

Multihazard Study at Tourism Locations in The Citatah Karst Area

Haikal Muhammad Ihsan, Alwan Husni Ramdhani

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Abstract Multihazards at important tourism locations are identified for sustainable tourism. The Karst area has tourism assets that have the potential for multi-hazard disasters. This study aims to identify multihazards at tourism sites in the Citatah Karst Area, West Bandung Regency. Tourism locations are identified using a survey method. Multihazards are analyzed using a Geographic Information System (GIS) with map product output. Based on the analysis, there are four types of disasters at 13 tourist sites in the Citatah Karst Area. The relative landslide hazard lies in the southwest Karst Citatah area, which has 13 potentially dangerous tourism sites. The earthquake hazard lies in the southeast and northwest areas with 13 potentially dangerous tourism locations. The danger of flooding lies in the Citarum river basin southwest of the Citatah Karst, with three potentially dangerous tourist sites. The potential for extreme weather hazards does not dominate the Citatah Karst Area, so it is relatively safe. However, several locations are included in the high category, namely in the southeast and northwest of the Citatah Karst Area. Each Multihazard at a tourism location is divided into four classifications: not affected, low, medium, and high. This research can be helpful in the development of disaster-based sustainable tourism potential.

Keywords: Multihazard; Tourism; Karst Area

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1. Introduction

Tourism locations with disaster hazard potential are important topics that can be discussed in the context of tourism sustainability. Tourism associated with disaster hazards often poses a risk to the safety and well-being of tourists (Williams and Baláž, 2013). Geographical conditions that are prone to natural disasters can cause emergency situations that have the potential to threaten material and non-material losses (López-Saavedra and

Martí, 2023). The impact of natural disasters on tourism often causes damage to tourism infrastructure, besides that disasters at tourism locations can also disrupt tourism operations and reduce the number of tourist visits (Cioccio and Michael, 2007).

Post-disaster recovery requires significant time and resources (Arvin et al., 2023), which can hinder the growth and development of tourism in affected areas. If a destination is deemed unsafe or too risky, tourists may choose another destination that is more stable and safer. This can result in a decrease in economic income for local people who depend on the tourism sector for

Haikal Muhammad Ihsan, Alwan Husni Ramdhani
Universitas Pendidikan Indonesia, Indonesia

haikalmihsan@upi.edu

their livelihood (Märgärint et al., 2023). This phenomenon has a serious impact on the tourism industry and the safety of tourists and managers. Characteristics of disaster hazard in Karst Areas need to be an important concern (Pueyo-Anchuela et al., 2009).

Karst hills have various management potentials and functions. The Citatah karst area is located in the western part of the Bandung basin with unique landforms. This area is located in Cipatat District which is on limestone with the Rajamandala formation (Shiska et al, 2017). There are activities that are always the subject of conversation in this area, namely tourism in the Citatah Karst Region (Wang and Xiao, 2020). Tourism activities in the area include rock climbing, caving, cultural history tours and nature special interest tours.

The karst zone has the potential to be utilized for socio-economic activities, science and even plays a role as a hydrological function in the process of water management for the sustainability of life (Irianto et al, 2020). The classification of karst areas is regulated in the Decree of the Minister of Energy and Mineral Resources Number 1456 K/20/MEM/2000 dated 3 November 2020 concerning guidelines for the management of karst areas which are divided into three classes. There are various kinds of karst classification theories such as classification Cvijic (1914), klasifikasi Gvozdeckij (1965), Sweeting (1972), other karst types and karst types in Indonesia (Utama et al, 2016). The karst area is usually limited by the separation between carbonate and non-carbonate rocks, where the

karstification process is usually less than optimal (Oktariadi et al, 2011).

Tourism activities in karst areas tend to have several potential disaster hazards. In managing tourism in the Citatah karst area, it is important to identify and understand these potential hazards (Pueyo Anchuela et al., 2015). Risk management measures should be taken to protect tourists, minimize negative impacts and promote tourism sustainability. This includes regular monitoring of geology and environmental conditions (Forth et al., 1999), build safe infrastructure, provide information and warnings to visitors about potential hazards, and build the capacity of local communities to respond to disasters or emergency situations that may occur (Wood et al., 2022).

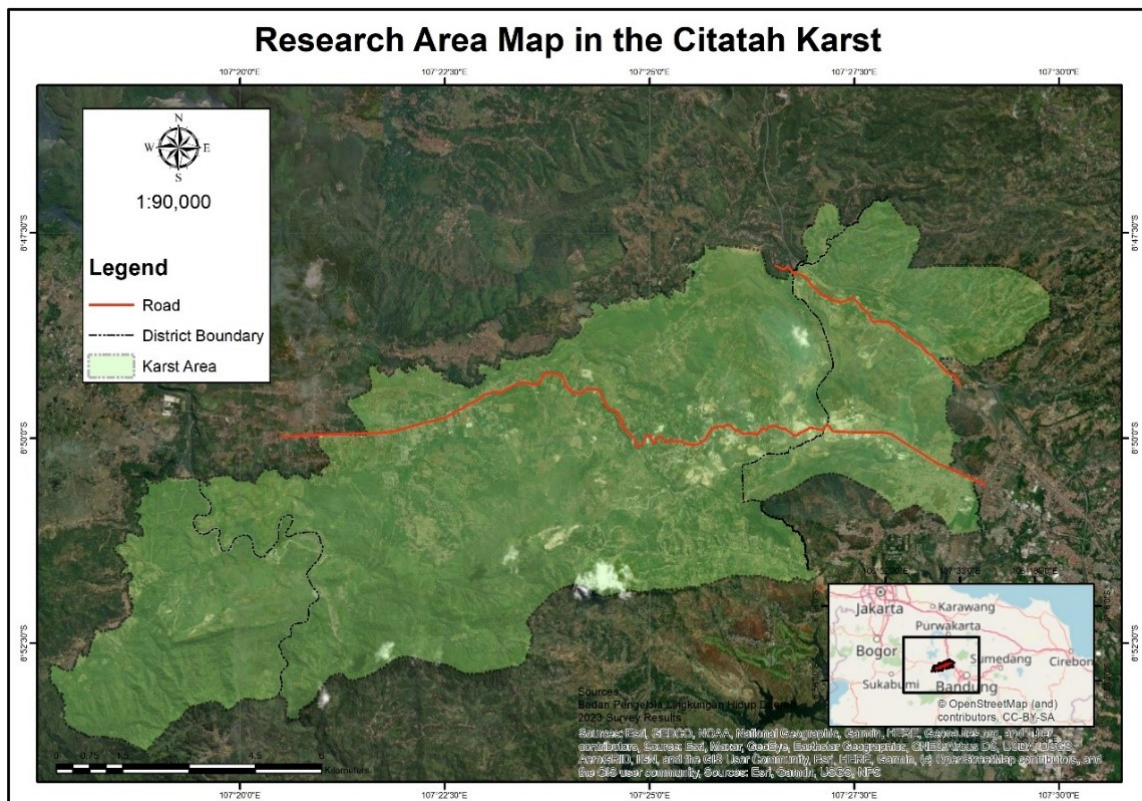
One interesting form of information in disaster visualization is a multi-hazard map (Lyu and Yin, 2023). This map can be one of the mitigation efforts in minimizing disaster risk. Identification of multi-hazard potential in the Karst area is very important to study (Mandal et al., 2022). Multi-hazard maps in Karst Areas provide support for risk minimization (Perrin et al., 2015). The Multi-Disaster Map can be represented from the INARISK National Disaster Management Agency (BNPB) combined with tourism locations in the Citatah Karst Area. A multi-hazard map on tourism sites in the Citatah Karst Region will be very useful for tourists and managers. Hazard risk can be minimized with multi-hazard information (Abarna et al., 2023).

The aim of this study is to identify multi-hazards at tourism sites in the Citatah karst area. The multi-hazard in question is several potential disaster hazards in the Citatah Karst Area. Identification results are presented in the form of a map, so that the visualization is more informative. multi-hazard maps in tourist areas can be useful in understanding and managing tourism Areas. The map can be a resource in good coordination between the government, local communities and the tourism sector is also important to build resilience and deal with

challenges that arise due to disaster hazards in the context of tourism.

2. Methods

This research was conducted in the Citatah Karst Area (Figure 1), West Bandung Regency. This location has many tourist areas with different geographical conditions. There are various types of tourist sites in the Citatah area, such as cliff areas, rivers, caves, hills and others. The unique local landform makes a difference in the potential for disasters so that a multi-hazard study needs to be carried out at the Citatah Karst tourism location.



Tourism Mapping

Tourism mapping is done by survey method. Tourism locations are plotted using a handheld Global Positioning System (GPS). The mapped tourism locations are locations that have developed, are developing and will be developed. The Citatah karst area is rich in natural resources that can be used as tourism, so mapping tourism locations can be an alternative material for developing Citatah karst tourism.

Disaster Mapping

Disaster mapping is carried out using Geographic Information System (GIS) software with secondary data which is freely available and can be accessed through the website <https://inarisk.bnppb.go.id/> on the GIS Service menu. GIS is capable of predicting multi-hazards with adjustable algorithmic capabilities (Youssef et al., 2023). Inarisk data can be accessed in raster format with a hazard value of 0 (low) - 1 (high), so it will be classified with values of 0 - 0.33 (low), 0.34 - 0.67 (medium), and 0.68 - 1 (high). In an area that is not affected, it will be given a value of 0 with an unaffected classification. This value is processed in GIS using the reclassify tool and, in the layout, based on the suitability of the data on the BNPB Inarisk. The disaster hazard map that will be made is a disaster that actually exists in the Citatah Karst Area based on the BNPB analysis.

Analisis Multi-Hazard

A multi-hazard study was carried out using intersect tools in GIS software at each tourism location and

potential for disasters in the Citatah Karst Area. GIS has good capabilities in multi-hazard analysis (Huang et al., 2016). Each tourism location is in a different karst morphology, so there will be different types of disasters. At the point of tourism location a multi-hazard classification extraction value will appear, so that potential disasters at different tourism locations will be identified according to the coordinates of the study. The output of this study is a combination of pariwisata maps and multi-hazard maps in the Citatah karst area.

3. Results and Discussion

Tourism Mapping

Based on the survey results, the Citatah Karst Area has 13 tourism potentials, namely Citatah Cliff, Stone Garden, Sanhyang Poek, Sanhyang Kenit, Indiana Camp, Sanhyang Heuleut, Mount Hawu, Pawon Cave, Ciburuy Lake, Bedil waterfall, Java waterfall, BD Saguling and Saguling Hot Spring. The tourism locations are scattered in the western and eastern regions of Karst Citatah. In the eastern area there are existing tourism, namely lakes, cliffs and hills which are used by the community as rock climbing sports and natural rock tourism typical of karst areas, besides that there are caves that have a high history, because human fossils were found in the area.

Table 1. Citatah Karst Tourism Locations

No	Elevation (masl)	Lat	Long	Name
1	361.59	-6.86867200769	107.35541598900	Air Panas Saguling
2	281.73	-6.86552896164	107.34956299000	BD Saguling
3	356.55	-6.86923200265	107.35591697500	Curug Jawa
4	528.61	-6.87351398170	107.35671702800	Curug Bedil
5	726.29	-6.83489603922	107.46950802400	Danau Ciburuy
6	551.69	-6.82353596203	107.43648399600	Gua Pawon
7	773.23	-6.83393203653	107.46313400600	Gunung Hawu
8	357.02	-6.87638897449	107.34163102700	Sanhyang Heuleut
9	682.44	-6.82582799345	107.43627201800	Indiana Camp
10	254.14	-6.85992800631	107.34784998000	Sanhyang Kenit
11	284.89	-6.86827403493	107.34725302100	Sanhyang Poek
12	709.14	-6.82458998635	107.43783398500	Stone Garden
13	637.32	-6.83525201865	107.42818901300	Tebing Citatah

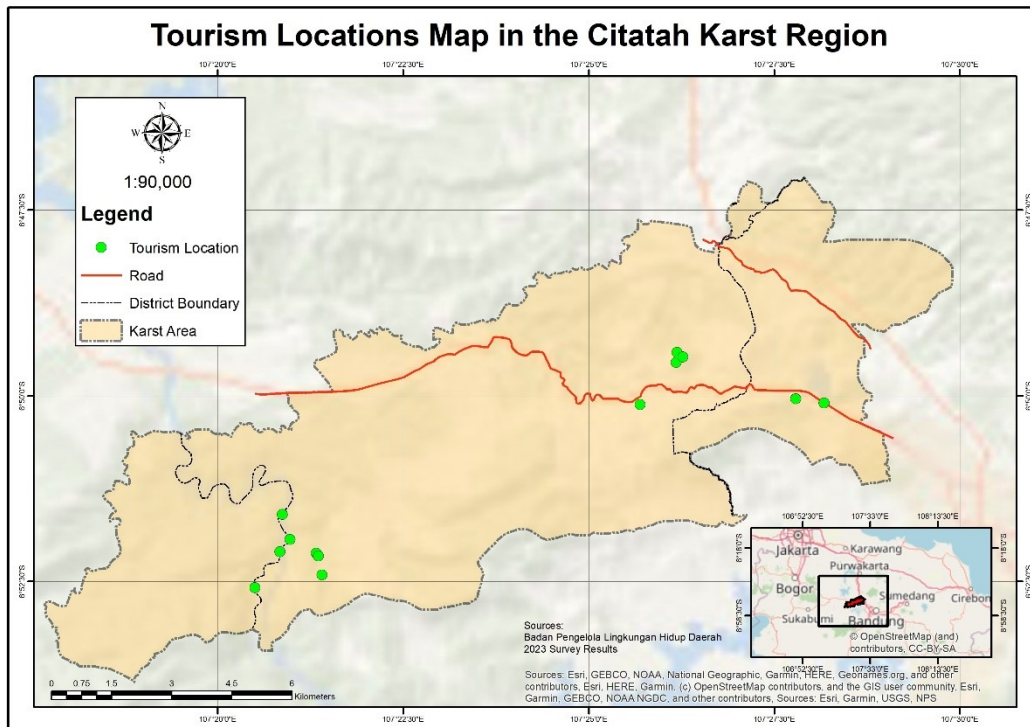


Figure 2. Distribution of Tourism Locations

In the western area of the Karst Citatah area is tourism located in valleys and rivers or alluvial areas. At that location there are tourist sites of caves and rivers which are usually visited by people to do tourism. In the western area there is also a river that flows between BD Saguling and Cirata, so

tourist destinations in the Karst Region waters such as underground rivers are scattered in western locations. This condition can be seen from Figure 2 and Table 1.

Multi-Hazard

Based on BNPB data, the Citatah karst area has 4 potential disasters with different distributions, namely floods, extreme weather, landslides and earthquakes. Flood disasters generally have the potential for alluvial areas around the Citarum river which flows between the two area BD Saguling. Landslides are relatively potential in areas of karst hills that have steep slopes. Rock and material landslides

can be one of the potential landslides in the Citatah karst area. The Citatah Karst Area has the potential for extreme weather hazards, but not too significant. The Citatah Karst area is adjacent to one of the active faults, namely the Lembang fault, so that in some areas it has a high earthquake hazard. Multi-Hazard conditions can be seen in table 2 and are explained for each disaster hazard at the Citatah Karst tourism location.

Tabel 2. Multi-Hazard on Citatah Karst Area

No	Elevation (masl)	Lat	Long	Name	Flood	Extreame Weather	Landslide	Earthquake
1	361.59	- 6.8686720 0769	107.35541 598900	Air Panas Saguling	None	None	High	Low
2	281.73	- 6.8655289 6164	107.34956 299000	BD Saguling	High	None	High	Medium
3	356.55	- 6.8692320 0265	107.35591 697500	Curug Jawa	None	None	High	Low
4	528.61	- 6.8735139 8170	107.35671 702800	Curug Bedil	None	None	High	Low
5	726.29	- 6.8348960 3922	107.46950 802400	Danau Ciburuy	None	High	None	High
6	551.69	- 6.8235359 6203	107.43648 399600	Gua Pawon	None	Low	High	medium
7	773.23	- 6.8339320 3653	107.46313 400600	Gunung Hawu	None	None	Low	High
8	357.02	- 6.8763889 7449	107.34163 102700	Sanhyang Heuleut	Low	None	High	Low
9	682.44	- 6.8258279 9345	107.43627 201800	Indiana Camp	None	Low	None	Medium
10	254.14	- 6.8599280 0631	107.34784 998000	Sanhyang Kenit	Low	None	Medium	Medium
11	284.89	- 6.8682740 3493	107.34725 302100	Sanhyang Poek	None	None	Medium	Low
12	709.14	- 6.8245899 8635	107.43783 398500	Stone Garden	None	Low	None	Medium
13	637.32	- 6.8352520 1865	107.42818 901300	Tebing Citatah	None	None	Medium	Medium

Landslide Hazard

The landslide hazard in the citatah area is included in the highest disaster hazard among other disasters. Based on the analysis, the highest landslide area is located in the southwest of the Citatah karst area. Tourism locations with high landslide hazard are Saguling Hot Spring, Saguling BD, Java Waterfall, Bedil Waterfall, Pawon Cave, and Sanhyang Heuleut. Areas with moderate landslide hazard are Sanhyang Kenit, Sanhyang Poek and

Citatah cliffs, while low hazard is Mount Hawu. At Citatah Karst there are tourist sites that are not prone to landslide hazards, namely Lake Ciburuy, Indiana Camp and Stone Garden. This condition is caused not only by the slope, but also by the condition of the rock which is weathered and still sturdy, so that there are different classifications of landslides in the Citatah Karst Area. Tourism Locations with landslide hazard can be seen in Figure 3.

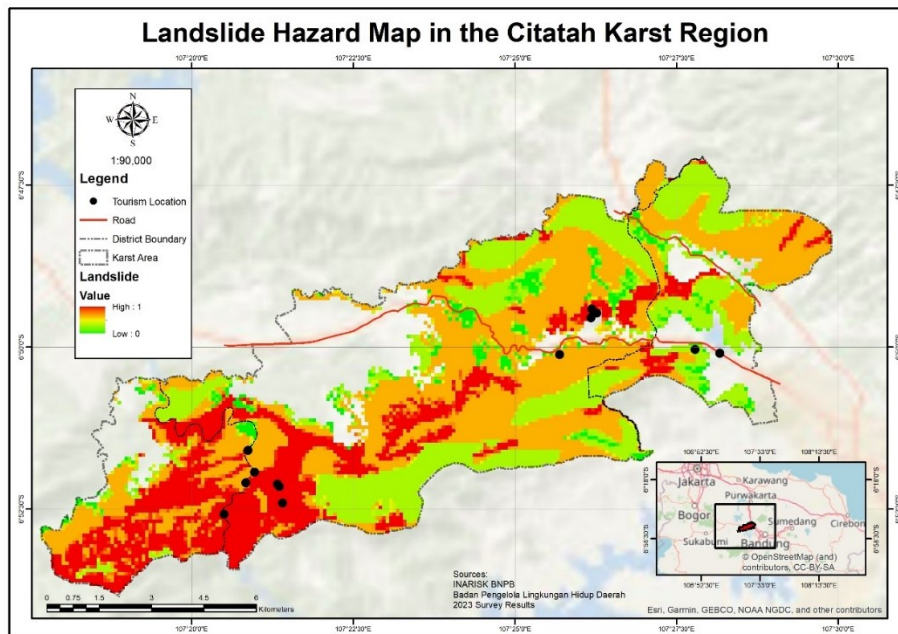


Figure 3. Map of the Distribution of Landslide Hazards in the Citatah Karst Area

Flood Hazard

The results of the analysis show that the Citatah Karst area has the potential for flooding in BD Saguling with high classification and Sanhyang Heuleut and Sanhyang Kenit with low classification. The three tourist objects are located in the Citarum Purba watershed. The area is an Alluvial area with volcanic and sedimentary source rocks. In this area the Karst Region is not quite dominant, but it is still within

the scope of the karst hydrogeological function. At other locations no flood hazard potential was found, because several locations were hilly and even cliffs, so only a small amount of flood hazard potential was identified in the Citatah Karst Area. Flood hazard conditions at tourism sites can be seen in Figure 4 of the flood hazard distribution map for the Citatah Karst Area.

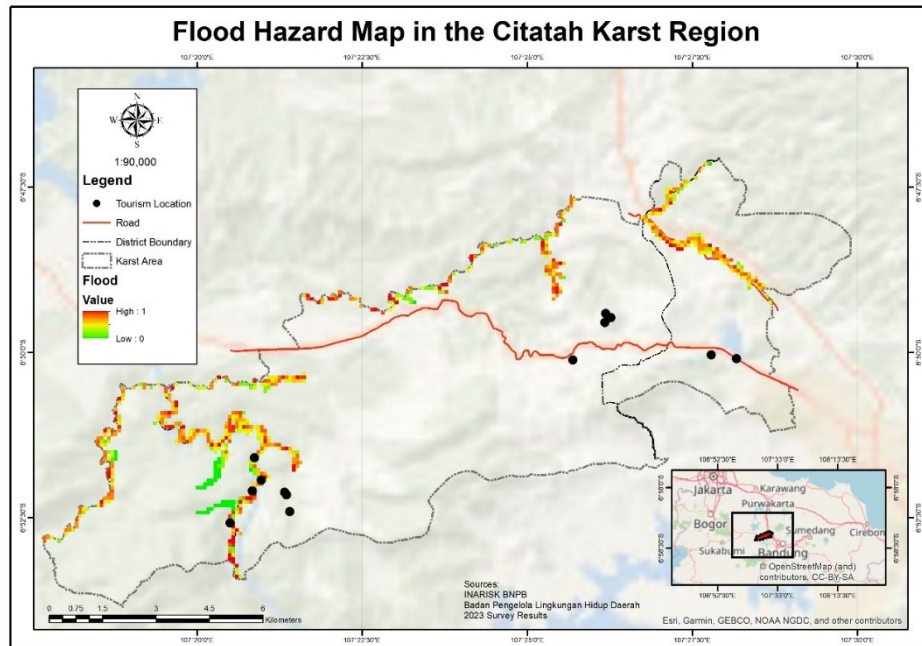


Figure 4. Map of Flood Hazard Distribution in Citatah Karst Area

Extreme Weather Hazard

Conditions of extreme weather hazards in the Citatah karst area are not dominated by disasters. Extreme weather in the Citatah Karst Area was identified in several tourist sites, namely Lake Ciburuy with a high classification. In addition, it was also identified in Pawon Cave, Indiana Camp and Stonde Garden with low classification. The value of the extreme weather hazard level in the Citatah Cindering Karst Area does not reach the highest peak, so it is relatively safe. Based on the results of an analysis of the distribution of extreme weather in the southeast and northwest areas of the Citatah karst area. Lake Ciburuy is located in the southeastern area of the Karst Citatah, so it is included in the high classification. Other tourism locations are relatively safe from extreme weather hazards. Extreme weather hazard conditions can be seen in Figure 5.

Earthquake Hazard

The southeastern and northwestern parts of the Citatah karst area are included in the high earthquake-prone category. In the southeastern area, several tourist sites are close to active faults, namely the Lembang fault, so there is a high potential for earthquakes. In general, the Citatah Karst Area has the potential for earthquakes, but with a different classification. The high classification is in the location of Lake Ciburuy and Mount Hawu. The current location is at Saguling BD, Pawon Cave, Indiana Camp, Sanhyang Kenit, Stone Garden and Citatah Cliff. The low classification lies in Saguling Hot Spring, Java waterfall, Bedil waterfall, Sanhyang Heuleut and Sanhyang poek. Earthquake hazard distribution can be seen in Figure 6.

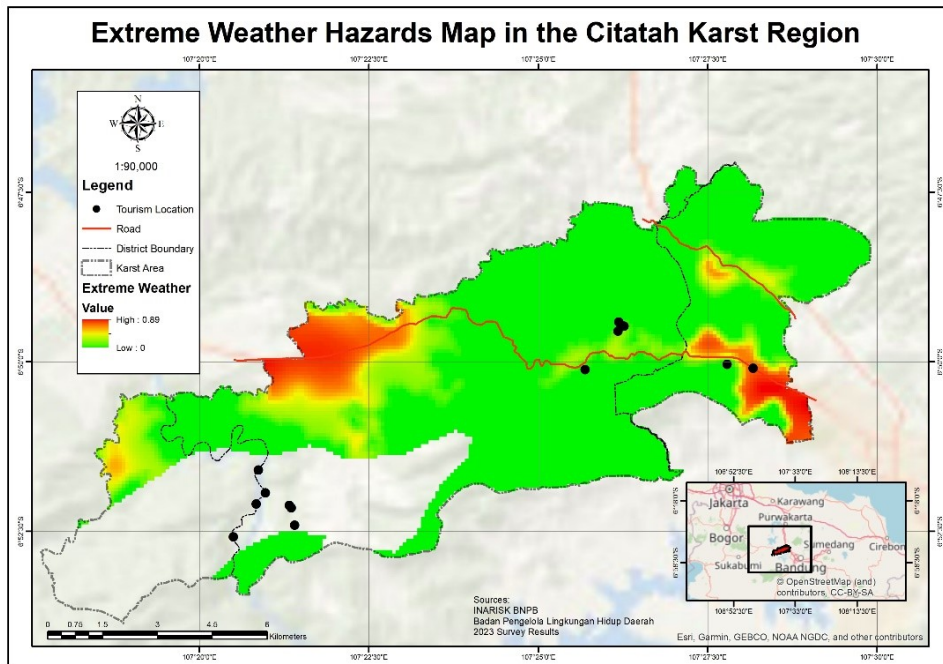


Figure 5. Distribution Map of Extreme Weather Hazards in the Citatah Karst Area

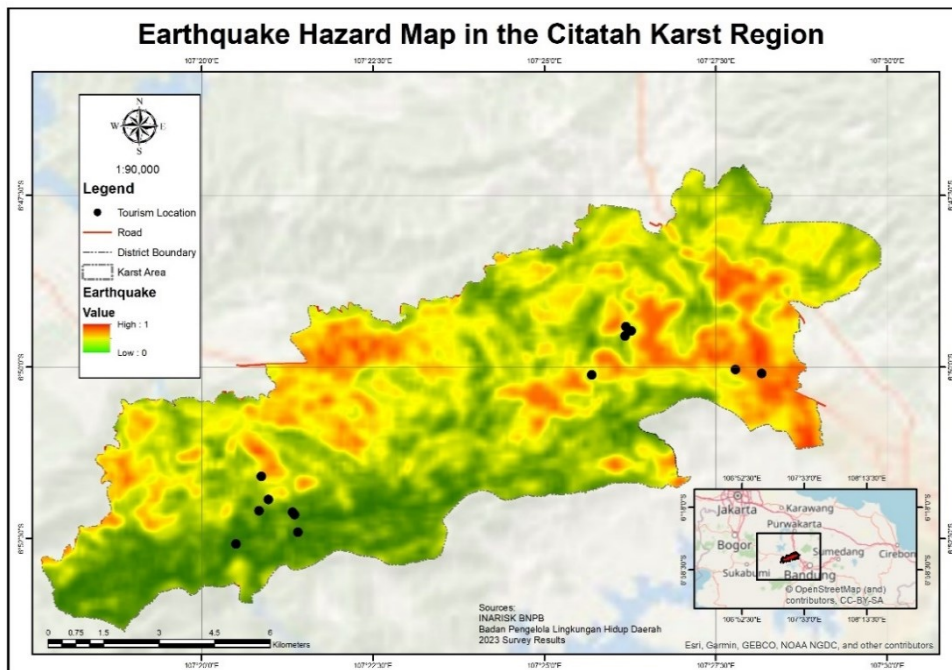


Figure 6. Earthquake Hazard Distribution Map of Citatah Karst Area

4. Conclusions

Tourism locations in the Citatah Karst Area are scattered in the southeast and southwest areas. The 13 tourism locations are grouped namely Citatah Cliff, Stone Garden, Sanhyang Poek, Sanhyang Kenit, Indiana Camp, Sanhyang Heuleut, Mount Hawu, Pawon Cave, Lake Ciburuy, Curug Bedil, Curug Jawa, BD Saguling and Saguling Hot Spring. The multi-hazards in the Citatah Karst Region consist of landslides, earthquakes, floods and extreme weather. The landslide hazard is relatively located in the southwest area of the Citatah Karst, due to the source rock and the slanting that support the landslide. Earthquake hazard lies in the southeast and northwest areas. In the southeastern area it is close to an active fault, namely the Lembang fault, so the potential for an earthquake is very high. The flood hazard lies in the Citarum river basin southwest of the Citatah Karst. This location is an alluvial area with volcanic and sedimentary source rocks. The potential for extreme weather hazards does not dominate the Citatah Karst Area, so it tends to be relatively safe, but several locations are included in the high category, namely in the southeast and northwest of the Citatah Karst Area.

The novelty of this research is that there is a spatial product that can provide information for multihazard adaptation in karst tourism areas. Information on multihazard disasters is very important to minimize the occurrence of casualties in disaster mitigation efforts in karst tourism areas. Managers, agencies, stakeholders and tourists can create evacuation schemes

if a disaster occurs at a tourism location. The continuation of this research can be directed towards an Early Warning System (EWS) which can be provided at tourism locations with a multihazard scheme.

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