THE POSITION OF TOURIST INFRASTRUCTURE IN FLOODED URBAN AREAS – CASE STUDY: BIHAĆ, BOSNIA AND HERZEGOVINA

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Key-words: natural disasters, urban floods, tourism, tourist infrastructure, Bihać.

Abstract. The severity and frequency of short-term but highly damaging urban floods have increased in recent years worldwide and have been caused by climate change. The casualties of urban floods are usually not high, but the material damage and economic losses can be quite significant due to the population density of these areas and the various economic activities concentrated in urban regions. For this reason, this type of flooding is always catastrophic. This paper explores the impact of urban flooding on the tourism infrastructure in Bihać using the multi-criteria ArcGIS analysis. The results show that 55.8% of the studied area is at a low elevation and has gentle slopes, making it particularly susceptible to flooding. Annual precipitation reaches up to 1,305 mm, with 35–38% of the total rainfall recorded in the urban centre of Bihać, where the key tourism infrastructure is located. The buffer zone analysis revealed that most hospitality and accommodation facilities are situated within 20 to 100 meters of the Una River's shoreline, making them directly vulnerable during seasonal floods. Despite this, the number of tourist arrivals has been steadily increasing – from 33,433 arrivals in 2021 to 48,330 in 2023, with foreign tourists accounting for 60% of all visitors. The research findings highlight the need for the implementation of precise spatial plans and protective measures to reduce the negative impact of floods on tourism trends in this city.

1. INTRODUCTION

Natural disasters/hazards refer to events such as earthquakes, droughts, floods, storms, forest fires, etc. In the short term, they cause damage in the form of physical harm to the environment, but also give rise to long-term issues for the affected communities. Estimates from the World Risk Report (UNU-EHS, 2016) indicate that most developing countries fall into the categories of medium to extremely high risk from natural hazards compared to developed countries. Additionally, there has been a dramatic increase in the economic losses caused by weather disasters during the past 50 years (United Nations, 2022). The loss and damages caused by natural disasters are expected to rise further in the future largely due to climate change and the increased disaster exposure and vulnerability of our modern societies (IPCC, 2012). Some of the largest natural disasters have occurred in recent years and have had a significant economic impact on developing countries, as was the case of the earthquake in Nepal in 2015 and the floods in India that same year.

Globally, the number of recorded natural disasters is increasing rapidly (Ritchie and Roser, 2019), making understanding their consequences and implementing appropriate management and governance crucial today. Floods are the most common form of natural hazard occurring in Bosnia and Herzegovina. At least once a year they occur in any given part of the country and cause significant material damage. An area of approximately 2,500 km^2 is at risk of flooding, especially along the Sava River and its tributaries. Heavy rainfall in May 2014 resulted in a total damage of over 2 billion euros, which accounted for 15% of the country's GDP. Analyses have shown that the private sector (small family businesses, as well as medium and large enterprises), the agricultural sector, and the civilian population

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suffered the greatest losses. The catastrophic consequences were a result of pre-existing drivers of environmental degradation, such as deforestation, construction/development in flood-prone areas, and other factors like inadequate flood protection infrastructure in urban areas, incomplete, damaged, or poorly maintained flood protection structures, and the lack of data and analyses defining the actual flood risk (Bosnia and Herzegovina Support to Flood Protection and Flood Risk Management, 2014-2020). Although natural disasters affect almost all economic sectors, the tourism sector is particularly vulnerable. Natural disasters disrupt the operations of individual tourism enterprises (Nguyen *et al.*, 2017), while also creating a "snowball effect" that completely destroys the key infrastructure and superstructure of tourism destinations (Pescaroli and Alexander, 2016). What is undoubtedly crucial is that they halt tourist demand, reduce overall tourist movement, and leave lasting negative effects on the destination and the tourism industry as a whole (Granville *et al.*, 2016). The extent of damage caused by disasters directly depends on the vulnerability of the affected areas. The actual damage is difficult to determine precisely because it is most directly reflected in destination management.

Disaster preparedness is poorly expressed, requiring the significant allocation of financial and human resources (Ritchie, 2004). The primary objective of this study was to scrutinize the fundamental facets of urban flooding and its implications for tourist infrastructure. To address this, the study posed several specific research questions:

RQ1: How do seasonal floods affect the functionality and sustainability of tourism infrastructure in Bihać?

RQ2: What are the most vulnerable locations of tourism infrastructure in Bihać and how can they be protected?

RQ3: How does the lack of flood data hinder risk assessment and the planning of protection for tourism infrastructure?

The limitation of this study was primarily the lack of a relevant database on the types of crises, their frequency, and the extent of damage to tourist infrastructure in Bihać. Future studies should pay special attention to the geographic predisposition to such situations of certain areas, the location of tourism resources, the degree of the damage incurred due to these occurrences, and finally, the options for mitigation and recovery. The research will also complement the existing scarce literature on crisis management in tourism, not only at the level of one city but at the level of the entire Bosnia and Herzegovina. Until today, a limited number of scientific articles have addressed the positioning of tourism infrastructure in urban areas prone to natural disasters, mostly focusing on coastal tourist destinations. This study represents a novelty in the realm of research concerning tourism and natural disasters. Its findings serve as a foundation for further exploration and the implementation of a completely new approach to spatial tourism development. This process should involve cooperation and encompass multiple aspects (economic, sociocultural, environmental, etc.) when considering tourism development in risk-prone areas. The study will serve as a basis for tourism planners to create new tourism maps, prioritizing future tourism infrastructural planning in high-risk areas. It provides a fundamental theoretical and methodological framework for other researchers in disaster tourism from neighbouring countries facing similar issues due to climate change.

2. THEORETICAL BACKGROUND

Urban flood and climate change

Urban development brings about changes in land cover, impacting elements of the natural water cycle. Roofs made of various materials, streets, parking spaces, and paved surfaces render the soil impermeable to water, causing increased surface runoff in cities (Tucci, 2007). As a result, urbanized areas often experience severe flooding during rainfall events (Ahmed *et al.*, 2017; Anker *et al.*, 2019). Climate scenario analyses and projections suggest a projected 60% increase in intense rainfall events by

2100 (NASA, 2020). Even small changes in average rainfall and variability can result in significant increases in extreme rainfall amounts, so it is likely that extreme rainfall events will be more intense and occur more frequently under the influence of climate change (Shahid *et al.*, 2016). Existing drainage systems will be overwhelmed due to the greater quantity and intensity of rainfall, leading to more frequent urban floods (Galloway *et al.*, 2018). Higher levels of urbanization result in the emergence of urban heat islands that promote increased convection during heavy localized rainfall (Trenberth, 2011). Urban areas are often flooded due to intense rainfall, rapid snowmelt, rising sea levels, lakes, rivers, or groundwater (Darabi *et al.*, 2019). Due to changes in microclimates and increased urbanization, the occurrence and consequences of urban floods are becoming increasingly severe. In recent decades, Europe has experienced a significant increase in hydrological extremes that have significantly impacted socioeconomic and natural systems (Huo *et al.*, 2020). The flood risks and vulnerability in Europe resemble the worldwide situation, especially after the extreme floods which occurred in central Europe in 2013 (Blöschl *et al.*, 2013) and the floods of southwestern England in 2015 and 2016 (Barker *et al.*, 2016). Over the past 20 years alone, more than 400 major floods were recorded in Europe (many of them catastrophic), which affected more than 8.7 million people, killing more than 2000, and leading to financial losses of more than 72 billion Euro. The risk of flood occurrence is interrelated with climate variability, especially in southern and eastern Europe (Guimarães Nobre *et al.*, 2017). In Southeast Europe, most of the precipitation occurs from October to March, though the peak of precipitation falls between December and February, where the average winter precipitation ranges from 70 to 700 mm (Hatzaki and Wu, 2015). This increases the risk of urban flooding occurrences. Built-up surfaces hinder water absorption in urban areas, and with the rise in extreme storms, the risk of material damages and human losses has escalated (Agonafir *et al.*, 2023). Inadequate drainage systems, the lack of infrastructure maintenance, and uncontrolled urban development that often does not comply with legal regulations result in increasingly frequent occurrences of floods in city centres. The risks of urban flooding will be further exacerbated, especially with more pronounced climate and land-use changes (Stocker *et al.*, 2013). Bosnia and Herzegovina ranks third in the world in terms of vulnerability to intense and prolonged rainfall (Kreft *et al.*, 2016). Since 2012, the country has faced several extreme climate and weather episodes, particularly floods, which have caused significant material and financial deficits, as well as human casualties (Ministry of Foreign Trade and Economic Relations of Bosnia and Herzegovina, 2016). Changing weather conditions and long-term climate changes expected in all seasons will lead to periods of extreme heat and cold, triggering more intense rainfall as well as prolonged droughts. Floods are not the most frequent natural disasters, but they cause damage to property and pose a threat to human lives. Additionally, they leave long-lasting consequences on the environment, as well as on the health of people and animals. The highest amount of rainfall in Bosnia and Herzegovina is generally associated with the spring, summer, and autumn seasons, during which heavy rain can persist for several days. Due to the terrain configuration and the composition of riverbeds, combined with the influence of the Genoa cyclone, abundant rainfall often leads to floods (Council of Ministers, 2012).

One way to mitigate the impact of floods is through flood mapping. Predicting flood-prone areas by creating flood risk maps is crucial for improving urban planning (Büchele *et al.*, 2006). However, due to the complexity of the urban environment, modelling urban floods and predicting flood-prone areas face many challenges (Chen *et al.*, 2009). In Bosnia and Herzegovina, certain areas have been identified as prone to flooding, mostly related to the three main waterways of the country: the Sava River, the Bosna River, and the Neretva River. One of the zones at risk of floods is Bihać, also a tourist centre in the Una-Sana Canton.

Natural crisis and the tourism industry

Tourism activities are sensitive to climatic conditions and are inherently location-dependent (Scott and Lemieux, 2010; Becken *et al.*, 2015). Although it is the fastest-growing industry in the world, it is susceptible to constant changes both at the local and global levels. The occurrence of specific crises

(natural or technical) in a tourist destination negatively affects the perception of the destination among a large number of tourists, especially during the post-pandemic recovery period. The term "crisis" is often used in various scientific fields, including medicine, psychology, economics, the environment, and others. However, the use of the term varies depending on the context and the fields of research (Maditinos and Vassiliadis, 2008). According to Lighthouse Readiness Group (2015), a crisis is a time of intense difficulty, trouble, or danger and can be personal, or confined to a small population, like a family, or a company dealing with a very serious problem. In the tourism industry, a crisis is understood as an event that usually leads to the sudden emergence of an unpredictable situation and a state of shock (Laws and Prideaux, 2005). McKercher and Hui (2004) emphasize that crises in tourism are inevitable and are, in fact, episodic events that regularly disrupt the tourism and hospitality industry. According to Beirman (2003), five main reasons ultimately result in a crisis in a tourist destination: 1) an international war or conflict and prolonged manifestations of internal conflict, 2) a specific act or act of terrorism, especially when targeting tourists, 3) a major criminal activity or a wave of crime, mainly when tourists are the deliberate targets of such acts, 4) natural disasters, such as earthquakes, floods, or volcanoes, causing damage to urban areas or the natural environment and consequently affecting tourist infrastructure, 5) health concerns related to epidemics and diseases; these can be diseases that directly affect humans or diseases that affect animals, restricting access to tourist attractions. Any form of crisis, when it occurs in a tourist destination, brings with it a large number of consequences, triggering a so-called "snowball effect". Several authors have emphasized the vulnerability of tourist destinations, and thus tourists, to crises, especially natural ones, which have become frequent in recent years.

Scott *et al.* (2012) highlight that tourism is facing more and more challenges related to weather conditions and extreme events. The tourism industry is most susceptible to local conditions, and like other businesses, it is subject to changing climatic conditions that affect when and how sales occur. Continuous climate and weather trends impact the vulnerability and sustainability of many businesses worldwide (Craig and Feng, 2018; Monahan *et al.*, 2016). Significant efforts within the tourism industry are needed to ensure economic sustainability in the future (Schliephack and Dickinson, 2017). Seasonality, timing, frequency, and severity of extreme events can affect business economic outcomes. Similarly, favourable conditions such as cloud cover, precipitation levels, and temperature can have positive or negative impacts on the operations of tourism entities (Rutty and Scott, 2016).

Scott *et al.* (2012) emphasize that the tourism industry has the potential to adapt to a wide range of climate change impacts on destinations and overall socio-economic development. However, a significant challenge facing tourism today is the inability to predict the consequences of climate change on future demand. For example, it's nearly impossible to provide information on the change in preferences of potential tourists visiting mountain resorts in the next 50 years, but it is possible to assess the physical consequences of the loss of snow cover due to climate change. The idea of future snow cover can then be predicted by quantifying expected snowfall, which will, in turn, implicitly determine the availability of winter tourism conditions (Craig and Feng, 2018).

There are several representative examples worldwide of how natural crises accompanied by earthquakes, floods, fires and hurricanes can harm the tourism industry. All the problems that natural crises cause in the tourism sector strongly reflect tourists' concerns for their own safety, as they directly influence attitudes and beliefs about the broader area affected by the crisis (Maditinos and Vassiliadis, 2008). The extent of damage caused by disasters directly depends on the vulnerability of the affected areas. Natural hazards also negatively impact tourists' psychological well-being because any unpredictable situation or the presence of a threat of their occurrence represents a psychological barrier in choosing a tourist destination (Genc, 2018). In other words, tourists decide to travel only after considering all potential risks in a destination. In a 2012 study on the vulnerability of Caribbean countries, it was noted that as much as 29% of resorts were partially or completely flooded by high water waves, while between 49% and 60% of properties were at risk of damage due to beach erosion caused by the same factor (Scott *et al.*, 2012), this significantly impacted the destination being visited.

Caribbean tourism has responded by implementing disaster management plans and procedures. To enhance the resilience of certain Caribbean destinations and their tourism industries, stakeholders in tourism should actively embrace disaster management practices and more closely integrate them into destination management programmes (Becken and Hughey, 2013). Bujosa *et al.* (2015) identifies issues with adaptation in coastal provinces of Spain and the declining popularity of the region due to challenges in adapting to climate change. The majority of research on destination adaptation has originated from developed countries, particularly ski regions (Kaján and Saarinen, 2013). Literature on building resilience of tourism enterprises to natural disasters in the context of destination management is still in its infancy and focuses on Southeast Asian countries as they represent emerging markets for tourism supply and demand (Hampton and Hamzah, 2016).

In February 2023, the Republic of Turkey was hit by earthquakes that had catastrophic consequences on human lives, infrastructure, and, among other things, tourism. Although initial reports suggested no significant cancellations of reservations (Rizzi, 2023), it is overly optimistic to expect no detrimental impacts of earthquakes on tourism. According to estimates, the decline in tourist visits to Turkey, caused by the earthquakes, will weaken the country's GDP by about 1% (Demiralp, 2023). Besides these significant economic burdens, the southeastern region of Turkey, which was affected by the earthquakes, is one of the least privileged regions in the country, with limited employment opportunities and the lowest income per capita (Demiralp, 2023). Although highly susceptible to external factors, tourism is an important economic sector for many countries and destinations, including Bosnia and Herzegovina. Over the past 20 years, tourism in Bosnia and Herzegovina has been influenced by specific circumstances, i.e., external factors such as war, aggression, refugee and migrant waves, transition, economic crises, natural disasters, and more. Despite all these crises, the country has significantly increased the total number of tourist arrivals in recent years, except for the 2020 and 2021 pandemic years.

The repositioning of Bosnia and Herzegovina on the tourism market was achieved by 2012, with significant spatial disparities in tourism development. A major challenge was presented to managers and tourism planners in Bosnia and Herzegovina to consider the impact of certain natural disasters in the tourism sector and develop strategies for their mitigation, aiming to protect not only the tourism business of specific areas dependent on the tourism industry but also society as a whole.

Tourism disaster management

The most direct damages of natural disasters are observed through the harm inflicted upon tourism infrastructure and superstructure. Merz *et al.* (2010) proposed a list of risky elements within the tourism industry, primarily highlighting direct material elements encompassing accommodation facilities, restaurants, bars, and facilities, leading to the destruction of the overall infrastructure such as roads and railways. Indirect damages manifest as disruptions in public services within the broader flooded area and business losses for companies outside the flood-affected regions. Indirect non-material damages are reflected in the negative perception of tourist destinations due to media coverage, as well as business cancellations due to insufficient crisis resilience. Urban floods simultaneously bring about changes in the supply and demand of tourist destinations (Amelung and Nicholls, 2014). They can also result in business losses, reduced tourist visits, infrastructure damage, and high costs for destination recovery (Hamzah *et al.*, 2012).

Studies on the impact of floods on tourism infrastructure indicate that this area must encompass multiple aspects, including mitigation, policies ensuring a more integrated approach (Becken, 2013; Espiner and Becken, 2014). The local environment and the local perspective of a particular destination influence the perception of floods, as tourism business owners and planners best understand the local environment in which they operate (Tsai and Chen, 2011; Saarinen *et al.*, 2012; Wyss *et al.*, 2014). Evaluating how urban floods affect the tourism infrastructure is challenging due to their consequences

depending on a range of socio-economic factors (Tol *et al.*, 2013). The positioning of the tourism infrastructure in urban systems prone to floods has raised a new set of questions and a heightened level of concern regarding future weather impacts and adaptation plans for specific areas (Cartwright *et al.*, 2013; Woodward *et al.*, 2014). Implementing adaptation plans has always been challenging due to a lack of research and information, technological constraints, and uncertainties leading to numerous barriers in assessing flood impacts that the tourism accommodation sector cannot overcome (Nhamo, 2013; Gómez-Martín *et al.*, 2014a). Furthermore, as a consequence, some tourists may decide to alter their travel plans and visit destinations where they would be exposed to fewer personal risks. If infrastructure is destroyed by a natural factor, it can affect destinations in the vicinity. For example, suppose a natural disaster damages a section of the highway that serves as an intermediary transfer for another tourist destination. In that case, a travel agency may have to change the schedules of its routes or, worst case scenario, find an alternative route that involves the complete exclusion of the affected destination. Such changes, whether partial or complete, ultimately result in a decrease in tourist visits to the broader area. To address such situations, establishing an efficient management system is necessary, as well as minimizing negative effects in the affected area. Conversely, poor practice and unsuccessful crisis management further intensify tourists' negative attitudes toward the affected destination. The tourism industry should actively participate in disaster risk reduction, taking them into account when planning and developing tourism products in destinations where natural actors are crucial for their occurrence (Seraphin, 2019). Tourism managers and planners should develop crisis and disaster response systems in individual destinations to protect the tourism development of that area, especially the overall economic development of the wider environment (Becken *et al.*, 2014). This emphasizes the importance of tourism development planning after a disaster (Faulkner and Vilulov, 2001) and the formal prevention documents accompanied by action measures to be implemented by local actors and entrepreneurs (Svirchev *et al.*, 2011). Disaster assessments are often conducted at the national level, which can result in unbalanced recovery processes, as well as a distorted distribution of funding and subsidies (Schmude *et al.*, 2018). One solution for successful tourism disaster management is developing a micro-level assessment model that will serve as a foundation for the understanding of the type, intensity, and frequency of a specific disaster, as well as the measuring of the consequences it leaves on the affected area. Recovery is more challenging in smaller, individual areas due to geographical disparities and the unequal development of the tourism infrastructure.

Regardless of how far existing research and literature have progressed, there is still a constant need to understand such processes better and examine existing strategies, especially those used in tourism, to limit or mitigate the impact of natural crises on the growing and increasingly significant processes of tourism development. Research on the effects of disasters in tourist destinations generally falls into the categories of emergency management, which focuses on preparedness and response phases, or solutions, adopting a structural engineering approach (Nguyen, 2016). Chan (2019) argue that it is necessary to recognize more fundamental phases of long-term tourism recovery, especially in information gathering, learning and experience acquisition about disasters, institutional reform, and the tourism sustainable development strategy and marketing. In various studies, long-term solutions have been recognized as vital for mitigating the impacts of natural disasters, but in reality, they are rarely implemented. Since disasters can pose significant challenges, long-term solutions should involve the contribution of multiple stakeholders striving for a successful solution that is continuously updated through feedback. Urban planning can provide theoretical backgrounds that are lacking in tourism planning studies. This paper contributes to the examination of the impact of urban floods on tourism infrastructure, emphasizing the use of appropriate urban planning, disaster management, and tourism infrastructure planning, suggesting collaborative action and active learning on the part of all stakeholders in the area in order to address shortcomings in disaster management available through current literature and various studies.

3. STUDY AREA

Bihać, located in northwest Bosnia and Herzegovina, borders the municipalities of Cazin, Bosanska Krupa, Bosanski Petrovac, and Drvar, and the Croatian municipalities of Donji Lapac, Korenica, and Slunj. Covering 900 square kilometres at an average elevation of 231 meters, the city's terrain includes fields, hills, and medium mountains, with abundant water resources from springs, streams, and rivers. The Una River, about 30 meters wide in Bihać, flows within the Black Sea basin and is shaped by the area's karst geological features, which influence the river's flow and basin characteristics (Nedović, 1991; Spahić, 1991). The Una River springs from several sources, including Velika and Mala Neteka springs, and the Vaucluse spring near Donja Suvaja. In its upper course, it receives water from tributaries like Srebrenica, Ljaljnovac, Joševica, and Sredica, and the Unac river downstream from Martin Brod. The river drops 154 meters from Martin Brod to Bihać, with notable waterfalls at Štrbački buk (23.5 meters) and Martin Brod (54.8 meters).

A rare natural feature of the Una River and its tributaries is the formation of travertine barriers, which create waterfalls and travertine islets near Martin Brod, Kulen Vakuf, and Ripča (Nedović, 1991). These formations depend on clear, well-aerated water with a specific chemical composition. Pollution and dry periods can halt the formation process (Đug *et al.*, 2017). The Una River's water levels peak in April and December, and are lowest in August. According to the Köppen-Geiger climate classification, the analysed area has the characteristics of a Cfb climate (temperate, warm, and humid climate with warm summers). The average annual isotherm value is 9.50°C. The lowest temperatures occur in January (-10°C), and the highest in August (20°C). Precipitation averages 1,305 mm annually, with the wettest month being November (200 mm) and June and July being the driest (70 mm) (Hrelja, 2022).

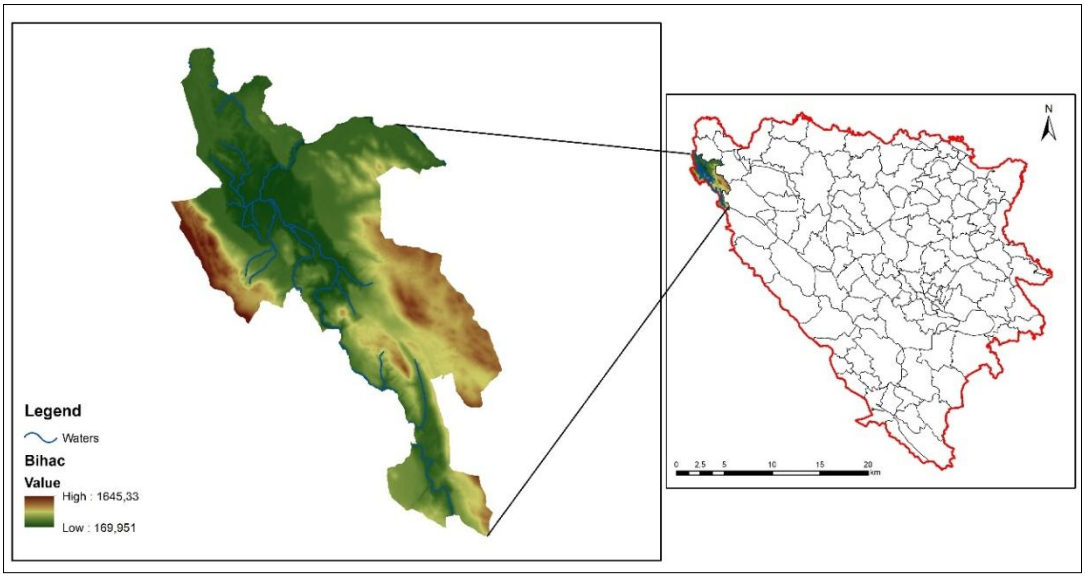

Fig. 1 – Geographical location of Bihać.
Source: ArcGis 10.6 database, modified by authors, 2024.

4. METHODOLOGY

This study explores the fundamental aspects of urban floods and their impact on the tourism infrastructure, specifically focusing on marking the tourist infrastructure on both sides of the Una River in the urban area of Bihać, Bosnia and Herzegovina. Additionally, the study's findings will enable the

identification of the causes of major water overflow in the city centre, as well as potential mitigation measures. Furthermore, the creation of maps depicting potential flood causes in Bihać will serve as a foundation for further research into this priority issue, which has multifaceted consequences in the region. Considering the frequent recurrence of this type of disaster, it is believed that this study will save time for decision-makers at the city level and enhance preparedness in finding suitable solutions. The first step towards mitigating the negative effects of floods in this area is identifying high-risk zones. The results of the study will also facilitate the marking of the tourist infrastructure catering to visitors in this region, which is prone to constant flooding. The following diagram represents the methodological steps of the research and shows the flow from one step to the next. The steps are connected in a logical sequence, from the selection of the study area to the resulting analysis and discussion.

Fig. 2 – Methodological steps of the research.
Source: Authors, 2025.

The analysis focused on the urbanized area of Bihać, particularly the tourism infrastructure along the Una River. Spatial and climatological data were used, including OpenStreetMap, the ArcGIS 10.6 database, and Digital Elevation Model (DEM) data. Five key criteria were considered: land use/land cover (LULC), terrain elevation, terrain slope, proximity to the river, and annual precipitation. ArcGIS tools were employed to process and analyse spatial data, identifying high-risk micro-locations vulnerable to flooding. The mapping also included the identification and visualization of tourism facilities along the Una River's shoreline, emphasizing their vulnerability to seasonal floods.

The multi-criteria ArcGIS analysis used in this study will, in turn, lead to an analysis of the current state and possibilities for improvement considering the lack of a database on floods not only in Bihać, but throughout Bosnia and Herzegovina. It is important to emphasize that there are no universal guidelines for selecting the factors causing floods in urban areas. For the purposes of this study, five different criteria were chosen based on the available literature data. These criteria were: land use/land cover (LULC), the elevation of the research area, the slope of the terrain, distance to the river (Thieken *et al.*, 2005; Fernández and Lutz, 2010; Ouma and Tateishi, 2014; Choubin *et al.*, 2019), annual precipitation, and distance between the tourist infrastructure and the riverbank.

– **Land use/land cover:** The Land Use/Land Cover (LULC) map for the year 2021 was obtained based on OpenStreetMap data (Fig. 3a) and the ArcGIS 10.6 database. The research area was divided into several main groups: urban areas (including residential buildings, individual housing units, and industrial facilities), pastures, and agricultural areas (areas under cultivation).

- **Elevation:** The Digital Elevation Model (DEM), with a resolution of 20m, confirmed that the elevation of the research area ranges from 170 to 1,645 meters above sea level (Fig. 3b).
- **The slope of the terrain:** The percentage of terrain slope plays a crucial role in the formation of floods, as it directly influences the speed of water runoff. Additionally, flat or low-lying areas with gentle slopes are most susceptible to floods (Wang *et al.*, 2015, Pirnia *et al.*, 2018). The slope map was created based on the Digital Elevation Model (DEM) of the research area using the ArcGIS 10.6 software. The slope varies, with the steepest slopes found along the canyon-like valley of the Una River. In the central urban part of Bihać, slopes range from 0 to 20% (flat terrains) (Fig. 3c).
- **Distance from the river:** The coastal area of the Una River in the city centre of Bihać is the most susceptible to high water overflow. Hence, the distance from the river plays a significant role in urban planning. The Euclidean distance from the river was calculated using the Euclidean Distance module in ArcGIS 10.6. In Euclidean distance, all locations are connected by the shortest straight-line distance (Fig. 3d).
- **Annual precipitation:** The annual precipitation map was created using the high-resolution datasets available in online databases from the University of East Anglia, and modelled using GIS software. The research confirmed that the highest annual precipitation occurs precisely in the city centre of Bihać (Fig. 3e).
- **Distance between the tourist infrastructure and the riverbank:** Several tourist and hospitality establishments are built along the banks of the Una River. Identifying these locations was done using data from the OpenStreetMap and ArcGIS databases, marking the active objects in the urban core of Bihać (Fig. 3f).

5. RESULTS

According to the research results, the urban area of Bihać is at risk from overflowing waters. Areas of the city located in valleys or at lower elevations are often affected by swiftly flowing water caused by extreme rainfall. The damage can be significant due to the sudden occurrence and rapid movement of large volumes of water (Sene, 2013). Floods in Bihać are a frequent occurrence, according to a detailed analysis by overlapping thematic maps created in ArcGIS which specifies that the key causes for this phenomenon are flat terrains, namely the elevation in the narrow city centre, as well as along the Una River, which does not surpass 200 meters, and the terrain slope, which is about 2^0 (55.8%) and is directly linked to the elevation. Climate change is another significant cause of floods, especially in recent decades, caused by an uneven distribution of large amounts of precipitation. The highest annual precipitation is observed precisely in the city centre, ranging from 35% to 38%, based on the ArcGIS analysis. The use of land (built areas) near the riverbank, which also serves as a protective zone, is another crucial factor in retaining large amounts of water in urban areas. Many areas at risk are concreted. It is essential to note that a considerable number of residential and hospitality units have been built illegally, disregarding any aspect of the city's spatial and planning documentation, resulting in multiple consequences in the area (floods and landslides). One important outcome of this research is the map of the buffer zone of tourist infrastructure in the city centre (Fig. 3) located along the Una River. This area mainly includes hotels and restaurants that directly serve tourists. The analysed tourist infrastructure (hotels, restaurants, viewpoints) is situated within 20 to 100 meters from the riverbank, making it directly vulnerable. During seasonal urban floods, the mentioned items (Fig. 4a and 4b) are also affected. Besides the tourist infrastructure, the floodplain of the Una River also covers a large number of individual residential units and residential buildings, which are within the buffer zone up to 80 meters from the main river flow (Fig. 3).

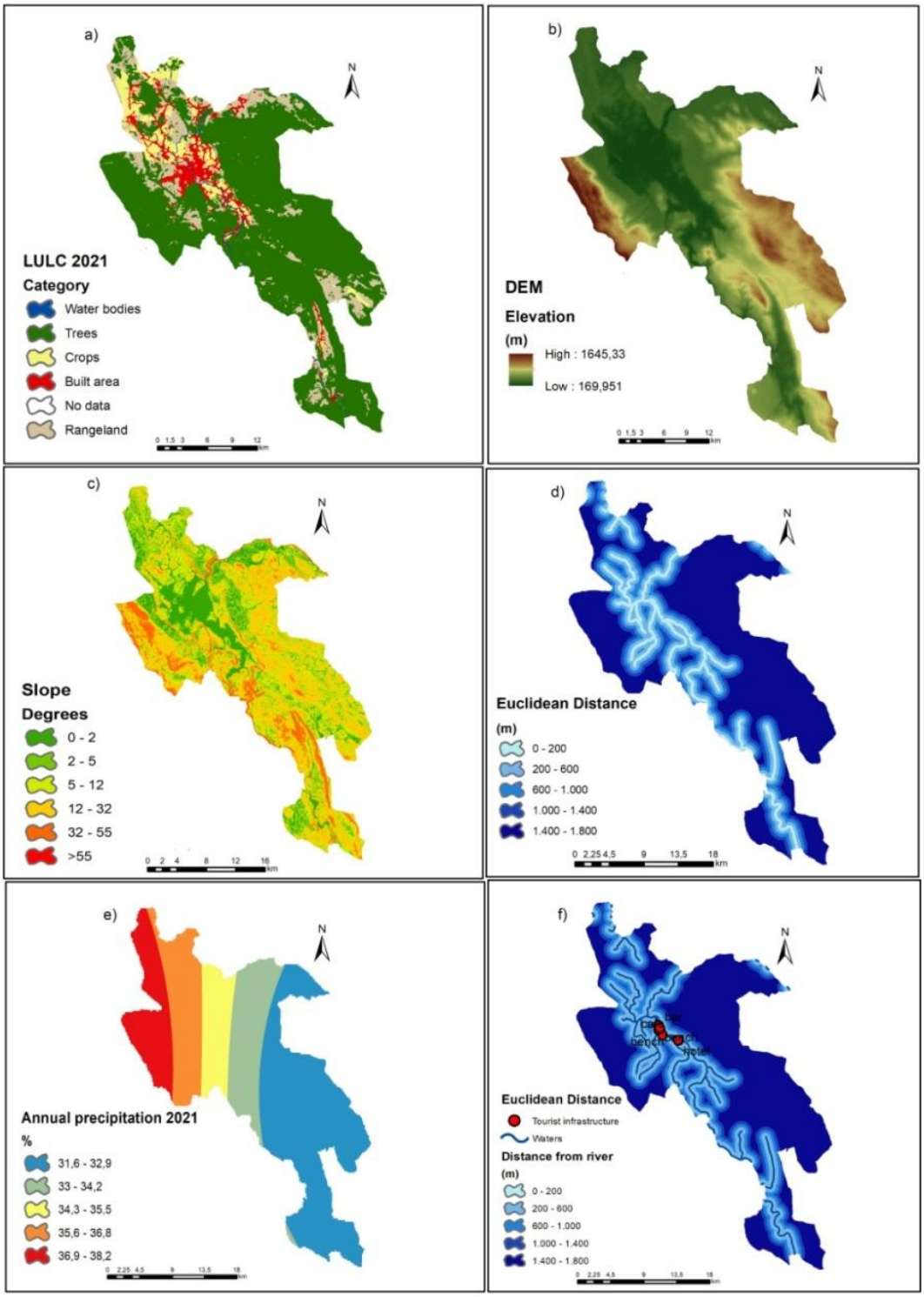

Fig. 3 – Criteria for determining the cause of urban flooding as GIS layers: a) Land use/Land cover, b) DEM (Digital Elevation Model), c) Slope, d) Euclidean distance from the river, e) Annual precipitation, f) Distance between the tourist infrastructure and the riverbank.
Source: ArcGis 10.6 database, modified by authors, 2024.

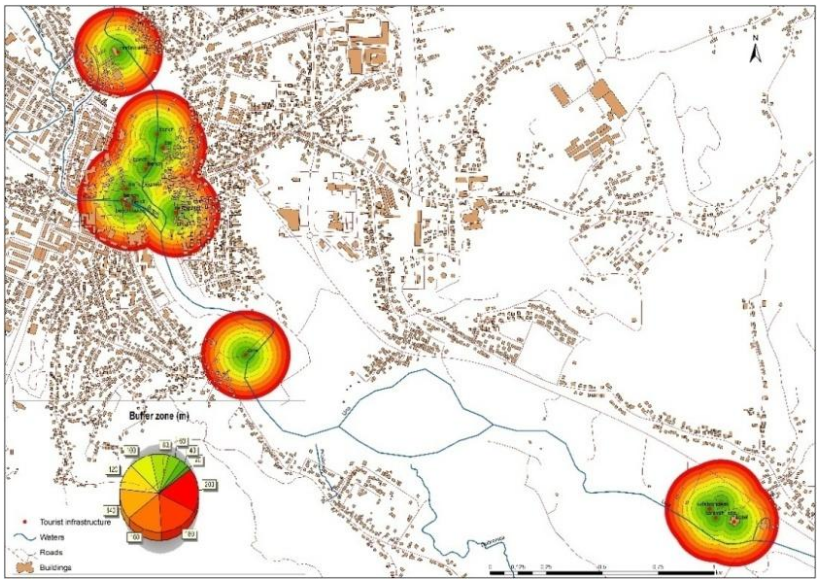

Fig. 4 – Distance between the tourist infrastructure and the river bank (buffer zone).
Source: ArcGis 10.6 and OpenStreet Map database, modified by authors, 2024.

The Una River stands as a pivotal hydrographic and economic anchor in the city of Bihać, drawing tourists to this part of Bosnia and Herzegovina. The abundant hospitality venues and accommodation facilities along its banks owe their existence to its relatively calm flow and mesmerizing emerald-green hue. These establishments cater to tourists, providing essential amenities. However, during periods of intense rainfall and increased surface runoff, the river frequently overflows its banks, causing material damage and instilling a sense of fear and panic in tourists. Therefore, the outcomes of this study will serve to enhance and develop an innovative approach to identifying such vulnerable areas. Additionally, it aims to define buffer zones to restrict further construction and urbanization in these regions.

Fig. 5 – A flooded hotel along the bank of the Una River.
Source: https://mondo.ba/Info/Drustvo/a1220529/Poplava-u-Bihacu-potopljena-naselja-uz-Unu.html, 2024.

Bihać is a city in Bosnia and Herzegovina that continuously experiences a steady increase in the number of tourist arrivals, except during the pandemic year. In 2021, Bihać was visited by a total of 33,433 tourists, made up of slightly more foreign tourists than domestic tourists. A total of 57,752 overnight stays were recorded. A slightly higher number of tourist arrivals was recorded in 2022 when Bihać had 44,090 arrivals, while in 2023, there were 48,330 arrivals. Over the three-year period observed, foreign

tourists led in terms of the number of arrivals with 76,046 arrivals, compared to domestic tourists who accounted for 49,807 arrivals (Federal Bureau of Statistics, 2024). The city's tourism offer is mostly seasonal; thus, the number of tourist arrivals corresponds to the nature of the tourism offerings. Bihać is at risk of various natural disasters, primarily floods and landslides. During the spring and autumn seasons, these factors largely hinder more massive tourist movements, negatively affecting the city's GDP as well as the one of Una-Sana Canton. The problem lies in inadequate disaster management and the haphazard construction of tourism and hospitality facilities, where spatial criteria have not been adhered to. The assessment of flood damage is crucial in developing tools for vulnerability mapping and risk assessment. Besides evaluating economic implications, it's essential to delineate the social, cultural, ecological, and political dimensions that might exacerbate or alleviate the damage (Yu *et al.*, 2009). To obtain more precise results regarding the geospatial suitability of land for tourism infrastructure construction, a multi-criteria analysis was conducted by overlaying thematic layers (Fig. 6) using the ArcGIS and ArcScene software. The ArcScene software was used to display the precise locations of catering and hotel facilities located along the banks of the Una River, based on Google Street Maps. Hence, the authors visualized the spatial position of objects which was not respected in the city's tourism and urban planning (Fig. 6).

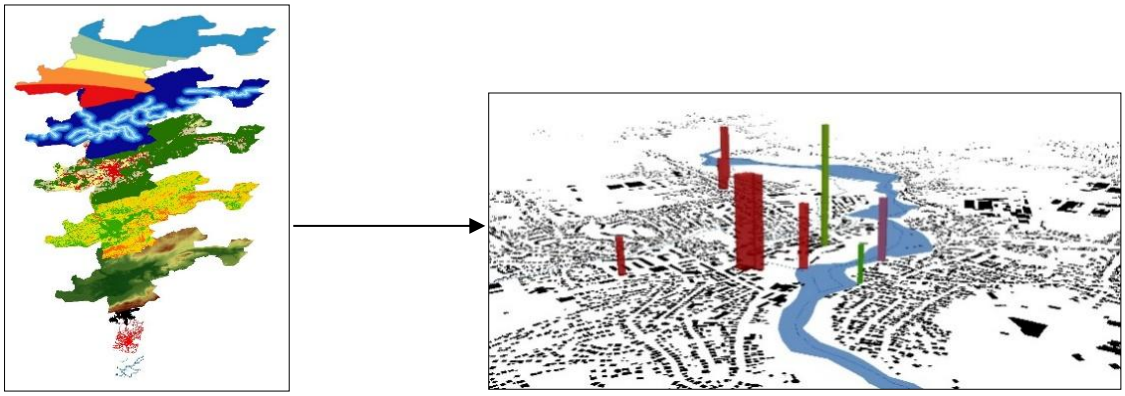

Fig. 6 – The process of overlaying thematic ArcGIS layers and the 3D model of tourist infrastructure.
Source: ArcGIS and ArcScene database, modified by authors, 2024.

The resulting map (Fig. 7) confirmed the earlier assumptions. All analysed tourist infrastructure is situated on terrains classified as very low suitable, meaning almost unsuitable for any type of tourist construction. Although from the aspect of other analysed criteria they are very suitable for construction (slope, altitude) and are predominantly urbanized, these terrains have been, nevertheless, based on DEM reclassification, land slope, LU/LC, annual rainfall and distance from the river bank, identified as unsuitable for tourist construction from the point of view of flooded terrain (Fig. 6). These are areas where floods are a frequent occurrence several times a year, particularly during spring and autumn when rainfall intensity is higher, leading to increased surface runoff. These terrains were identified based on the reclassification of DEM (Digital Elevation Model), the slope, land use/land cover (LU/LC), annual precipitation, and distance from riverbanks, which makes them unsuitable for tourism development due to their susceptibility to flooding. Further construction and development of the tourism infrastructure in this area should focus on sites falling within buffer zone 2, specifically areas situated more than 100 meters away from the river's protective zone (Fig. 4). A significant problem and limitation for further research is the lack of data on existing structures built illegally and flooded during the Una River's overflow.

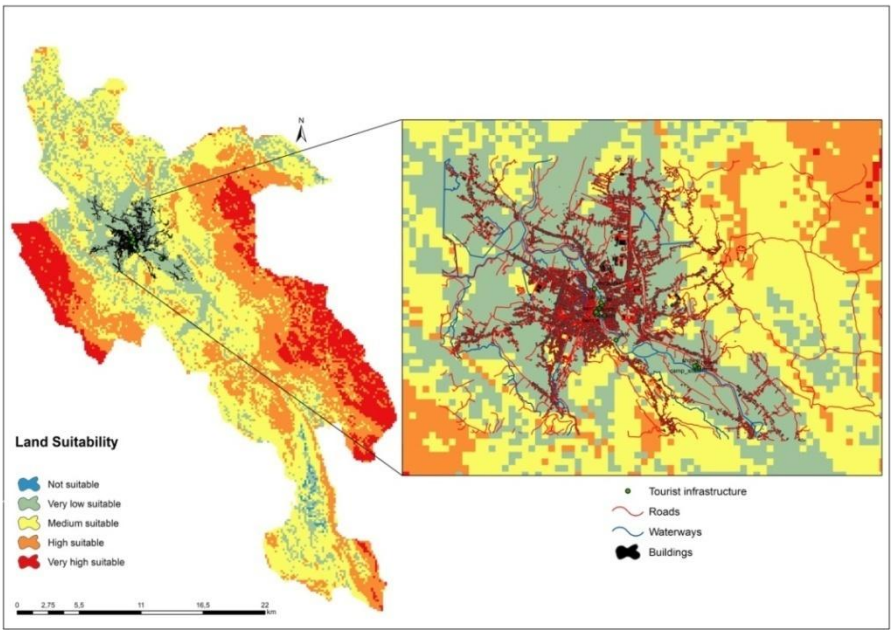

Fig. 7 – Categories of land suitability from the aspect of flooding for tourist construction.
Source: ArcGIS database, modified by authors, 2024.

6. DISCUSSION

From the conducted research, it is evident that floods cause significant material damage to the local population as well as hinder the influx of tourists during certain periods of the year. The tourism sector is increasingly exposed to flooding in many destinations, both coastal and inland (von Bergner and Lohmann, 2013). The floods that hit Prague in 2002 had a significant negative impact on tourism, reducing visitor numbers by as much as one-third and resulting in the cancellation of 30,000 reservations for national airline flights (Maharjan, 2014). Similarly, the devastating effects of Hurricane Katrina in 2005 led to a complete halt in the tourism sector in the U.S. state of New Orleans, where floods caused massive economic losses and long-term disruptions to tourism (Walters *et al.*, 2014). Australia frequently faces flash floods, which pose a serious threat to tourism, particularly during peak travel seasons. These floods are characterized by short warning periods, a high risk to human life, and significant consequences for the local tourism infrastructure (Windle and Rolfe, 2013). Many tourist destinations in Australia are increasingly at risk of flooding, which could jeopardize their long-term sustainability and attractiveness (Windle and Rolfe, 2013). Cities in developing countries, such as Mumbai, are particularly vulnerable to seasonal flooding, which disrupts the tourism sector each year (Ranger *et al.*, 2011). The city's vulnerability is reflected in substantial economic losses, particularly through damage to the tourism infrastructure, the extent of which depends on floodwater levels (Looney, 2012). In Bangladesh, frequent flooding presents a significant barrier not only to tourism development but also to broader economic stability, hindering the country's long-term progress in this sector (Shahid, 2012).

Besides all the negative, mainly economic consequences that urban floods leave in the area, there are also "positive effects", most notably reflected in the reduction of land and property prices in urban areas, thereby directly reducing the development disparity between urban and rural areas. Additionally, it leads to a polycentric tourist development of the region, meaning a more even distribution of tourists in urban and suburban areas. For example, during the 2016 – 2018 period, when urban floods occurred, there was a 31% annual increase in the number of tourist arrivals (Investment Profile City of Bihać,

2020). The reason for the increase in the number of tourists during the mentioned period, despite multiple floods, is attributed to the Una National Park, which consistently generates a high volume of tourist visits, experiencing a constant rise year after year (Tulić, 2017). The Una National Park lies outside the defined flood risk buffer zones, specifically not situated in the city centre that was the subject of this analysis. Tourist statistics are maintained at the level of the city of Bihać and the Una-Sana Canton. Consequently, the provided data pertain to the broader Bihać area. It's essential to note that significant flood protection structures are not present in the Una River basin, and levees are constructed in very short stretches within the narrow urban area of Bihać (Flood Risk Management Plan for the Sava River Basin in the Federation of Bosnia and Herzegovina 2024–2029). A measure to mitigate flood impacts involves adapting to them, since floods cannot be entirely prevented. However, their adverse effects can be reduced by providing specific financial aid to every at-risk structure (Flood Risk Management Plan for the Sava River Basin in the Federation of Bosnia and Herzegovina 2024–2029). Considering the available tourism statistics in Bihać, it can be observed that tourist arrivals are consistently increasing, although there are still prominent seasonal fluctuations in tourist movements. The continuous increase in the number of tourist arrivals indicates that floods are becoming less of a significant barrier for tourists, which does not align with the theoretical assumptions of this research. One reason for this disparity could be the lack of comprehensive tourism statistics management, where across the entire territory of Bosnia and Herzegovina there is no unified system for reporting and monitoring tourist arrivals, as seen in other European countries.

Although the research provides significant insight into the impact of urban floods on the tourism infrastructure in Bihać, there are several limitations that should be considered when interpreting the results.

A key limitation of this study is the lack of a detailed database on the frequency, intensity, and economic consequences of floods in Bihać. While spatial analyses using ArcGIS tools enabled the identification of high-risk micro-locations, more precise quantitative data on the damages to the tourism infrastructure would further enhance the quality of the analysis. The data used are based on existing precipitation and flooding patterns, while future climate change may significantly affect the frequency and intensity of these events. Long-term predictions require the application of additional models that include climate projections. Although the multi-criteria analysis allowed for the precise mapping of vulnerable areas, the methodological framework was limited by the availability of data. Factors such as urbanization and infrastructure quality were not included as key criteria, which may affect the accuracy of risk assessment for tourism facilities. The study primarily focused on the spatial aspects of flooding, while the economic losses due to the non-functionality of tourism facilities were not quantified. Future research would benefit from including an analysis of the tourism sector revenue before and after seasonal floods, as well as the costs of implementing protective measures. Although the research focused on the specific case of Bihać, a comparative analysis with similar destinations would provide a broader context and a better understanding of adaptation strategies.

7. CONCLUSIONS

The conducted research has confirmed the initial assumptions regarding the factors contributing to the occurrence of floods, the extent of their spread, and their effects on the tourism development of the destination. It is evident that floods have become a widespread phenomenon in urban areas in recent years. The reasons behind this are the inadequate protection, monitoring, and control of risky areas. Such natural disasters significantly impact the tourism sector because tourism is a spatial phenomenon heavily dependent on surrounding factors. The research results have also highlighted the importance of using geospatial data to identify, map, and further forecast such phenomena, which is crucial for future urban planning and development in major cities and suburban areas. The previously conducted analysis can

play a significant role in planning the development of tourism and tourist infrastructure in the city of Bihać. The research concludes that it is necessary to create a disparity in the distribution of tourist infrastructure across the entire municipality of Bihać, not just in the city centre, which will increase the number of tourist visits even during times of more frequent floods caused by climate change. Geospatial data, especially a multi-criteria analysis of the causes of urban floods throughout the country, enable the assessment of their effects on various economic sectors. Additionally, the geospatial database allows for a comparison of urban centres and tourist infrastructure at risk of major water overflow, as well as the effects of these factors on tourist movements. Considering the detailed analysis of flood-prone areas that often recur in the same locations over a longer period, it is essential for all decision-makers and stakeholders in the tourism sector to develop a detailed tourism plan to adapt and mitigate this increasingly frequent negative effect of climate change. The results of this study emphasize the importance of tourism development planning before and after disasters, as well as the collaboration between all interested parties in the area. This primarily refers to various stakeholders and their cooperation, a crucial factor in destination management during natural disasters. This study also highlights the importance of respecting geographical characteristics and their transformation for the purposes of tourism development in order to facilitate social justice and enhance the well-being of society with a commitment to sustainable development. We must not forget that competitive tourist destinations have the potential to increase tourist spending, attract and satisfy a growing number of visitors, provide unforgettable experiences, and do so profitably while improving the well-being of the destination and preserving its natural beauty for future generations (Crouch, 2007). The results will serve researchers and tourism planners in creating future disaster management systems, as well as in the better organization and allocation of tourism resources.

The results of the multi-criteria ArcGIS analysis revealed that 55.8% of the studied area has low elevation and gentle terrain slopes, making it particularly susceptible to seasonal flooding. The highest amount of annual precipitation, between 35% and 38%, was recorded in the central part of the city, where the majority of tourism infrastructure is located. The buffer zone analysis showed that key tourism facilities, including hotels and restaurants, are situated within 20 to 100 meters from the Una River's shoreline, making them directly exposed to floods. Despite these challenges, the tourism sector in Bihać has experienced continuous growth. Between 2021 and 2023, the number of tourist arrivals increased from 33,433 to 48,330, with foreign tourists accounting for 60% of the total number of visitors. This trend indicates the sector's resilience, while also highlighting the need for strategic planning to mitigate the negative impact of floods on tourism.

To improve flood risk management and ensure the long-term sustainability of the tourism infrastructure, it is essential to implement adequate protective measures, such as the construction of embankments and drainage systems, particularly in areas identified as high-risk through GIS analysis. Additionally, stricter spatial criteria should be introduced for the construction of tourism facilities near the Una River, with a minimum safe boundary of 100 meters for new development. Creating a comprehensive database on flooding and tourism infrastructure would enable more precise risk monitoring and informed decision-making. Increasing awareness of flood risks among the local community, tourism operators, and authorities is crucial for the effective implementation of adaptation measures, while the development of tourism products not solely reliant on the Una River contributes to reducing the sector's dependence on flood-prone areas. Future research should focus on the long-term analysis of the impact of climate change on flood patterns, the development of advanced GIS models for a more precise assessment of infrastructure vulnerability, and the investigation of the economic sustainability of protective measures to ensure their long-term viability. Additionally, a comparative analysis with other urban areas in Bosnia and Herzegovina would provide a broader understanding of strategies for protecting tourism resources, enabling the development of universal models for flood risk management.

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