Investigating the Impacts of Earthquakes on Ethnic and Religious Groups: Bucharest, Romania

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Submitted by:

Eli Benevedes

Owen Lally

Hung-En Li

Abigail Perlee

Eileen Piombino

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Report Submitted to:

Professors Robert E. Kinicki and Melissa Butler

Worcester Polytechnic Institute

Authorship

Section	Author(s)	Main Editor(s)
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Abstract

Bucharest, an Eastern European urban center and the capital of Romania, is located within a region of high seismic activity. Currently, the city employs preparedness measures to minimize the impacts of earthquakes, but these do not eliminate risk. By collecting data that examines preparedness practices in Bucharest, this project compares these to other cities in the Balkan Peninsula, and identifies societal components at-risk during an earthquake, the team will build an understanding of current preparedness in Bucharest. We will conduct further research to characterize the distribution of Bucharest's ethnic and religious groups and assess their vulnerability to earthquakes, allowing the team to determine the extent to which earthquake preparedness and impact varies across ethnic and religious groups.

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1.0 Introduction

Since 1990, earthquakes have claimed an average of 27,000 lives worldwide each year (Guha-Sapir, 2011). Beyond loss of life, earthquakes have lasting economic and emotional impacts (Armaș et al., 2017) and can cause major structural damage, weakening or destroying buildings and infrastructure. Damage to roads, power grids, and plumbing can hinder relief efforts, and leave affected populations without necessary utilities (Magda, 2019). The term earthquake hazards refers to the physical phenomena that result from seismic activity, and the term risk refers to a region's vulnerability to these hazards and capacity to recover from them. While all individuals within a region may experience the same earthquake hazard, the ability for individuals to prepare for and recover from earthquakes depends upon social and economic factors.

The Balkan Peninsula is particularly susceptible to earthquakes as it sits between the African, Indian, small Cimmerian, and Eurasian tectonic plates (Bala et. al, 2015). Countries within the region have experienced major earthquakes throughout their history, with earthquakes occurring as recently as 2019 in Albania and 2021 in Croatia (USGS, 2021). Within northern Romania, the Vrancea region experiences frequent seismic activity that can result in major earthquakes throughout the Balkan Peninsula (Bokelmann, 2014). Earthquake risk across the peninsula varies based on the vulnerability of the natural environment and man-made structures. Several areas within the Balkan Peninsula have high earthquake risk, including cities where higher population and building density, expansive infrastructure, sub-standard construction during periods of expansion, and socio-economic and political variables increase susceptibility to loss. Located 150 kilometers southwest of the Vrancea seismic zone, Bucharest, Romania exhibits many of these characteristics. Some experts have even identified Bucharest as “the most earthquake prone capital in the European Union” (Armaș et al., 2017).

Previous work examines how specific characteristics of Bucharest contribute to its high earthquake risk. The city’s failing architecture and infrastructure are among these factors. Many of Bucharest’s buildings are aging and have sustained damage in previous earthquakes. Moreover, many of the city’s structures originate from a period of lax building codes following the fall of communism and do not meet more modern standards of quality and safety. As a result, the Romanian government has identified 346 buildings in Bucharest at high risk of collapse in the event of an earthquake (Suditu, 2020). The potential for damage from collapse is exacerbated by the close proximity of these structures to other buildings due to high population and building density (Schlumbohm, 2020; Cavoli, 2017).

Historic earthquakes have given researchers the opportunity to identify patterns of building destruction and damage within Bucharest’s city limits (Armaș, 2012). Armaș’ findings serve as groundwork for future estimations by demonstrating which components of the city have been vulnerable in past earthquakes. Research has built upon this by taking the socio-economic and societal characteristics of Bucharest into account in vulnerability assessments. Researchers calculated an overall vulnerability for regions of the city using indicators such as socioeconomic status, average income, population and building density, proximity to resources, and building and infrastructure fortitude with ground acceleration and damage patterns from past earthquakes. This research concluded that vulnerability is not uniform across Bucharest (Armaș, 2012; Armaș et al. 2017). Figure 1.1 clearly illustrates this variability.

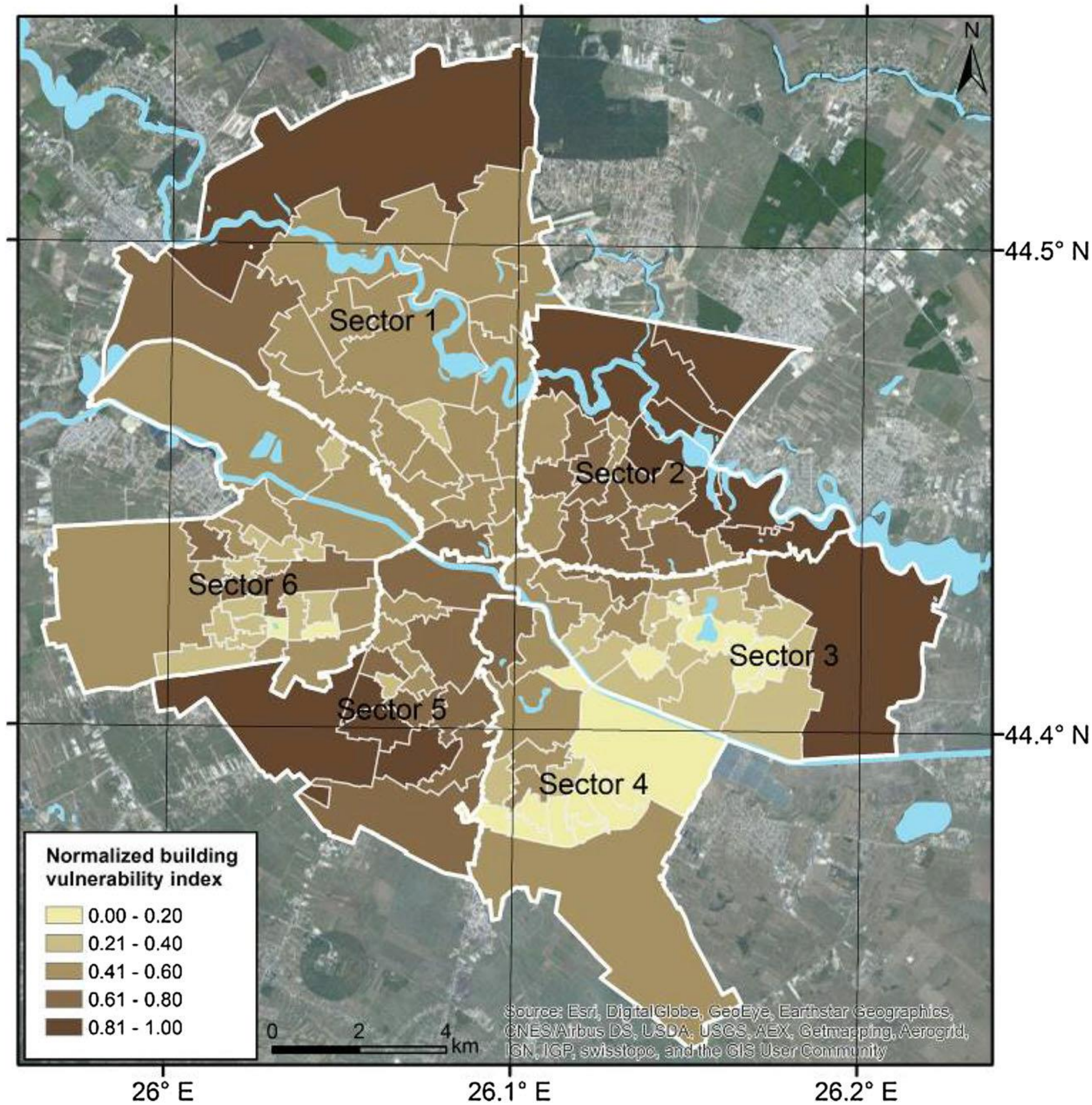

Figure 1.1: Normalized vulnerability assessment for residential buildings. Armaș et al. (2017)

These studies reveal uneven preparedness for earthquakes across Bucharest. However, there is limited research that draws links between areas of higher risk and the social characteristics of the people that populate these areas. While research shows that individuals of certain ethnic and religious identities tend to reside in higher concentrations within different regions of cities (Rampton, 1995), further exploration can characterize this phenomenon in

Bucharest and therefore determine the implications of earthquake preparedness within these groups.

The goal of this project is to evaluate the earthquake vulnerability of specific religious and ethnic groups within the city of Bucharest to determine the extent to which preparedness varies across these different groups. The objectives to achieve this goal are as follows:

1. To identify current earthquake preparedness practices in Bucharest and the Balkan Peninsula
2. To establish which societal and infrastructural components are most at-risk in the event of an earthquake
3. To characterize the ethnic and religious groups of Bucharest and evaluate the earthquake vulnerability of these groups.

To accomplish these objectives, the team will utilize various research methods including analyzing existing data, conducting surveys and interviews, and applying existing evaluations to the city of Bucharest. Interviews with experts will identify factors that make cities, specifically those across the Balkan Peninsula, highly vulnerable to damage from earthquakes. Interviews with residents will indicate how these factors impact those living in these cities, how residents perceive earthquake preparedness, and how personal experience with earthquakes, individual education, and social factors impact this preparedness. Resident surveys and existing data will aid in characterizing ethnic and religious distribution throughout Bucharest and identify if these groups are reliant on city features that earthquakes may significantly impact such as infrastructure or transportation. Findings fromthese methods will also determine if data from the most recent census is reasonably reflective of Bucharest today.

2.0 Background

This chapter introduces the Balkan Peninsula, Romania, and Bucharest and contextualizes seismic activity within these regions in order to elucidate their earthquake hazard. This chapter then discusses historical earthquakes in Bucharest and analyzes the political changes that have occurred in the years since to identify lasting impacts on earthquake preparedness. Finally, this chapter identifies socioeconomic factors and impacts of earthquake preparedness and emergency response.

2.1 The Balkan Peninsula, Romania, and Bucharest

The Balkan Peninsula (see figure 2.1) is a geographic area in southeastern Europe. Although there is no consensus on the nations that are a part of the Balkans, published lists usually include Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo, Montenegro, North Macedonia, Serbia, and Slovenia, the European part of Turkey, and Romania. This project focuses on Bucharest, the capital city of Romania.

Figure 2.1: Map of the Balkan Peninsula. Allcock et al. (2020).

The word “Balkan” originates from the Turkish word for “a chain of wooded mountain” (Allcock et al., 2020). This is unsurprising, since the Balkans lie within the mountain ranges known as the Alpine orogeny (Bala, 2015). The mountain ranges in the Balkan Peninsula include the Rhodope Mountains along the Greek-Bulgarian border, the Dinaric range down the Adriatic coast to Albania, the Julian Alps from northeastern Italy to near the capital of Slovenia, and the Carpathians from Slovakia and southern Poland to southwestern Romania.

Many ethnicities live within the Balkans (Allcock et al., 2020). Albanians, Ashkali and Balkan Egyptians, the Sarakatsani, South Slavs, Balkan Turks, and the Eastern Romance people are some of the ethnic groups that reside in the Balkans. The South Slavs are the largest ethnic group in the Balkans with a population of around 30 million while the Eastern Romance people are the second largest ethnic group consisting of Romanians, Aromanians (Macedo-Romanians), Megleno-Romanians, Istro-Romanians, and Moldovans (Allcock et al., 2020).

Romania, like much of the Balkan Peninsula, has areas of mountainous terrain. Figure 2.2 shows the topography in Romania, with areas of higher elevation in red and lower elevation in green. The Carpathian Mountains form a semicircle around the Transylvanian Basin (Latham et al., 2020) which then transitions into fertile plains in southeast Romania, along the Danube River and its tributaries.

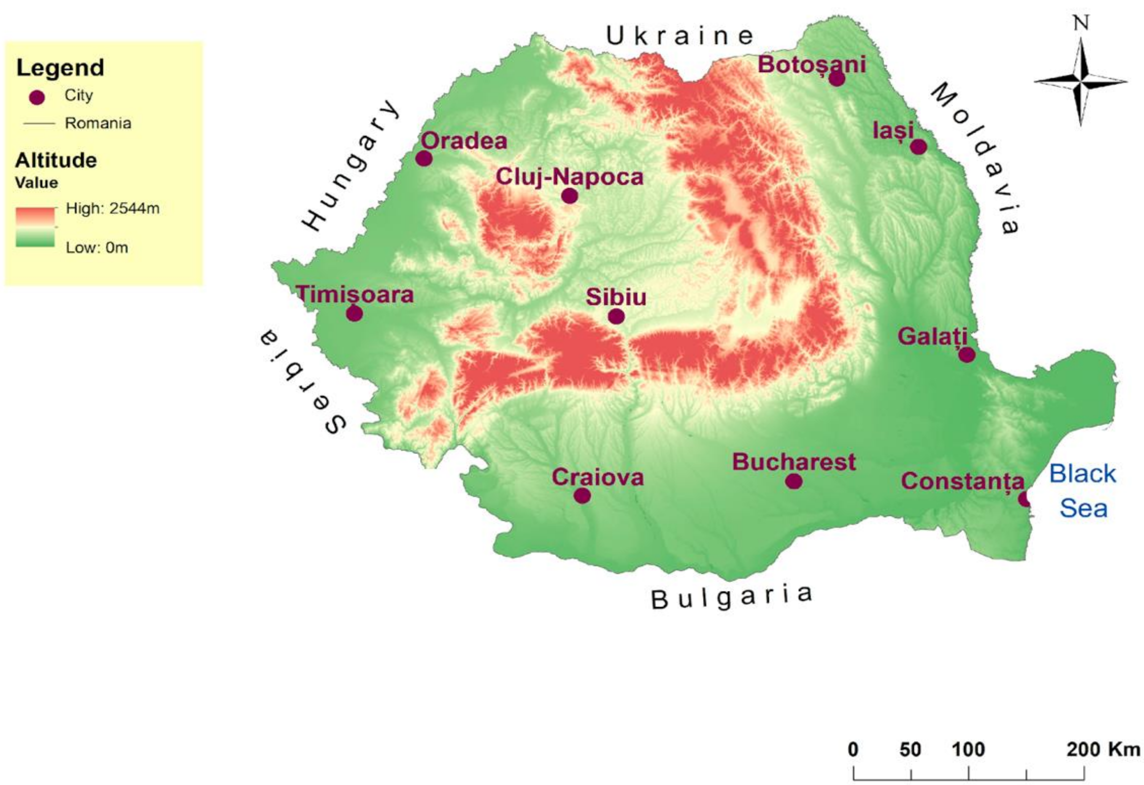

Figure 2.2: Topography of Romania. Adapted from Banc et. al (2020).

As of 2020, the population of Romania is around 19 million with a population density of 84.6 people per square kilometer (Schlumbohm et al., 2020). Romania is home to many ethnic groups, including Romanians (~87%), Hungarians (6.5%), Romani (~3%), Germans, Jews, and Dobruja Muslims (~0.4%) (Latham et al., 2020).

The Romanian capital of Bucharest is home to 9.3% of the country's population. Bucharest became the capital of Romania in 1862 and is the center of Romanian media, culture, and art (Zamfir & Corbos, 2015). Like the rest of Romania, the Romanian ethnic group makes up most of the population at 89.9%. According to the United Nations Department of Economic and Social Affairs (2019), other ethnic groups living in Bucharest include, Hungarians (6.6%), Romani (2.5%), Ukrainians (.3%), Russians (.2%), Germans (.3%), and Turks (.2%).

2.2 Earthquakes and Seismic Potential in the Balkans

Earthquakes occur when two tectonic plates, or pieces of the Earth's crust, move past each other causing violent shaking of the Earth's surface (USGS, n.d.). The Richter scale, a common method of measuring the magnitude of earthquakes (Rafferty, 2020), is logarithmic, meaning that a 5.0 earthquake has a magnitude over 30 times greater than a 4.0 earthquake. Earthquakes can range from minor (3.0 to 5.0 on the Richter scale) to moderate (5.0 to 7.0) to major (above 7.0).

The Balkan Peninsula is a high seismic hazard area due to numerous fault lines throughout the region. The tectonic activity in the Balkans has a close relationship with its mountain chains in the Alpine orogeny. Figure 2.3 shows the Carpathian Mountain range, which stretches from Poland to Serbia.

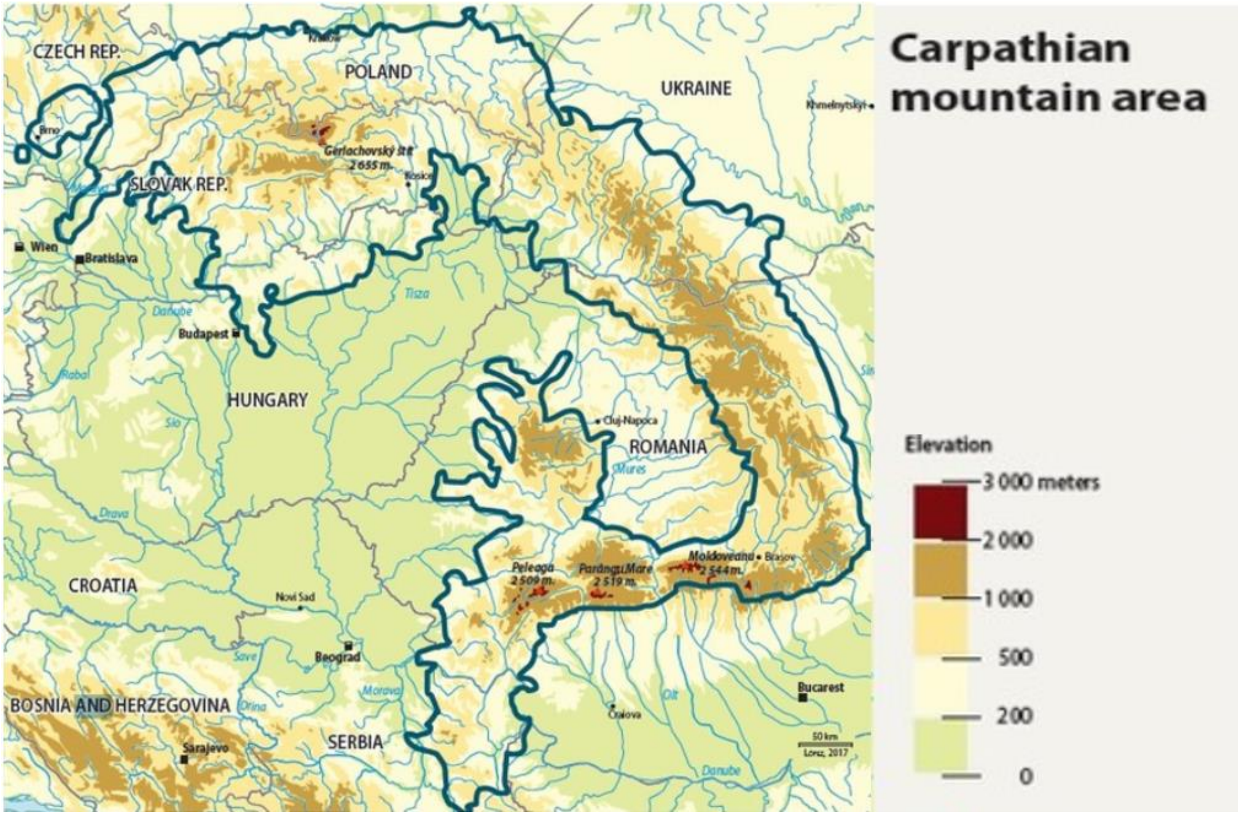

Figure 2.3: The Carpathian mountains. Adapted from Climate ADAPT (2006).

The collision of the African, Indian, and small Cimmerian plates from the south with the Eurasian plate in the north formed these mountain chains (Bala, 2015). The sliding of these plates causes most earthquakes in the Balkans (Musson, 1999). The city of Bucharest in particular is an area of high hazard because the Carpathians and Balkanides that form the Carpathian Mountains surround the city of Bucharest to the North and West (Gorshkov, et al., 2000).

The Balkan Peninsula has around ten regions that seismologists classify as moderate to high hazard zones, or areas with a 10% or greater chance of experiencing an earthquake of magnitude 5.0 or greater in the next 50 years (Du Brulle, 2014). Figure 2.4 is a European seismic hazard map that highlights regions of high hazard in red. Countries in or near the Balkans that have high hazard cities include: Albania, Austria, Bulgaria, Croatia, Greece, Hungary, Romania, Serbia, Slovakia, Slovenia, and Turkey (Bala, 2015).

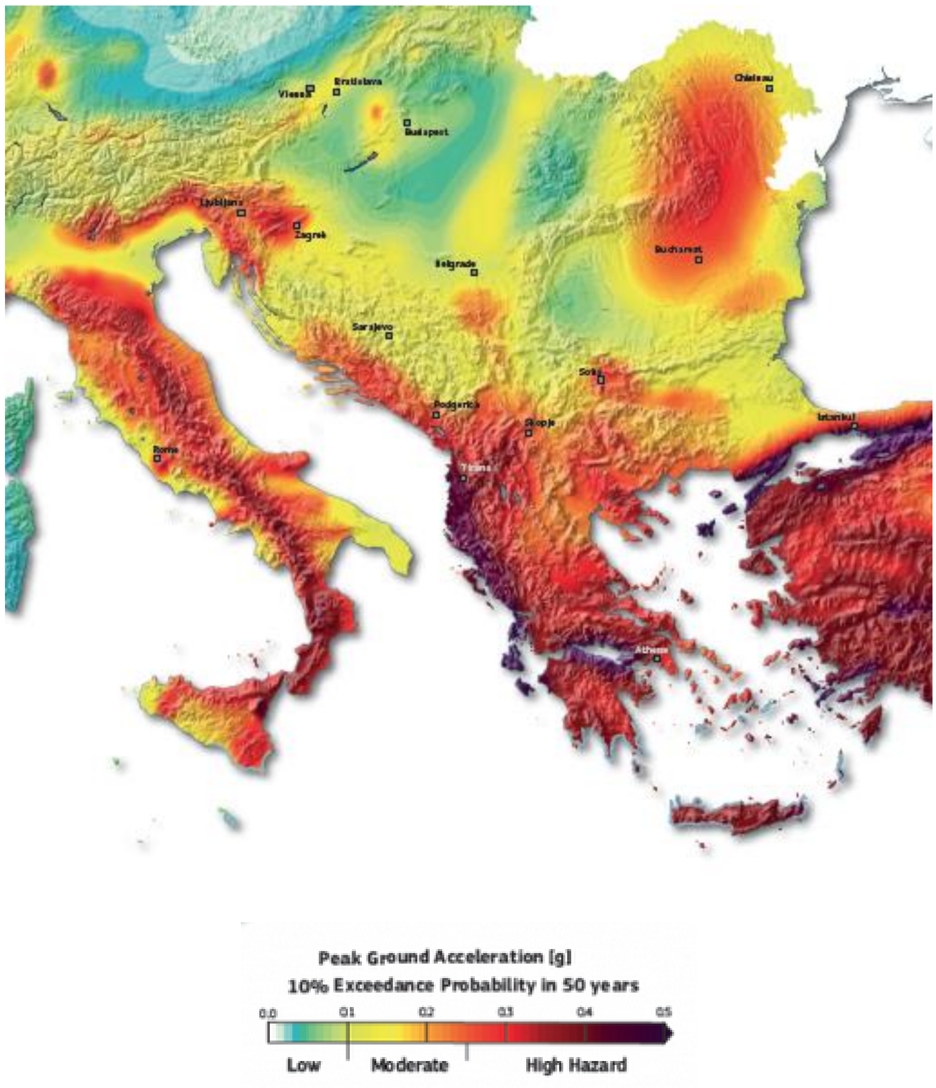

Figure 2.4: European Seismic Hazard Map. Giardini (2013).

The high hazard nature of the Balkan Peninsula corresponds to a history of seismic events. Figure 2.5 depicts dots varying in size and color based on focal depth and magnitude. These dots represent past earthquakes, and the figure plots them on the location of their origin. Beyond indicating the volume of earthquakes in the Balkan Peninsula, this source also depicts the distribution of these occurrences. Vrancea County, highlighted in yellow, has experienced several earthquakes of high magnitude and focal depth. This region is 150 kilometers northeast of the Romanian capital of Bucharest. Bucharest's proximity to Vrancea County makes seismic activity a necessary consideration for city residents and officials.

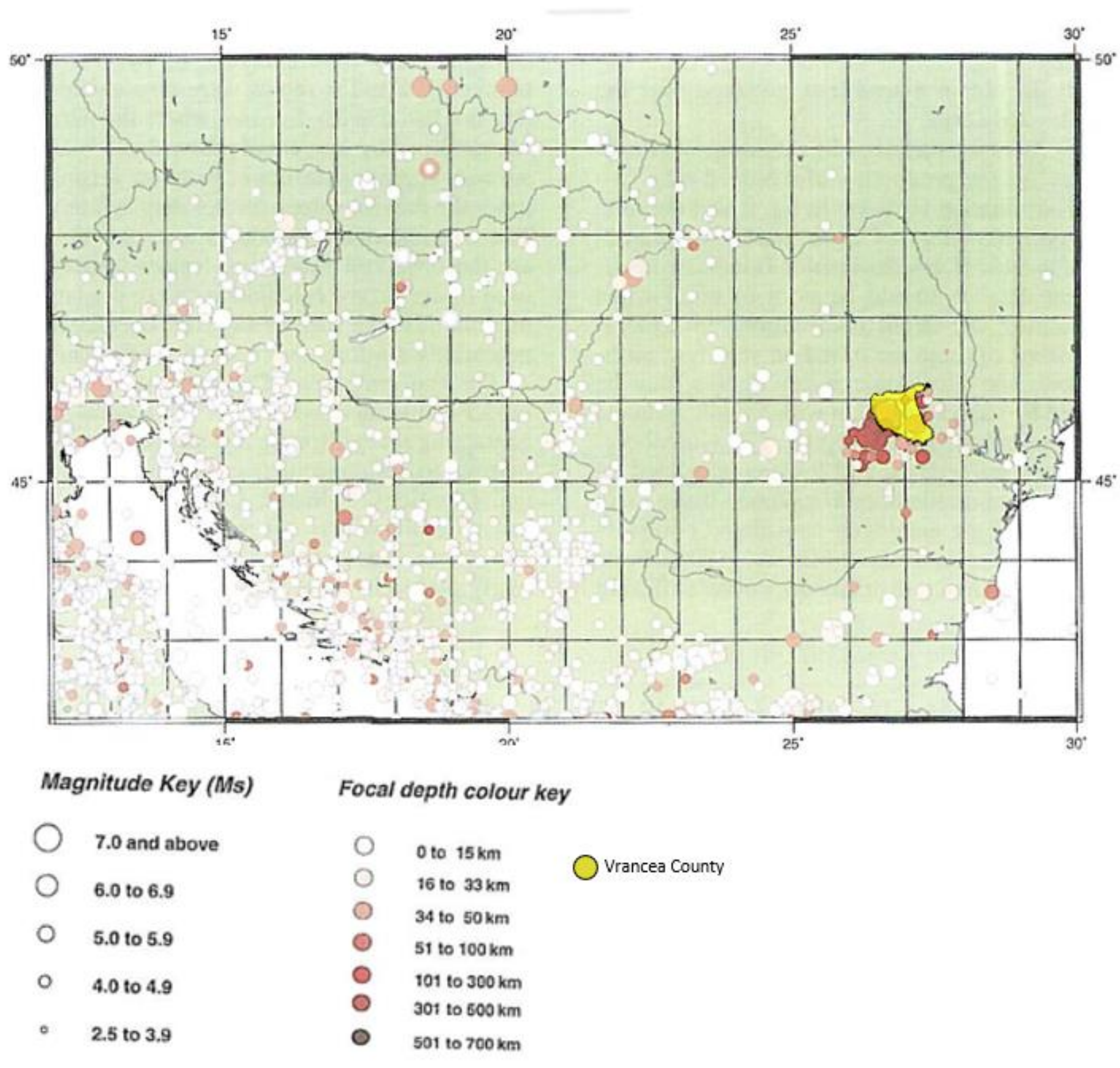

Figure 2.5: Seismicity of the Northern Balkan Region [Map]. Musson, R. (1999).

2.3 Politics and Corruption in the Balkans

Between 1948 and 1989, Romania was a communist state in the Eastern Bloc. During this period, Romania's industrial sector and, consequently, its economy grew rapidly (Topan, 2018). Romanian infrastructure could not keep up with this "chaotic" growth (Stoica, 2012). In 1930, 77% of Romanians worked in the agriculture industry. By 1980, this number had dwindled to only 29% (Mazower, 1999). Bucharest was one of the cities to see drastic population growth, increasing from 650,000 people in 1950 to two million in 1989. To accommodate this growth, the communist regime built hundreds of multistory residential buildings (Odobescu & Bird, 2018). Following the USSR's model of communism, Romanian dictators viewed the housing market as unproductive and therefore not worth significant investment (Andrusz, 1985). During this period, the Romanian government also lacked funds due to dictator Nicolae Ceauşescu's policy of paying off external debts (Mungiu-Pippidi, 2010) and the creation of many structures that were more ornate than practical (Odobescu & Bird, 2018). Without economic incentives nor the necessary capital, the Romanian government constructed many high-rise apartment complexes that were not seismically stable.

In addition, corruption within the communist government in Romania contributed greatly to the instability of buildings. A 2015 report titled "The Presidential Commission for the Analysis of the Communist Dictatorship of Romania" identified corruption as one of the key pillars of this era (Vasile, 2015). Bribery and corruption within the construction industry often led to construction that was unnecessary, unsuitable, or defective or dangerous (Sohail & Cavill, 2006). These defective or dangerous buildings could catastrophically fail during an earthquake.

According to a United Nations study on corruption within the western Balkans, about 12.2% of businesses in the building and construction industry had participated in a bribe within the 12 months leading up to the UN's survey. Serbia and Albania had the highest percentages of bribery across all industries, with 17% and 15.7% of businesses participating respectively. Businesses that paid bribes participated in 7.1 bribes per year on average (Bisogno, 2011).

There is significant evidence that corruption exists within Romania's industry sectors. Between 2007 and 2013, the nation dedicated around 6.6% of its GDP to the construction sector. However, as a source investigating corruption states, "the end results in terms of project finalization and quality did not match this investment" (Doroftei & Dimulescu, 2015). This paper suggested that two main factors are indicative of corruption: contracts that the government awards to a single bidder, and contracts it awards to companies with political connections. About 40% of contracts valued at over €1 million that the Romanian government awarded between 2007 and 2013 matched at least one of these two factors. On average, the paper estimated that private construction companies pocketed €200 million per year through these contracts (Doroftei & Dimulescu, 2015). Corruption in the construction industry is not harmless to residents of a region. When a city experiences unchecked corruption, researchers have shown the quality of buildings to decrease (Tanzi & Davoodi, 1997). In a region of high seismic hazard, this can be disastrous.

2.4 Historical Earthquakes in Bucharest

Bucharest experienced major earthquakes in 1940 and 1977. On the morning of November 10, 1940, fault planes located in Vrancea generated an earthquake registering between 7.6 and 7.7 on the Richter scale. Data published in the proceedings from the 15th World Conference on Earthquake Engineering sought to accurately estimate the death tolls through aggregation of existing research. The resulting figures estimated 593 deaths and 1,271 injuries, with 140 and 300 occurring within Bucharest city limits respectively (Georgescu & Pomonis, 2012).

Beyond loss of life, Bucharest suffered significant impacts to society, including the collapse of the Carlton Building. Figure 2.6 displays the building before the earthquake, and the remaining rubble afterwards (Georgescu & Pomonis, 2012). This building was 12 stories in height and was the city's largest concrete-reinforced building. The complete destruction of the Carlton Building was a public illustration of the failure of Bucharest's construction. The earthquake called into question the advancement of architecture in the city as well as the security of housing and businesses in the face of potential natural disasters, which prompted the government to change construction practices and building codes. However, the inability to uniformly apply these measures decreased their efficacy (Georgescu & Pomonis, 2012).

Figure 2.6: The Carlton Block before collapse (left) and after collapse (right). Georgescu, E & Pomonis, A (2012).

In 1977, Bucharest experienced yet another large magnitude earthquake originating from the Vrancea Region. Occurring on the evening of March 4, 1977, this earthquake registered at 7.2 on the Richter Scale. The earthquake resulted in 1,578 deaths and 11,321 injuries with 1,424 and 7,598 occurring in Bucharest respectively. As this data reflects, casualties were concentrated in Bucharest, with more than 90 percent of total deaths occurring within the city limits. This is largely due to the collapse of "19 high-rise apartment buildings (of 7 to 14 storeys) that were constructed in the inter-war period as reinforced concrete frames designed only for gravity loads" (Georgescu & Pomonis, 2012). The distribution of damage to dwellings and infrastructure was concentrated within Bucharest. Figure 2.7 depicts the distribution of buildings destroyed by the earthquake, with more than 25 percent of the total destroyed dwellings located within Bucharest. Similarly, Figure 2.8 indicates the distribution of dwellings requiring strengthening following the 1977 earthquake, with nearly 50 percent of dwellings located in Bucharest.

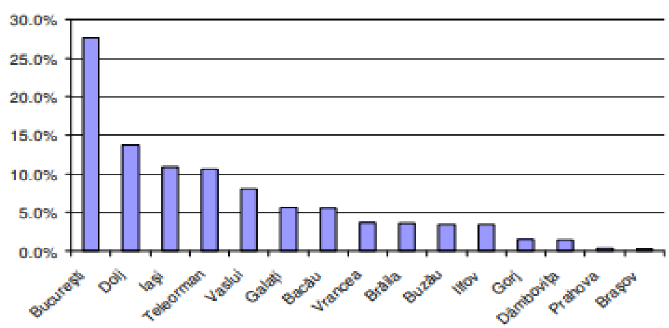

Figure 2.7: Chart of the territorial distribution of destroyed dwellings in 1977. Georgescu, E & Pomonis, A (2008).

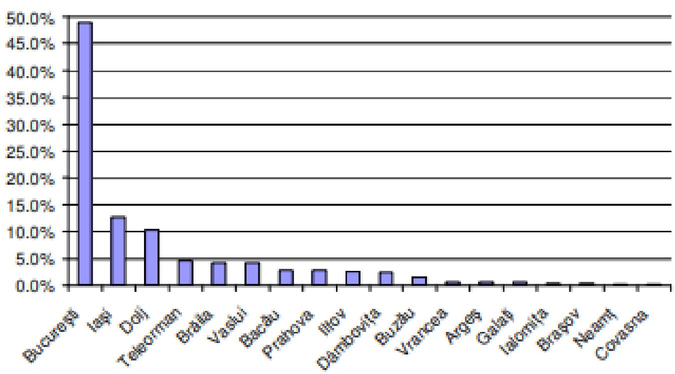

Figure 2.8: Chart of the territorial distribution of dwellings requiring strengthening in 1977. Georgescu, E & Pomonis, A (2008).

Researchers consider this earthquake among the most economically taxing natural disasters to occur in Romania to date. The 1977 earthquake was responsible for losses equivalent to 8 billion US dollars today, which constituted more than 6% of Romania's GDP at the time (Simpson et al., 2020). To alleviate the monetary cost and loss of life associated with natural disasters, governments must establish and follow preparedness measures. These measures shift time spent recovering from a disaster to time spent preparing for a disaster, and reduce the funds governments and municipalities invest into disaster recovery (Anderson, n.d.).

2.5 Earthquake Preparedness in the Balkans

By investigating the success and potential shortcomings of earthquake preparedness plans in other Balkan countries, researchers can compare and analyze the current status of Romania. In 2012, the United Nations and the World Meteorological Organization started an initiative called "Building Resilience to Disasters in Western Balkans and Turkey." This project aimed to assess and improve the preparedness of the Balkans for all types of disasters including fires, floods, landslides, and earthquakes. This project identified high-risk locations and made suggestions to local governments to improve disaster preparedness. The final stage in the project was a follow-up review of the Balkan region to assess the effectiveness of these suggestions. This subsequent study revealed significant progress in earthquake preparedness. Most of this progress was in public awareness and in regulations for new construction (Gencer, 2014).

Despite this progress, there still remains a serious lack of preparedness for almost all of the assessed regions. The largest remaining problem identified in this study was a lack of compliance with building regulations. City officials in this region indicate a serious shortage in their financial ability at a city level to proactively address these problems, as governments normally only provide money for disaster relief. Fortunately, the study identified one outlier: the city of Dubrovnik in Croatia. They have created a building code policy for all new construction to increase safety during a major seismic event. Additionally, they have developed an innovative response plan in the event of a disaster that includes 22 government-funded shelters to house anyone displaced during a natural disaster (Gencer, 2014). After instigating these plans , Dubrovnik has also seen a large increase in tourism in recent years which has positively contributed to their economy (Marinova, 2020). The progress shown in Dubrovnik can serve as an example for the rest of the Balkans of what is possible for disaster preparedness.

Albania, like many Balkan countries, shares multiple similarities with Romania. The countries are geographically close, and have similar political backgrounds, with both countries transitioning from communism to capitalism within the last century. Due to this similarity, Albania's 6.4 magnitude earthquake in November of 2019 is relevant to modern-day Balkan earthquake preparedness. This earthquake left 51 people dead and over 3,000 injured and highlighted the shortcomings of the country's earthquake preparedness plans. Almost all of Albania's earthquake plans focus on relief for victims after an event, instead of preemptive action to save lives. After this earthquake, the Albanian government found temporary housing for over 6,300 displaced citizens (Freddi et. al, 2021). There was also an extensive financial relief plan which allocated 63 million US dollars (7 billion leke) for the rebuilding of homes across the country. This quick response from the Albanian government was an effective reaction to the crisis (World Bank, 2019), but the damage had already been done. The World Bank Post-Disaster Estimation identified insufficient building codes and adoption of Eurocodes as a major reason for much of the damage. The reactive nature of Albania's earthquake preparation is an example of why reactive measures to earthquakes are important, but not sufficient by themselves (Dorka, 2015).

Directly following the earthquake in 2019, the Albanian government deployed a team of engineers to identify which buildings were safe to occupy and which warranted condemnation due to structural damage. These engineers provided suggestions on how to change the current building codes to prevent structural failure. Their first suggestion recommended architects take seismic risk into account when designing new structures. Secondly, the engineers recommended eliminating the practice of removing walls to create retail space on the first floor of buildings. Finally, they recommended that structural changes to a building require approval from a structural engineer (Blagov, 2020). Although these engineers suggested solutions for Albania specifically, similar measures in Romania would improve earthquake preparedness.

2.6 Bucharest Earthquake Preparedness

Since the fall of communism in Romania in 1989, residential development in Bucharest has expanded into surrounding rural communities. This is partially due to law 1/1989, which repealed communist-era laws limiting urban development and city sprawl (Suditu, 2009). After passing this law, the government's role in the production of housing decreased, and construction of residential housing shifted to the private sector. In the 90s, private investors turned agricultural land in the city outskirts into new residential buildings, expanding city limits. This trend continued in the early 2000s, as "the lack of comfortable alternative dwellings at accessible prices led to the research of solutions in the rural areas around" (Suditu, 2009).

While private developers have constructed many new buildings in Bucharest since 1989, there are still buildings within the capital that are much older. These older buildings are much more susceptible to earthquake damage, as new building codes hold modern structures to higher standards. The age of buildings usually depends on their distance from the city center. Figure 2.9 shows how building age varies throughout Bucharest. In the center of the city, buildings constructed before 1900 are the most common, while buildings from after the fall of communism are most common in the outskirts of the city.

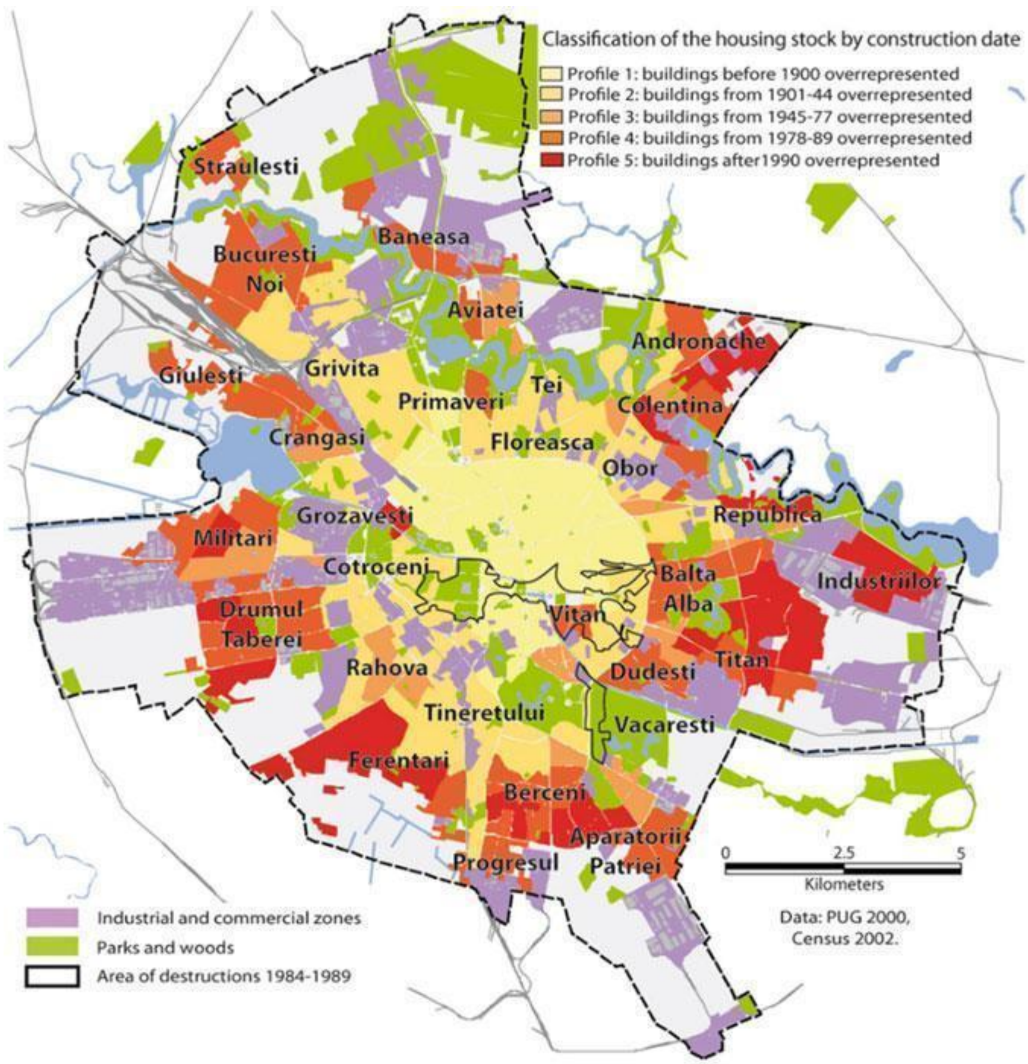

Figure 2.9: Land use and building age in Bucharest. Marin (2018).

Laws regarding seismic building codes have evolved over time in Romania. The 1963 Romanian Building Code (P13-1963) was the first major building code that dealt with seismic restrictions, with minor updates in 1970. After the major earthquake in 1977, the government updated the code to incorporate portions of the American Concrete Institute codes, with minor updates in 1990 and 2006. These updates changed concrete ductility requirements, which is how much a structure can move before it permanently deforms (Vacareanu, 2004). However, these newer codes apply to only a fraction of buildings currently in Bucharest, as the government does not actively enforce changes landowners must make for older properties (Suditu, 2020). The Technical University of Civil Engineering in Bucharest processed building data from the 1992 census (Lungu, 2000). According to this data, in 1992, construction after 1977 accounted for only 6.7% of the 108,821 buildings in Bucharest. In comparison, construction before World War II accounted for at least 21.7% of building stock in 1992. Therefore, even with these improved building codes, most buildings in Bucharest are at the same or higher risk as they were in the 1977 earthquake.

In 1991, the post-communist government developed plans to identify and reduce the number of buildings at risk of collapse from an earthquake. This document began the process of identifying “red dot” buildings, which are “constructions with a high risk of collapse on seismic designing force” (Suditu, 2020). Figure 2.10 shows an antique arts shop designated as high risk and marked with a red dot that is circled in yellow.

Figure 2.10: Red dot building in Bucharest, Simpson, Pomonis, & Georgescu (2020).

Between 1992 and 1997, the government evaluated almost 1,600 buildings based on the P100/92 design standard norms. These norms identified different emergency categories, depending on the urgency of repairs: U1 at a max of 2 years, U2 at 5, U3 at 10, and U4 with 15-20 years. After the adoption of the P100-3/2008 norms, the government also classified buildings into seismic risk categories. These categories are buildings with high risk of collapse during an earthquake (RsI), buildings for which earthquakes are likely to present major structural damages (RsII), buildings which may present structural damage but do not significantly impact structural safety (RsIII), and buildings that met new seismic code standards (RsIV). As of early 2020, around half of the 1600 buildings the government had classified did not meet new seismic codes. Of those 1600 buildings, 346 buildings have a RsI classification while the government has marked more than 400 others as RsII or RsIII (RsII or RsIII).

There are multiple public and private entities that are responsible for disaster risk management within Bucharest. The Ministry of Public Works, Development and Administration is the main building regulation authority in Romania. They approve “technical intervention solutions" to repair important buildings such as hospitals and shelters directly after an earthquake. They also approve solutions to repair existing buildings classified in the highest risk category. The mayor of Bucharest is responsible for identifying buildings that may be damaged during an earthquake, and notifying residents who are in vulnerable buildings. Finally, private owners and public property administrators must track and get technical expertise from certified technical experts for repairs regarding buildings they own that do not have protection against seismic risks. Unfortunately, public and private actors have not completed or documented these actions further increasing Bucharest’s vulnerability (Suditu, 2020). While one source claims that “a new National Seismic Risk Reduction Strategy is under preparation at the Ministry of Public Works… to be enforced in 2021-2050,” the project team was not able to find any supporting documentation for a new risk reduction strategy (Georgescu, 2020).

2.7 Socioeconomic Impacts of Earthquakes

High magnitude earthquakes produce long-lasting economic effects. Generally, economic losses due to earthquakes are direct or indirect losses. In this classification, direct losses indicate damages to structures and property sustained during the seismic event. Structural costs depend on existing value estimations or rebuilding costs. While varying levels of architectural and engineering consistency across regions introduce some uncertainties into these calculations, "reasonably sound loss-estimation methods currently exist to project direct damage to buildings…" (National, 1992). For non-structural losses, estimates vary between regions, and the researcher who is evaluating the cost.

Although earthquakes alone are non-discriminatory, taking place regardless of the race, culture or class of victims, one source suggests that lower-income and minority groups face significantly higher losses (National, 1992). These groups are often concentrated in areas with the poorest construction and maintenance of housing (Van Kempen, 1994), resulting in disproportionate structural and property damages during a natural disaster. Additionally, they generally receive the smallest proportion of disaster relief relative to the general public, resulting in lower-income groups "consistently bear[ing] a disproportionate share of the losses" (National, 1992). Moreover, the lower classes are less likely to have either health, life, or property insurance (National, 1992). While this is true in general, researchers have not yet identified this correlation within Bucharest.

Indirect economic losses are difficult to quantify. This is because business interruption, economic stagnation, and changes to day-to-day life depend highly upon societal aspects that researchers cannot easily factor into estimations. For example, earthquakes may result in transit interruptions. In regions that rely on public transportation as a "lifeline service", interruptions would induce larger long-term economic losses than those seen in a region that is less reliant on transportation systems (National, 1992).

In 2012, Iuliana Armaş published the study titled "Multi-criteria vulnerability analysis to earthquake hazard of Bucharest, Romania." This study combined five variables to create a map of the varying levels of vulnerability in Bucharest by using 2002 census data. Firstly, the researchers calculated environmental vulnerability by using ground acceleration values of recent earthquakes, a measure of how violent the shaking is. Secondly, they calculated social vulnerability through multiple factors including elderly population, housing density, and average number of persons per household. They then used unemployment rate, income inequality, and population density to calculate the economic vulnerability of the population. Armaş' group then calculated building stock vulnerability by using the age and average height of buildings, type of buildings, and residence density in those buildings. Finally, they used the term "capacity" to indicate a specific area's ability to respond to disaster. To calculate capacity, the group used factors such as distance to hospitals, fire stations, and police stations to define the area's preparedness level. Finally, Armaş combined this research into an overall vulnerability map. In 2017, Armaş updated the original vulnerability analysis using census data from 2011 to create an up-to-date vulnerability analysis (Armas et al., 2017). Figure 2.11 illustrates this updated vulnerability analysis of Bucharest.

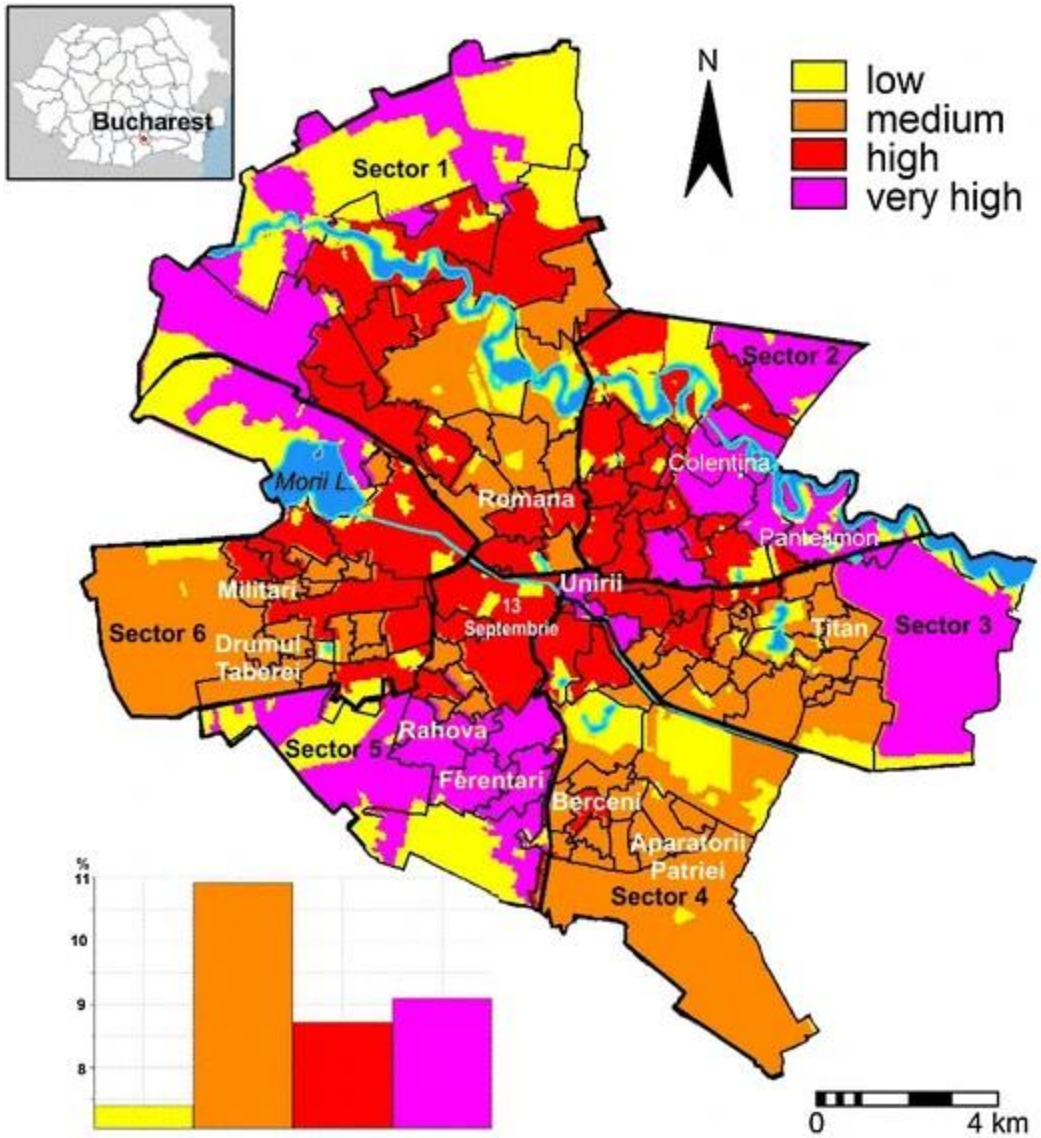

Figure 2.11: Vulnerability map of Bucharest. Armaş et al. (2017).

Figure 2.11 displays an interesting trend with regards to regions of high and very high vulnerability. This figure shows that a large proportion of regions categorized as highly vulnerable are concentrated in the center of the city. Figure 2.9 shows that the age of buildings in the center of the city is often greater than that of those on the outskirts. This is the main reason Armaş' report deemed these regions as high risk. In contrast, nearly all regions the researchers labeled as very high risk reside towards the outskirts of the city. Commonly, poorer citizens and minorities tend to live outside of the center of cities (Van Kempen, 1994). While this holds true for many cities, data does not yet exist that links earthquake vulnerability to different ethnic and religious groups.

Many individuals and groups within Bucharest have a direct stake in this project because the effects of earthquakes directly impact them. In the initial stages of the project, our team will gauge relative preparedness within the Balkan Peninsula. This information is relevant to residents and officials of the region as it provides useful insight into what practices are effective across the peninsula. The ethnic and religious groups the team will study stand to benefit if this project reveals that they are at a higher risk for loss in the event of an earthquake. In this case, these individuals have the opportunity to take further personal action or advocate for enhanced practices by the government. City officials also have a stake in this project as the onus will be on the city of Bucharest to adjust its earthquake preparedness plans to protect its minorities. Future researchers and experts in the field of seismology will be able to apply this method of analysis to other earthquake-prone cities, allowing them to identify larger trends that exist. Finally, experts in the fields of engineering, seismology, and sociology also have an important stake in this project as it is their work that seeks to characterize the effects of earthquakes and improve preparedness measures, as well as inform new research such as this report.

3.0 Methodology

The goal of this project is to evaluate the earthquake vulnerability of specific religious and ethnic groups within the city of Bucharest to determine the extent to which preparedness varies across these different groups. The objectives to achieve this goal are as follows:

1. To identify current earthquake preparedness practices in Bucharest and the Balkan Peninsula
2. To establish which societal and infrastructural components are most at-risk in the event of an earthquake
3. To characterize the ethnic and religious groups of Bucharest and evaluate the earthquake vulnerability of these groups.

The team will accomplish these objectives over the seven-week period from March 24 to May 13, 2021. While the focus of this project is within the Balkan Peninsula and specifically within the city of Bucharest, we will pursue all objectives remotely to ensure the safety of the team, collaborators, and study participants during the COVID-19 pandemic. The team has established a set of methods to execute in order to accomplish these objectives. Figure 3.1 displays these tasks in the light blue boxes. This investigation will explore the perception of, reaction to, and preparedness for earthquakes across the Balkan Peninsula with a focus on the city of Bucharest. Through the completion of these objectives, the team will examine the societal impacts of earthquakes within Bucharest relative to other areas within the Balkan Peninsula to accurately assess the current state of preparation within Bucharest and identify the extent to which this preparedness varies for religious and ethnic groups within the city.

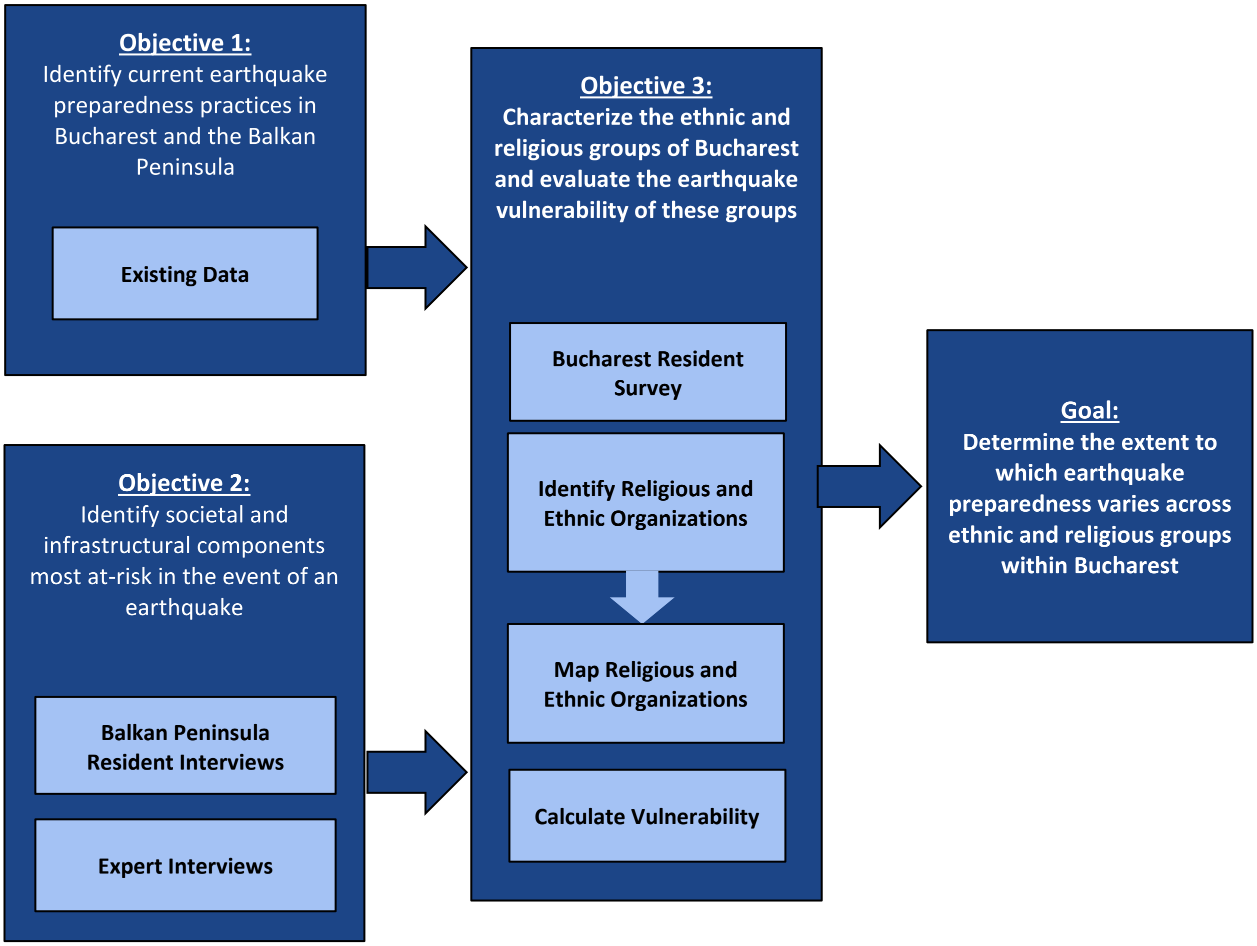

Figure 3.1: Flowchart of the necessary objectives and tasks to accomplish the project goal

3.1 Objective 1: Identify Current Earthquake Preparedness Practices in Bucharest and the Balkan Peninsula

The first objective of this project is to identify earthquake preparedness practices that both Bucharest and other regions of the Balkan Peninsula currently employ. To understand Bucharest's preparedness and execute the proposed objectives, the project will build a working knowledge of what measures are currently in place. The team expects that Bucharest employs preparedness measures including building codes, capacity limits, and emergency response plans, but research in the IQP term will target producing a more complete list of practices within the city. After identifying the preparedness practices within Bucharest, the team will compare these to practices in other cities within the region. This objective focuses on comparing practices within the Balkan Peninsula, as many of the countries within this region have similar political climates and earthquake potential. This comparison enables the team to both contextualize and gauge preparedness within Bucharest by revealing whether it is more or less prepared than other cities within the region and what specific measures yield this preparedness.

3.1.1 Collection of Existing Information

The only task involved in the completion of this objective is conducting extensive research to reveal the laws and codes that the governments of Bucharest and other cities within the Balkan Peninsula have in place with regards to earthquakes. The research will use sources such as government websites, peer-reviewed articles, and legal documents to compile a list of common practices governments use to prepare for earthquakes in the Balkan Peninsula. We will utilize database search engines such as Google Scholar and the WPI library resources page to search keywords relevant to the project in order to identify existing resources and examine practices utilized throughout the Balkan Peninsula to prepare for earthquakes. These archival results will serve as a basis for the rest of the project as they contextualize preparedness within the Balkan Peninsula and initiate the process of establishing where and why this preparedness varies.

3.2 Objective 2: Identify Societal and Infrastructural Components Most At-Risk in the Event of an Earthquake

The next objective is to investigate and identify which societal and infrastructural components are most vulnerable to earthquakes in the Balkan Peninsula. The team will work to uncover the rationale behind preparedness measures employed by local governments in order to determine which aspects of Bucharest's physical and social environments are vulnerable to earthquakes. True preparation requires action on the part of both the government as well as individuals. Thus, gauging education and individual agency in minimizing earthquake risk to build a comprehensive knowledge of societal vulnerabilities within Bucharest and the Balkan Peninsula is an element of this objective. Interviews with both experts and residents of various cities within the Balkan Peninsula will provide the information necessary for this objective.

3.2.1 Balkan Peninsula Resident Interviews

The project plan is to conduct online interviews with 15-20 residents of the Balkan Peninsula. This includes residents of Romania, Albania, and Croatia. The team believes these interviews will provide personal accounts, opinions, and experiences of earthquakes and their corresponding risk and preparedness. This will allow us to assess the performance of social, structural, and infrastructural components of the city during and after earthquakes as observed by residents. Moreover, residents who have experienced earthquakes in the past can identify the challenges they faced in post-disaster life. The expectation is that uncovering these challenges will reveal trends in the societal components that earthquakes significantly impact.

Our team recognizes that the largest challenge associated with this methodology is identifying and contacting a sufficiently large sample group that represents the goals of this project and its stakeholders. Consequently, our approach involves contacting universities around the Balkan Peninsula to connect with students and possibly locals. Similarly, WPI has project centers in both Bucharest and Albania that can serve as a resource to find individuals to interview. Additionally, we propose reaching out to local religious centers and ethnic organizations to identify potential interviewees. These practices would introduce a greater diversity in the interview sample. The team will employ a snowball sampling method wherein each interviewee identifies additional individuals that may be willing to speak with us. Interviews across different cities within the Balkan Peninsula will also aid in ensuring a sufficient sampling pool.

The team has created an interview guide (see Appendix C) for a semi-structured virtual interview with these residents. The team will ask demographic questions (see Appendix B) at the beginning of the interview to obtain results that cut across different demographic groups and that reflect the contexts of the individuals' experiences and identities. The main topics include personal experiences with earthquakes (C.1-C.2), lasting impacts of earthquakes (questions C.3, C.9), reaction to earthquakes (C.4-C.8), earthquake preparedness (questions C.13-C.23), and perceived effects of earthquakes (C10).

3.2.2 Expert Interviews

Another method in achieving this objective is interviewing experts on seismology and structural engineering to reveal the physical vulnerabilities associated with earthquakes, as well as experts in sociology to uncover the social vulnerabilities associated with earthquakes. Initial interviews will target WPI professors in the structural engineering department. These interviews will investigate the structural and infrastructural components of cities that are typically vulnerable to earthquakes, and inform adjustments to the set of questions for interviews of experts from the Balkan Peninsula. The next step will involve contacting universities in Romania, Albania, and Croatia to identify professors who are willing to participate and advise this research regarding the specific vulnerabilities within their countries. These experts will include authors from the published sources utilized in the background chapter of this project. Hopefully, these expert interviews will include individuals such as Professor Iuliana Armaş and

Professor Bogdan Suditu, whose expertise in seismic risk and hazard in the Balkans has shaped the direction of this project.

Appendix D contains the specific questions for a semi-structured virtual interview with these experts. Each expert interview includes questions about seismic risk in their country and the impacts of earthquakes on their cities (questions D.1-D.4). They also include demographic questions (occupation, field of study, location) to situate the results of the interviews within the context of the city of origin and the expertise of the interviewee (questions D.5-D.12). The main topics of the interviews include the buildings and infrastructure at risk within cities in the Balkan Peninsula, the social and socioeconomic constructs at risk within these cities, and role of current preparedness measures in minimizing risk within these areas. This information will present the physical and social components at risk within the Balkan Peninsula and why these components are especially vulnerable.

3.3 Objective 3: Characterize the Ethnic and Religious Groups of Bucharest and Evaluate the Earthquake Vulnerability of these Groups

The next objective is to characterize the composition of ethnic and religious groups by region in the city of Bucharest. This will enable the team to determine the distribution of these groups throughout the city. Since existing research states that preparedness is uneven throughout the city (Armaş, 2012; see also Armaş et al., 2017), accomplishing this objective will lead to a qualitative assessment of the preparedness of ethnic and religious groups. Bucharest is mostly comprised of Romanians (~87%), with minority groups of Hungarians (6.5%), Romani (~3%), Germans, Jews, and Dobruja Muslims (~0.4%) (Latham et al., 2020). Similarly, the majority of Bucharest's residents are Orthodox Christians, but the expectation is that research will identify other minority religious groups throughout the city. The methods for executing this objective are surveying residents, mapping local churches and ethnic organizations, and applying an existing vulnerability evaluation to specific groups within the city.

3.3.1 Collection of Existing Data

This method involves compiling resources with religious and ethnic data for the city of Bucharest. The focus of this method is to convey a qualitative interpretation of the current distribution of these groups within Bucharest. Moreover, since later methods propose the use of census data, this characterization will determine the extent to which data from the most recent 2011 census is reflective of Bucharest now. Conventional research practices will reveal existing surveys and studies regarding ethnic and religious trends within the city. In addition, building connections with organizations in Bucharest may yield sources regarding ethnic and religious composition. For example, the team plans to contact outreach programs, resource centers, ethnic and religious organizations, and university departments that study the social components of Bucharest. While it is unlikely that these organizations will have adequate data to conduct a quantitative assessment, the hope is that these organizations will have qualitative insight from serving and studying these groups.

3.3.2 Church and Ethnic Organization Mapping

Additionally, the team will map places of worship of several religions across Bucharest. The team will accomplish this by identifying these places of worship then locating them with Google Maps. We will use a similar method to locate resource centers and organizations associated with specific ethnicities within the city. Some examples of these organizations include the Hungarian Institute in Bucharest and the Russian Center in Bucharest.

The plan is to identify more organizations through snowball research techniques wherein organizations identify other organizations that the team can contact.

After identifying these places of worship and organizations linked to ethnic groups, the next step is to map their locations on an overall risk map developed by experts in existing research (Armaş et al., 2017). This map will visually represent the distribution of resources and places of gathering utilized by ethnic and religious groups. Moreover, the following research phase entails ascertaining to what extent the locations of these buildings are indicative of high concentrations of individuals belonging to these groups in the surrounding areas. If this analysis identifies a correlation, the resulting map will qualitatively approximate regions of Bucharest that ethnic and religious groups inhabit. Because the map will overlay these places of worship and organizations on the vulnerability map, the resulting visual may uncover possible relationships between ethnicity and religion groups and earthquake risk.

3.3.3 Survey of Residents in Bucharest

The team will conduct a survey of Bucharest residents in order to collect data regarding several key social elements within Bucharest. The survey specifically focuses on ethnic and religious groups and intends to reveal their experiences with societal features that an earthquake would impact. These features include infrastructure, transportation, residencies, and resources. This information will identify trends across these groups and assess to what extent variations of living experiences due to religious and ethnic identity influence earthquake preparedness in Bucharest.

The team realizes the challenge of collecting adequate data from minority groups because the majority of Bucharest's citizens are Romanian and Eastern Orthodox at over 80% of the population each. Thus, the team will employ methods that attempt to identify a survey pool with enough diversity to draw strong conclusions but working remotely requires significant assistance from people and organizations in Bucharest. The team proposes distributing access to the survey through various places of worship in Bucharest. This will help the survey reach residents of as many religious identities as possible. Similarly, the team will distribute access to the survey through different ethnic organizations. While some may decline to distribute the survey, the team expects that coordination with as many organizations as possible will enhance the results of the survey.

The team has compiled a list of survey questions in appendix F to collect the desired data. All questions are optional and the survey will include a statement of anonymity and address respondents' rights. The team will assemble these questions into a Google survey for distribution to residents in both English and Romanian.

3.3.4 Vulnerability Calculation

The team's final method in achieving this objective is to use census data to quantify how earthquakes may disproportionately affect different ethnic and religious groups within Bucharest. The team will achieve this objective by inputting data from the 2011 census for specific religious and ethnic groups into a vulnerability evaluation established in existing research (Armaş, 2012). This prior research utilizes an analytical technique to calculate a numerical score that represents the earthquake risk of a given area. This investigation will expand on this technique to compare earthquake risk across different religions and ethnicities within the city of Bucharest.

Census data from IPUMS-International contains valuable information about where residents live within the city, their economic status, and their religious and ethnic affiliations (Minnesota, 2020). Unfortunately, the most recent census was in 2011. To determine if this census data is still a reasonable reflection of Bucharest, the team will compare the census data to the qualitative results of the previous methods within this objective. Furthermore, this comparison will assess whether the distribution of ethnic and religious groups represented in the census has changed substantially in the last decade. The team will perform calculations using 2011 census data even if this comparison reveals changes since 2011, as this analysis will still provide an understanding of the 2011 situation, as well as provide a framework for future researchers to evaluate data from the upcoming 2022 census.

Our calculations will use the formulas presented in a report authored by Armaş in 2012, but our study entails a separate analysis to find the overall vulnerability score for each ethic and religious group. This investigation expands upon Armaş' work because ethnicity and religion are not considerations in her initial report and separate scores for these groups will illustrate any major disparities in vulnerability across religious and ethnic divides. These calculations will require data and utilization of the specific formulas enumerated in Appendix D to calculate five values: environmental vulnerability, social vulnerability, economic vulnerability, building stock vulnerability, and capacity. Calculations will then combine these factors into overall vulnerability, or the measure of how likely a person or place is to sustain loss from an earthquake hazard.

The team will categorize census data by region, ethnicity, and religion. This new categorization process will enable calculations based on all three of these factors, yielding a numerical score of overall vulnerability for each religious and ethnic group by region in Bucharest. After obtaining these values, the team can also average these scores across the six counties within Bucharest to produce an average overall vulnerability for ethnic and religious groups across the city as a whole.

3.4 Data Analysis

For all three objectives, the team will collect a large amount of data through research, interviews, and surveys. We will analyze all of this information and present it in a clear and concise manner. Based on information found in existing resources, the team will create a chart with earthquake preparedness measures of different cities. We will indicate this with check marks in specific cells to identify if a country has taken those preparedness measures. This will serve as a visual representation of the comparison of preparedness measures through the Balkan Peninsula achieved through research. This chart will be the main deliverable for objective one, but will include information obtained during the expert interviews conducted for objective two. The results of this process will provide a background of the preparedness measures of Bucharest in comparison to other Balkan countries.

Objective three requires the use of survey data to gain a qualitative understanding of the religious and ethnic composition of Bucharest. After the team evaluates the results of these surveys, we will use the data to supplement objective one and two. The first step is to organize the data by ethnicity, and assess responses to determine identifiable trends within each ethnic group. To perform a quantitative analysis of this survey data, it is necessary to code the responses. Outlined in appendix H is the process of coding that this project will employ. Once the team has identified trends across religious and ethnic groups, we can determine the extent to which these identities correlate to varying earthquake preparedness and vulnerability.

Both objective two and objective three utilize interviews as a source of data. These interviews will result in a large amount of qualitative information in the form of transcripts. The team will request permission to record video and audio of each interview and will take notes on each response during the interview. The team will then produce transcripts from the audio recordings after the interview, with the live notes from the interview serving as backups. Appendix H depicts the method that this project will use to code these transcripts. For interviews with residents, we will analyze these coded responses to observe trends and connections across the residents' experiences and opinions. For the coded results from interviews with experts, the team will identify connections in which components of infrastructure are most vulnerable to earthquakes and how this affects residents of Bucharest.

3.5 Summary

Earthquakes are a threat to the residents of Bucharest. Since it is not possible to prevent natural disasters, preparedness is the only defense. Upon completion of the goals and objectives outlined, the team hopes to provide a definitive answer on whether or not earthquakes disproportionately impact different religious and ethnic groups in Bucharest. If the team finds a positive correlation, meaning certain groups are at higher earthquake risks, the onus will be on the city to respond and protect its minorities. If the team does not find a correlation, this project will still be a valuable outline used to complete a follow-up assessment using future census data. Regardless of the outcome, this project will be valuable in assessing Bucharest's earthquake preparedness and the impacts this has on different cultural groups in the city.

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Appendix A: Interview Confidentiality Statement

You are being asked to participate in an interview about your experiences during an earthquake. Before you agree, however, you must be fully informed about the purpose of the interview, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation.

During this interview, we will ask you about your personal experiences regarding earthquakes. We will ask you to tell us about where you were, how you felt, and what happened after you experienced the earthquake.

The interviewer will be taking notes during the interview based on responses. If consent is given, audio and video will also be recorded. This will be used to accurately recount provided information for future purposes.

This interview pertains to earthquakes, and while questions were crafted with the interviewee in mind, we recognize that some of the topics discussed may be sensitive. At this point in time, we ask that you consider your well-being before agreeing to proceed with this interview.

There is no benefit to participants in this interview.

Records of your participation in this interview will be held confidential so far as permitted by law. However, the study investigators, the sponsor or it's designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data will not identify you without explicit consent.

No possibility of injury is anticipated in participating in this interview. However, you do not give up any of your legal rights by signing this statement.

For more information about this research or about the rights of interview participants, please contact:

Ruth McKeogh, 508 831-6699, irb@wpi.edu, IRB Manager
Gabriel Johnson, 508-831-4989, gjohnson@wpi.edu, Human Protection Administrator
Owen Lally, 860-338-5039, olally@wpi.edu, Interview Coordinator
ID2050 research team, N/A, gr-balkan-D21@wpi.edu, Group with all ID2050 team members

Appendix B: Common Interview Questions

B.1 What gender do you identify with?

B.2 How old are you?

B.3 Where are you from?

B.4 Where are you currently living?

B.5 What ethnicity do you identify with the most closely?

B.6 What religion do you identify with the most closely, if any?

B.7 Have you ever personally experienced an earthquake?

B.8 If more than 1, how many, and where?

B.9 How has this experience shaped your perception regarding earthquakes?

Appendix C: Resident Interview Questions

Earthquake experiences

C.1 What were your experiences during the earthquake?

C.2 What were your experiences in the hours after the earthquake?

C.3 What were some physical changes around (earthquake location) after the earthquake?

C.4 What was the social atmosphere around (earthquake location) following the earthquake?

C.5 What were the emotional reactions of those around you?

C.6 What types of assistance did you witness in the aftermath of the earthquake?

C.7 Was there media coverage of disaster relief?

C.8 What were the reactions of those around you to the earthquake?

C.9 To what extent did the earthquake change any aspects of your life?

C.10 To what extent does experiencing an earthquake change how you perceive earthquakes?

C.11 Do you have friends or family that have experienced an earthquake?

C.12 Would you be willing to provide contact information so that we could reach out to them about a possible interview?

Earthquake Awareness

C.13 Could you tell us what you know about the history of earthquakes in your country?

C.14 Do you know what organizations are responsible for earthquake preparedness?

C.15 Do you know what earthquake preparedness measures these organizations are taking in your country?

C.16 To what extent were the preparedness measures implemented effectively?

C.17 (For those from Romania) What do you know about red dot buildings in Bucharest?

C.18 How common are red dot buildings near where you live?

C.19 Has anything been done about these buildings?

C.20 How would you feel about living in a condemned building like a red dot building?

C.21 Do you have a disaster plan if an earthquake happens??

C.22 What are some measures you have personally taken to prepare for an earthquake?

C.23 What are some measures you have seen others take to prepare for an earthquake?

Appendix D: Expert Interview Questions

Note: These questions will differ between the experts we interview. Before conducting an interview with an expert, the team will do research to understand the kind work this expert has done to help inform what questions may be the most relevant.

<u>Infrastructure questions for seismologists and structural engineers</u>

D.1 Where are you currently working/studying?

D.2 What is your current occupation and status at _______?

D.3 What is your current field of study?

D.4 How long have you worked/studied _______?

D.5 What types of infrastructure are heavily affected by earthquakes?

- D.6 How does this affect the general public?
- D.7 What are some lasting effects of earthquakes?
- D.8 What components of infrastructure are vulnerable specifically in your city/country?

D.9 What are some common preparedness measures taken in your city?

- D.10 To what extent would you say these measures are effective? Why?
- D.11 To what extent would you say these measures are sufficient?
- D.12 How do the preparedness measures in your country compare to neighboring countries?

<u>Social questions (will be asked to sociologists)</u>

D.13 What are some influences or links between socioeconomic or cultural groups and earthquake risk on socioeconomic or cultural groups?

- D.14 To what extent are there differences in vulnerability between socioeconomic groups?
- D.15 How about ethnic groups?
- D.16 Religious?
- D.17 Can you explain the causes of these differences?
- D.18 Follow up questions should ask about the specific research they've done, as its very

relevant to our project

D.19 What role does the government play in earthquake preparedness in (country)?

D.20 In what ways does the communist past of (country) influence the current earthquake risk and preparedness

Appendix E: Survey Confidentiality Statement

You are being asked to participate in a survey about your knowledge and experience with earthquakes. Before you agree, however, you must be fully informed about the purpose of the survey, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation.

During this survey, we will ask questions about demographics, any personal experience you have with earthquakes, and what you know about earthquake preparedness in Bucharest. All questions are optional, but please answer as many as you are comfortable with.

There is no benefit to participants in this survey.

Records of your participation in this survey will be held confidential so far as permitted by law. However, the study investigators, the sponsor or it's designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data, but it will not identify you by name. Any publication or presentation of the data will not identify you without explicit consent.

No possibility of injury is anticipated in participating in this survey. However, you do not give up any of your legal rights by signing this statement.

For more information about this research or about the rights of survey participants, please contact:
Ruth McKeogh, 508 831-6699, irb@wpi.edu, IRB Manager
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Appendix F: Bucharest Resident Survey

General Demographics

F.1 What is your gender?

a. Male
b. Female
c. Other (Please specify)
d. Prefer not to answer

F.2 What is your age?

a. 21 and under
b. 22 to 34
c. 35 to 44
d. 45 to 54
e. 55 to 64
f. 65 and above
g. Prefer not to answer

F.3 What ethnicity do you identify with the most closely?

a. Romanian
b. Romani
c. Hungarian
d. Ukrainian
e. Russian
f. German
g. Turkish
h. Muslim
i. Other (Please specify)

F.4 What religions do you identify with the most closely?

a. Eastern Orthodox
b. Protestant
c. Roman Catholic
d. Islam
e. Other (Please specify)

F.5 What is your annual household income?

a. 15,000 lei or less
b. Between 15,000 and 25,000 lei
c. Between 25,000 and 50,000 lei

d. Between 50,000 and 100,000 lei
e. Between 100,000 and 150,000 lei
f. Between 150,000 and 200,000 lei
g. Greater than 200,000 lei
h. Prefer not to answer

F.6 What is the approximate distance in kilometers from your place of residency to your place of worship?

a. *Numeric Textbox*

F.7 Please select the neighborhood where you live.

a. *Answers not listed for brevity. This question will be presented as a drop-down box, so that the team does not have to manually code responses.*

F.8 What kind of housing do you live in?

a. Apartment (not government funded)
b. Single home (not government funded)
c. Government-funded housing
d. Condominium
e. Other (Specify)

F.9 What is your primary method of transport?

a. Car
b. Bus/Trolleybus
c. Train
d. Uber/Lyft/Rideshare (or equivalent)
e. Walking
f. Other (Please specify)

F.10 What is your secondary method of transport?

a. None
b. Car
c. Bus/Trolleybus
d. Train
e. Rideshare service (Uber, Lyft, etc.)
f. Walking
g. Other (Please specify)

F.11 How often do you utilize public transportation (train, bus/trolleybus, metro)?

a. Daily
b. Multiple times a week
c. Once a week
d. Once a month
e. Once every few months

f. Rarely
g. Never

F.12 How long is the commute to your local grocery store via your primary method of transport?

a. Less than 5 minutes
b. 5-15 minutes
c. 15-30 minutes
j. 30-45 minutes
k. Greater than 45 minutes

F.13 How often do you go shopping for groceries in a week?

a. Numeric textbox

Earthquake Risk

F.14 How many earthquakes have you experienced?

a. Numeric textbox

F.15 I believe an earthquake would significantly impact my (check all that apply):

a. Living arrangements
b. Transportation
c. Health
d. Access to necessities
e. Other (Specify)

F.16 Do you believe your housing area is at high risk to experience damage by an earthquake relative to surrounding areas?

a. Yes
b. No
c. Not sure

F.17 Have you ever seen these red dots on buildings in Bucharest?

(http://internationalreporting.media.illinois.edu/romania/entry/signs-of-trouble.orig)

a. Yes
b. No

F.18 Is there a red dot on your building?

a. Yes
b. No
c. Unsure

F.19 Do you have friends or family who have a red dot on their building?

a) Yes
b) No
c) Unsure

F.20 What do you believe these red dots indicate?

a. Textbox

F.21 What emotions do you feel when you see these red dot buildings?

a. Textbox

F.22 How close do you live to a red dot building?

a. Less than 1km
b. 1 to 4km
c. 5 to 9km
d. 10 to 15km
e. More than 15km

f. Do not know/Prefer not to answer

F.23 In your neighborhood, approximately how many buildings do you think have this red dot?

a. 0
b. 1-2
c. 5-10
d. 10-20
e. Greater than 20

Appendix G: Multi-Criteria Vulnerability Analysis

The equations and factors in these sections are from previous research regarding earthquake vulnerability analysis (Armaș, 2012; Armaș et al. 2017).

Data Used to Calculate Vulnerability Factors

Category	Values used to calculate
Environmental vulnerability	Average acceleration values for medium magnitude earthquakes
	Average acceleration values for high-magnitude earthquakes
Social Vulnerability	Ratio of elderly population
	Ratio of children
	Ratio of female population in total population
	Ratio of widows in female population
	Housing density
	Average number of persons per household
	Average number of wage earners per household
	Minimum level of education

	Women with many children
Economic vulnerability	Percentage of unemployed
	Ratio of low incomes to high incomes per mapping units
	Degree of occupancy per room
	Room area per person
	Average area of rooms
	Private residences with more than 5 rooms
	Population density per residence
Building stock vulnerability	Residence density in building
	Density of buildings per census units
	Age and average height of buildings
	Type of buildings per census units
Capacity	Distance to hospitals
	Distance to fire stations
	Distance to police stations

	Accessibility and distance from green and barren areas
	Literacy rate

Equations Used to Calculate Earthquake Vulnerability Risk

We will use the following equations to calculate the numerical values represented on the final map.

$$R = H + V_{OV}$$
$$V_{OV} = V_t / C$$

R = Risk

H = Hazard

V_{OV}= Overall vulnerability

V_t= Total vulnerability

C = Capacity

Additionally, we will utilize the following formulas to calculate vulnerability.

Social vulnerability = $(N_P + N_c + N_{ME}) - (N_{WE} + N_f + N_{WI} + N_H)$

Economic vulnerability = $(N_U + N_L) - (N_{HM} + N_{HW})$

Housing stock vulnerability = $(N_{RA} + N_{PA} + N_{O5}) - (N_O + N_D)$

Category	Statistical indicator (per census unit)	Symbol	Equation	Relative Change Factor
Social Vulnerability	Ratio of elderly in population	N_e	N_e^t / N_p^t	↑

	Ratio of female population in total population	N_f	N_f^t/N_p^t	↑
	Ratio of children	N_c	N_c^t/N_p^t	↑
	Ratio of widows in population	N_{wi}	N_{wi}^t/N_w^t	↑
	Housing density	N_h	N_p^t/N_{ho}^t	↑
	Average number of wage earners per household	N_{we}	N_{we}^t/N_p^t	↓
	Minimum level of education	N_{me}	N_{me}^t/N_p^t	↑
	Women with 5 children or more	N_{w5}	N_{w5}^t/N_w^t	↑
Economic vulnerability	Ratio of unemployed	N_u	N_u^t/N_p^t	↑
	Ratio of low incomes	N_l	N_l^t/N_p^t	↑
	Ratio of high	N_{hw}	N_{hw}^t/N_w^t	↓

	incomes (women)			
	Ratio of high incomes (men)	N_{hm}	N_{hm}^t/N_m^t	↓
Housing stock vulnerability	Room occupancy per household	N_o	N_p^t/N_r^t	↓
	Average household room area	N_{ra}	N_a^t/N_r^t	↓
	Household population density	N_d	N_p^t/N_h^t	↑
	Average number of private households with 5 or more rooms	N_{o5}	N_{05}^t/N_p^t	↓
	Average room area per person	N_{pa}	N_a^t/N_p^t	↑

Appendix H: Process of Coding Survey and Interview Results

The team will utilize inductive coding to analyze these written responses. Inductive coding is different from other methods because it uses the survey or interview answers to create the codebook (Durrett, 2016)). This is much more appropriate for this project than other methods such as deductive coding which uses a pre-set codebook regardless of what the survey answers contain. The team will perform the following steps:

1. The team will calibrate our coding process by individually coding a single interview. We will compare our results with each other, and make adjustments to themes so that each member's coding is consistent with each other.
2. Break dataset into smaller samples.
3. Read a sample of the data.
4. Create codes that cover the sample.
5. Read a different sample of data, apply codes.
6. Note where codes don't match or where additional codes are needed.
7. Create new codes based on the second sample.

This will result in categories that the team will utilize to quickly and consistently code all survey data. The team will then analyze this categorized data as if it were quantitative.