an asset, facility, equipment, network, or system, or part of an asset, facility, equipment, network, or system, that is essential for providing critical services. In the current era, critical infrastructure encompasses equipment, buildings, structures, installations, and services that are viewed as a whole, denoting systems necessary for the smooth functioning of the state. The very word 'critical' indicates to us that it is about the provision of goods, products, and services that are extremely important for the economic and social well-being, prosperity, security, and functioning of the state. Namely, if critical infrastructure belongs in urban areas and ensures the satisfaction of basic needs under urban conditions, then we are talking about urban critical infrastructure. Its role, then, is to shape cities socially, politically, and ecologically, influencing their appearance.

Furthermore, on the one hand, the development of cities and urban areas is directly dependent on urban critical infrastructure. In general, energy, water, food, transportation, health, public order, and security are among the most critical infrastructures in cities with a larger number of inhabitants. In essence, over half of the world's population currently resides in urban areas, and research indicates that this population is expected to increase by more than 70% by 2050. For example, Hurricanes Katrina, Sandy, and Harvey significantly impacted the cities of New Orleans, New York, and Houston, where their actions created major crises and caused extensive damage to critical urban infrastructures, thereby affecting energy supply, communications, transportation infrastructure, and production services. (Lomba-Fernández, Hernantes and Labaka, 2019). When we examine the critical infrastructure, it becomes apparent that it is vulnerable to numerous threats from both internal and external environments.

Such threats can be divided into those arising from the natural environment and those caused by human actions, that is, those with a technical-technological character, such as technological accidents, explosions, and fires. The critical infrastructure on which the provision of other goods in the state depends, as well as the needs of the population, is threatened to the greatest extent by natural disasters, technological accidents, criminal activities, and terrorist acts. Bearing in mind that today, almost every critical infrastructure function relies on information and communication technologies, it is part of the cyber sphere. This would mean that a cyber attack on critical infrastructure is often singled out. Let us go back just a few years, during the COVID-19 pandemic, which demonstrated that diseases caused by the pandemic could also pose a threat to critical infrastructure in cases where it relies on critical personnel for management. Natural disasters, such as earthquakes, hurricanes, and floods caused by adverse weather conditions, occur when changes in weather negatively affect the structure and functioning of critical infrastructure. As such, they cannot be easily avoided. Today, due to increasingly frequent climate changes, this type of threat is becoming more significant than it was before. However, criminal activities such as theft, sabotage, and terrorist activities are mainly carried out to undermine the security of crit-

ical infrastructures, all in pursuit of achieving political goals. Namely, cyber-attacks are becoming increasingly frequent, aiming to compromise the confidentiality, integrity, and availability of data and information, which are extremely important for this type of organisation. The basis for this protection is the security technologies for information systems, such as cryptography and security communication protocols.

The primary goal of protecting critical infrastructure is to ensure its continuous operation, thereby enabling the uninterrupted supply of essential products and services required by both the state and society. Firstly, the protection of critical infrastructure can be viewed through resilience, which encompasses the ability to withstand and recover from natural or intentional destruction resulting from the impact of criminal and terrorist activities. In such cases, security measures would include a set of physical, technical and organisational measures to monitor and protect critical infrastructure elements. So, the entire security system should be understood as an integrated system composed of elements and processes that function as a means of protecting critical infrastructure. The functions of this system include deterring potential attackers, detecting intrusions into protected objects, denying access, and the like. On the one hand, the basis for protecting critical infrastructure is precisely strengthening its resilience. The resilience of critical infrastructure refers to the indicator that ensures its operation in conditions where negative external and internal factors are present.

Many countries depend on critical infrastructures, while critical infrastructure networks, systems and facilities provide the basic services and products on which the country depends and by which the population functions. Thus, many cities rely on critical infrastructure, which also enables them to function and develop. However, when the resilience and safety of urban critical infrastructure are improved, the resilience and safety of the entire community and urban environment are also improved. Namely, the protection of critical infrastructure ensures continuous access to the goods that the city's population uses daily and the satisfaction of their needs. Protecting critical infrastructure ensures the continued availability of essential services, including energy, oil, natural gas, water, food, transportation, public services such as healthcare, and more. Critical infrastructure can improve its resilience and security by leveraging private security and private resources. Therefore, in such cases, private security plays a crucial role in protecting critical infrastructure, and private security companies are essential for this purpose. Of course, we are referring to professional companies that invest the most in their human and material resources while also contributing to the quality of the services they offer and provide. It is also worth noting that the private sector's role in protecting critical infrastructure dates back to the September 11, 2001, attacks (Marković, 2024).

7. Conclusion

It is crucial to invest in all critical infrastructures, as damage to them can have serious consequences, necessitating the assistance of multiple countries to implement safety and protection measures (Komazec & Janković, 2023). It is imperative to educate and train personnel in the field of critical infrastructure protection, with a special focus on this area (Jovicic, 2022). In the Netherlands, protecting critical infrastructure is considered a crucial aspect of national security. Since the end of the 1990s, the degree of investment for better management of critical infrastructure protection has increased. The Netherlands also adopted the National Plan in 2001 for securing telecommunications in the event of unforeseen circumstances, as well as the National Cyber Security Strategy. Namely, in 2017, the Republic of Slovenia included critical infrastructure of national importance. It also adopted the National Cybersecurity Strategy and established a national network of operators for quick and efficient responses (Marjanović, 2020).

The telecommunication infrastructure very easily becomes a target of terrorist organisations. Certain studies point out that a terrorist attack will primarily be aimed at the telecommunications infrastructure and thus have the most significant impact on the entire social system. In that case, we can expect that the telecommunications infrastructure will be the main target of terrorists in future attack attempts. Critical infrastructure is the foundation upon which social and economic functions depend; the disruption or loss of any element of critical infrastructure can have a profound impact on the lives of many people. In this regard, mutual investment and exchange of approaches and experiences can contribute to improving the resilience of critical infrastructure (Mataić, 2022).

In our current era, we are witnessing the construction of industrial facilities that bring with it the presence of hazardous substances, as well as the development of transport infrastructure, which in turn increases the

possibility of human errors (Korajlić & Marjanović, 2022). When the resilience and safety of urban critical infrastructure is improved, the resilience and safety of the entire community and urban environment is also improved. Namely, the protection of critical infrastructure ensures continuous access to goods that the city's population uses daily, both to satisfy their needs and to access various services. By protecting critical infrastructure, including energy, oil and natural gas, water, food, sewage systems, and transportation, public services such as healthcare, public order, and security are provided.

This contributes to security, satisfies the population's needs, and improves the quality of life. In this case, critical infrastructure can improve its resilience and security by leveraging private security and private resources. Security companies. Thus, private security plays a crucial role in protecting critical infrastructure, while private security companies specialise in tasks essential for its protection. Of course, here we are referring to professional companies that, by investing in their human and material resources, contribute to the quality of the services they provide. The role of the private sector in national security is not a new concept. In truth, the engagement of the private sector in protecting critical infrastructure was discussed intensively only after the September 11 attacks. 2001 (Marković, 2024).

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