

CLIMATE CHANGE AND ITS IMPACT ON STEĆCI IN THE TERRITORY OF BOSNIA AND HERZEGOVINA

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INTRODUCTION

The analysis of climate changes in Bosnia and Herzegovina is based on monitoring two fundamental climatic elements: **air temperature** and **annual precipitation**. The Sarajevo meteorological station maintains a continuous and homogeneous observation record for these two climatic elements spanning 137 years (from 1888 to 2025), providing an exceptionally representative dataset for tracking climate change and variability in Bosnia and Herzegovina. In the analysis of climatic elements, particular attention has been given to the **past 30 years**, during which **climate change trends have been especially pronounced**.

The main characteristic of the thermal-pluviometric regime is **warming** combined with **stagnation in humidity**. The average annual temperature over the entire instrumental period is 9.8°C, with a linear warming trend of 1.7°C. The average secular value of annual precipitation is 918.8 mm, with a slight increase of 14 mm.

Using **spatial modeling based on thermal and pluviometric changes**, areas in Bosnia and Herzegovina **most vulnerable to climate impacts**, such as landslides, floods, and wildfires have been identified.

A particular focus of the conducted research was directed toward the assessment of flood risk and its comparison with the distribution of stećci (medieval tombstones), with the aim of identifying the most vulnerable sites across the territory of Bosnia and Herzegovina. For this analysis, among the climatic data, the most significant were those related to the pluviometric regime.

AREA OF RESEARCH

- Bosnia and Herzegovina (51.129 km²) is located in the area Southeast Europe- the western part of Balkan Peninsula.
- Bosnia and Herzegovina borders three countries: Croatia to the north and northwest, Serbia to the east and Montenegro to the southeast.
- Sarajevo is the capital city of Bosnia and Herzegovina.
- Bosnia and Herzegovina is country of high mountains and peaks (The highest mountain is Maglić, at 2,386 meters), as well as lowland areas. The Country has access to the Adriatic Sea at the town of Neum.
- Almost 50% of the territory of this country is covered by forests, and in some parts there are some of the oldest rainforests in Europe (Perućica Lom, Janj and other);
- The area of Bosnia (north part) is often described as the colder part, the climate is mostly moderately continental. The summers are warm and the winters are quite cold with a lot of snow. The area of Herzegovina is described as the sunny part of our country. The Mediterranean climate prevails in the south of the Herzegovina. The summers are extremely hot and the winters are milder, with a lot of rain and less snow.
- The rivers belong to the Black Sea (Sava, Drina, Una, Bosna...) and Adriatic Sea basins (Neretva, Trebišnjica ...)
- Bosnia and Herzegovina is also a country of lakes, some of which are natural (Boračko, Prokoško, Orlovačko and other) and some artificial (lakes on the Neretva river, lakes on the Drina river...)- Bosnia and Herzegovina is inhabited by numerous plant and animal species, among which some extremely rare (endemics).
- According to the 2013 population census, there are about three milion (3.531.159) inhabitants living in Bosnia and Herzegovina.
- As a result of long-term settlement, Bosnia and Herzegovina possesses significant cultural and historical heritage, among which stećci - medieval tombstones, hold great value. Out of 70,000 recorded stećci (though recent field research suggests there may be around 100,000), approximately 60,000 are located in Bosnia and Herzegovina, across 3,300 sites.

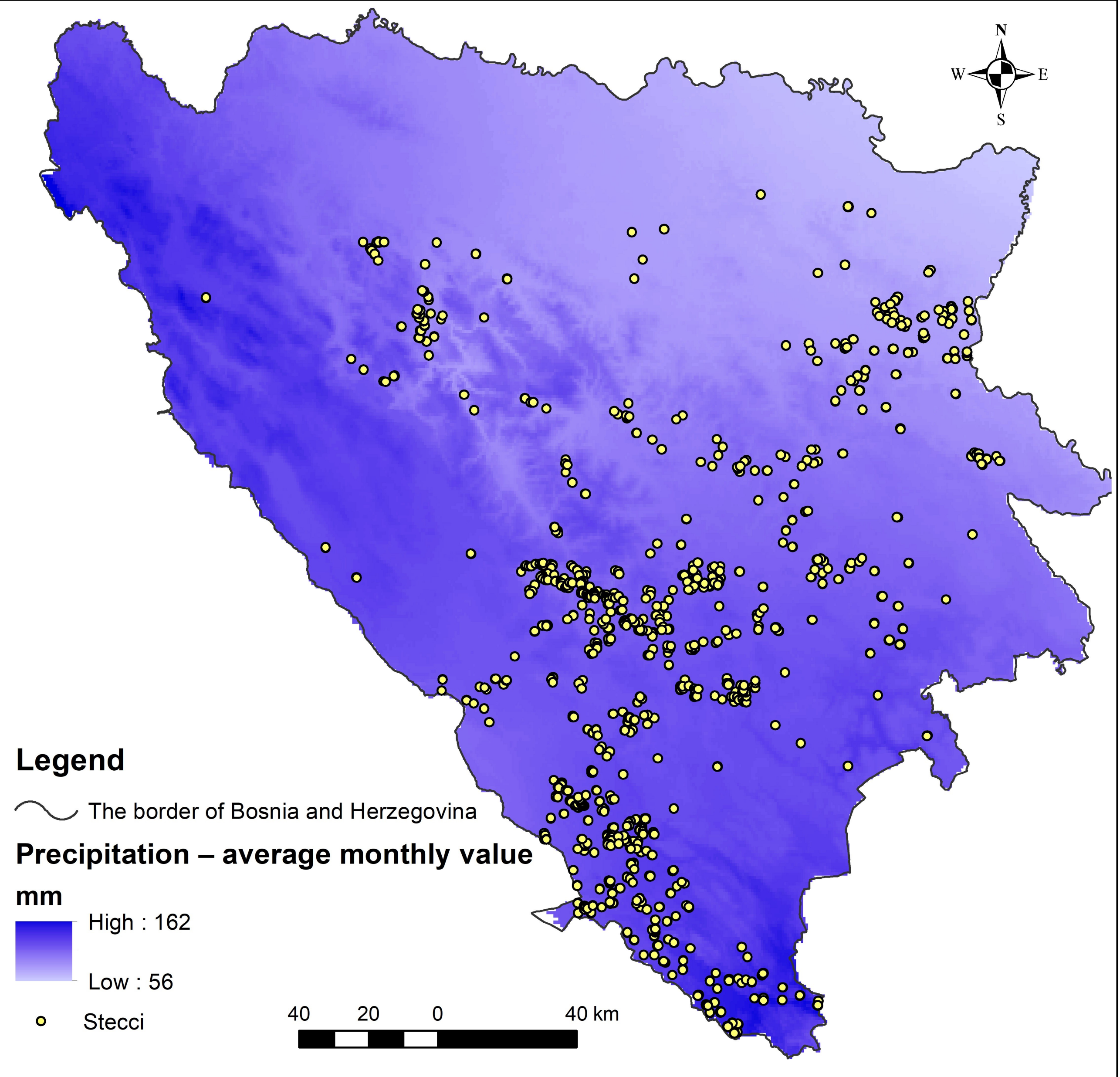


Figure 1: The average monthly precipitation for the recent thirty-year climatic period and the spatial distribution of stećci in Bosnia and Herzegovina

MATERIALS AND METHODS

The flood risk model and its impact on the cultural and historical heritage (stećci) was implemented through several phases:

Phase 1: Collection of all necessary spatial data (climatic, geomorphological, hydrological, land cover, and the spatial distribution of stećci), followed by geoprocessing, digitization, and validation of the data.

Phase 2: Multi-criteria analysis of the factors influencing flood occurrence.

Flood Risk Map (FRM)= Elevation + Slope + Land Cover + Precipitation + Proximity to Streams/Channels.

Figure 2: Methodology of flood risk assessment

For each defined factor, weighted interpolation values were determined according to their influence on flooding in specific areas.

Phase 3: Analysis, synthesis, and systematization of spatial flood risk data and the spatial distribution of stećci.

CONCLUSION

Based on the conducted multi-criteria analyses, it can be concluded that a significant portion of the territory of Bosnia and Herzegovina is exposed to flood risk. Areas classified as being at very high (14.04%) and high flood risk (14.47%) together cover nearly one-third of the country's territory. Zones with medium flood risk account for 24.27% of the territory, while areas classified as having very low and low flood risk make up 28.49% (with low risk zones specifically accounting for 18.74%).

The main reason for this spatial distribution lies primarily in the geomorphological and climatic characteristics of the region, particularly the pluviometric regime.

The highest flood risks occur in the lowland hypsometric zones and in the valley and basin expansions of major river systems. Areas located below 500 meters above sea level represent more than one-third (39.68%) of the total territory, while nearly flat terrains (with a slope of 0–2°) account for 14.83%.

Parameters of the pluviometric regime, depending on other physical-geographical factors, are crucial for defining flood risk zones. The long-term average maximum monthly precipitation is 162 mm, while the minimum is 56 mm. There are significant variations in precipitation amounts across climatic seasons. The average maximum monthly precipitation for the winter season is 137 mm; for spring, 126 mm; for summer, 110 mm; and for autumn, 162 mm. The average minimum monthly values are as follows: winter 46 mm, spring 53 mm, summer 43 mm, and autumn 56 mm.

The months with the highest precipitation are November (184 mm), December (163 mm), and October (161 mm), while the lowest values are recorded during the summer months, particularly in July (33 mm).

Almost half of the stećci are located in areas not threatened by floods. More precisely, in the very low-risk flood zone—the zone least exposed to flooding—12.0% of the total number of digitized stećci (19,992) are located. In the low-risk zone, 32.8% of stećci are situated. A total of 25.6% are located in the medium-risk zone, while nearly one-third of all stećci are found in areas exposed to very high flood risk. Specifically, 16.1% are located in the high-risk zone, and 13.5% in the very high-risk flood zone.

Future research should focus on the more detailed identification and digitization of all stećci across Bosnia and Herzegovina, in order to obtain more comprehensive and relevant results regarding their exposure to flood risk. Additionally, further studies will address other climate-induced hazards, such as landslides, wildfires, and related threats.

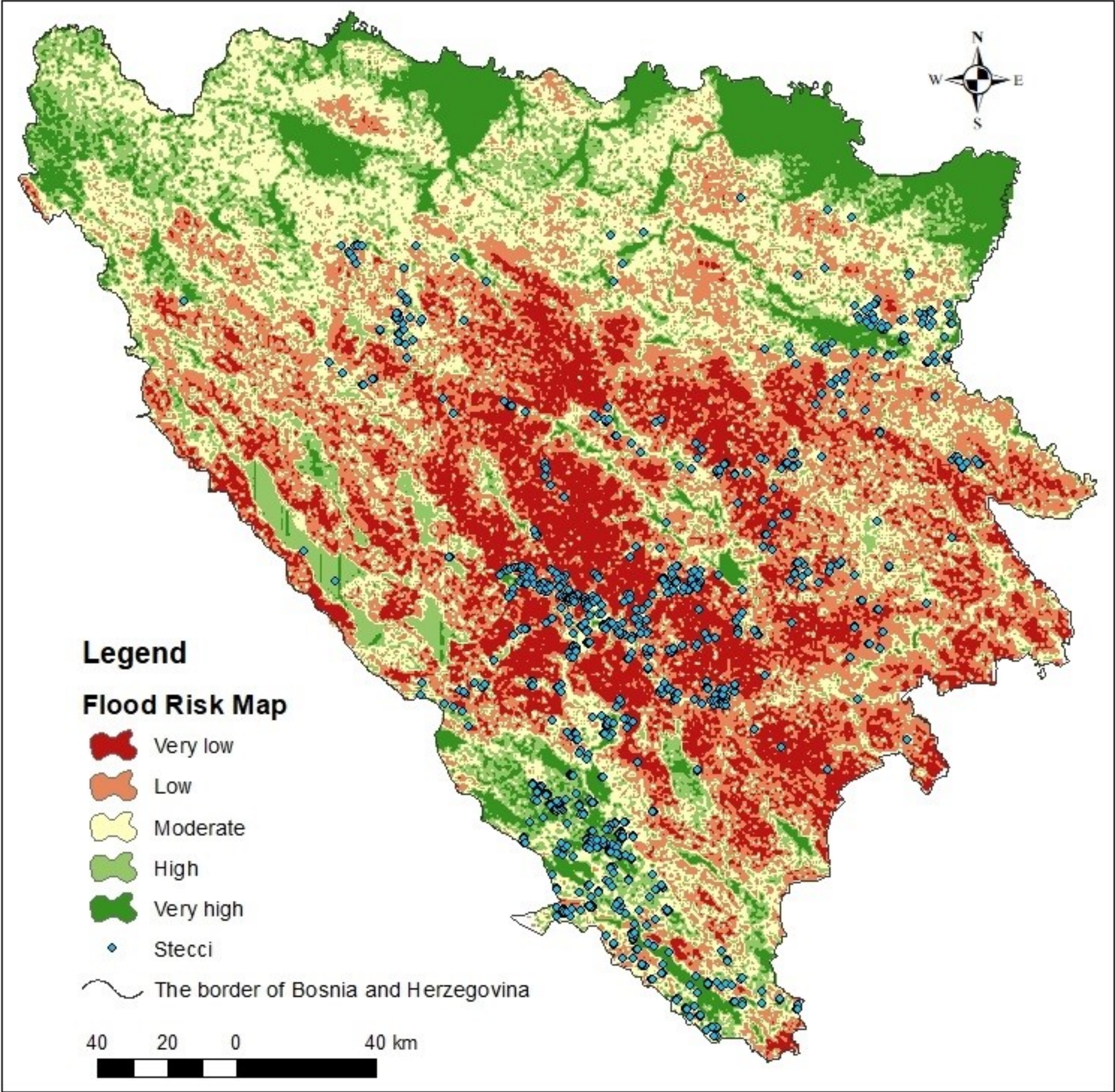


Figure 3: Flood Risk Map and the spatial distribution of stećci in Bosnia and Herzegovina