Potential Vulnerability to Hydrological Disasters in the Gunungsewu Gunungkidul Karst Area

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Abstract. The study aims to analyze the potential for hydrological disasters in the Gunungsewu Gunungkidul karst area. The study method used is survey and direct observation of the karst area. Participants are residents with local backgrounds, visitors, farmers, fishermen and traders. The results of the study showed that there were differences in the potential for hydrological disasters in several areas in Yogyakarta, namely, the allogenic river Kalisuci, the mouth of the underground river and Baron Karst Beach, the funnel-type dolin in the form of the Luweng Pego karst cockpit, and the karst lake bowl-type dolin in Seperangan. The potential for hydrological disasters can be prevented and minimized through cooperation between the government and local communities.

Keywords: Vulnerability, Disaster, Karst.

1 Introduction

Karst areas are places where limestone or carbonate rocks dissolve. This dissolution process creates distinct and unique geological forms such as caves, dolin, and complex groundwater flow patterns. The water source in karst areas is very deep below the earth's surface and is between two impermeable layers, which makes the problem that is often encountered in karst areas is water limitation [1]. Karst hydrology is usually characterized by a network of secondary porosity and a subsurface drainage system that flows through underground rivers (SBT) [2]. The channels that develop in karst aquifers are usually complicated. The process of morphological formation under the surface of the karst, which consists of dissolution and karstification dominates the hydrological characteristics of karst areas and makes them different from other areas. The results of dissolution, which are usually found in limestone and dolomite, are characteristic of morphological land formations known as karst [3], [4].

Karst hydrological disasters have been widely discussed and researched by hydrologists. The existence of underground water flow and the absence of surface flow are also characteristic of karst. Water catchment areas and shallow groundwater resources are closely related. Rainwater that falls on the water catchment area will seep under the

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soil surface through the infiltration process and then form a groundwater reserve through the percolation process. Water catchment areas to ensure that clean water is continuously available to the area underneath. The hydrology of karst surfaces becomes less developed because the growth of karst causes more processes to form subsurface water flows. Water resources are found mostly below the earth's surface. This condition makes this region very vulnerable to hydrological disasters.

Hydrological disasters that occur in karst areas can result in significant losses to society and the environment. Therefore, monitoring and mitigating hydrological disasters in karst areas is very important to reduce losses to the community and the environment. The article aims to analyze the potential for disasters in the region Gunungsewu Gunungkidul karst, identified the main factors that affect the vulnerability of hydrological disasters in each of these regions.

2 Methods

This research was carried out in four karst areas in Yogyakarta, namely, Kalisuci. Baron Beach, Luweng Pego, and Seperangan Lake The type of research carried out is by using qualitative methods. The research design must match the chosen approach. The procedures, techniques, and tools used in the research must also be compatible with the established research methods [5]. Researchers use instruments, data collection, and qualitative analysis to emphasize meaning.

Data collection was divided into two, namely primary and secondary, for primary data collection using interviews conducted in Luweng Pego. Observation is carried out to complement the form of observation as a tool to obtain more information. The observation in this study was carried out as a fieldwork in Integrated Landscape Geography [6]. Interviews were conducted to obtain data and get more information from informants who are directly related to disaster vulnerability that can occur in the Kalisuci karst area, Baron Beach, Luweng Pego, and Seperangan Lake. A key informant or research informant is a person who is used to provide information about the situation and conditions of the research background and is a person who really knows the problem to be researched [7]. Meanwhile, secondary data collection uses literature studies (information from journals) where literature studies are used as supporting data by looking for previous research as secondary data [8]. Data analysis is the process of systematically searching for and structurally data obtained from the results of interviews, field notes, and documentation by organizing data into categories, describing them into units, synthesizing, organizing them into patterns, choosing which ones are important and what will be studied, and making conclusions so that they are easy to understand by yourself and others [9].

The data analysis used in this study is by using qualitative descriptive analysis, namely the researcher describes physical conditions based on the results of quantitative research on disaster vulnerability that can occur in the Kalisuci karst area, Baron Beach, Luweng Pego, and Seperangan Lake.

3 Results and Discussion

3.1 Result

Hydrological disasters are natural disaster phenomena that occur in waters such as rivers, lakes, and oceans. Hydrological damage includes floods, landslides, and droughts caused by changes in weather, rainfall, humidity, temperature, and wind. These hydrological disasters are usually associated with extreme water abundance or scarcity and can have a significant impact on the environment, human life, and infrastructure. In this study, the author discusses hydrological disasters in the locations of Kalisuci, Baron Beach, Luweng Pego, and Seperangan Lake.

3.1.1 Hydrology Disaster in Kalisuci

Hydrological disasters in Kalisuci, Yogyakarta include Karst Floods and Landslides. This disaster occurred due to the geomorphological and hydrological characteristics of the karst area which allowed the percolation of surface water and underground flows. These floods are triggered by high rainfall that increases the volume of water in the underground flow system, causing overflows through ponors or cave mouths. The complex aquifer system in this karst area is vulnerable to hydrological changes that trigger sudden and rapid flooding. The study on flooding in the Kalisuci karst area identified the importance of flood vulnerability mapping and groundwater management for disaster mitigation.

The next disaster was a landslide. Landslides in the Kalisuci karst area are geological phenomena that are influenced by various natural and human factors. According to some experts, the characteristics of karst soils consisting of limestone rocks that are easily dissolved by water are the main factors that cause vulnerability to landslides. This dissolving process produces underground cavities and reduces the stability of the soil surface. Geomorphologically, karst areas have a unique soil structure with caves and underground rivers that can accelerate the dissolution process and cause landslides to occur more frequently. The method of assessing landslide vulnerability in karst areas involves the use of remote sensing technology, field surveys, and geographic modeling techniques [10], [11].

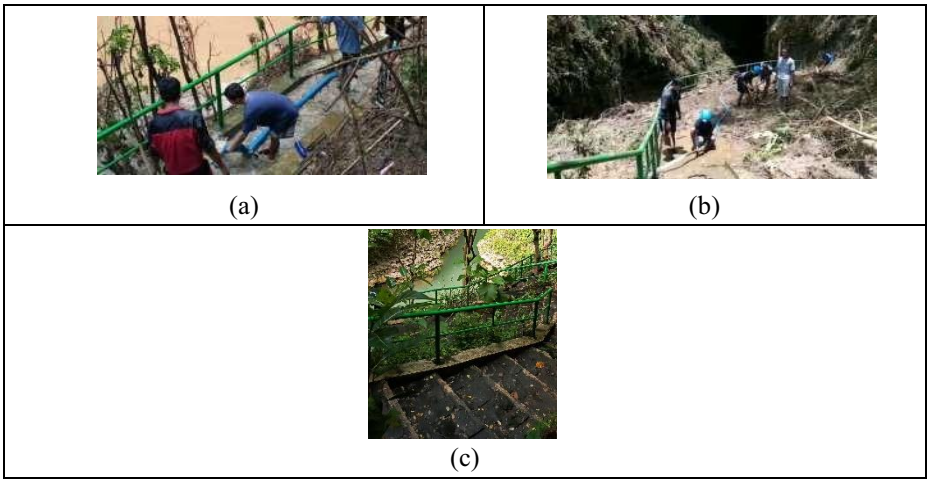

Fig. 1. Comparison of the situation of the Kalisuci when (a) Flood occurs [12]. (b) Landslides [11]. (c) normal situation.

3.1.2 Hydrological Disaster at Baron Beach

Hydrological disasters at Baron Beach include Floods, Coastal Abrasion, and Tsunamis. The flood disaster at Baron Beach occurred due to very high rainfall, resulting in rivers overflowing and inundating the area around the beach. These floods not only damaged infrastructure and property, but also had a significant impact on local economic activities, especially the tourism sector which is the mainstay of the local population [13].

The next disaster is Coastal Abrasion. Baron Beach has undergone significant abrasion, resulting in a dynamic change in the coastline between 2010 and 2018 [14]. The abrasion occurs because the beach is directly adjacent to the Indian Ocean and is located between two steep cliffs that form the morphology of pocket beach. Abrasion at Baron Beach causes significant damage to the coastal structure and impacts the local ecosystem as well as tourism activities in the area [15].

The next disaster was the Tsunami. Although no data has been obtained on having experienced a tsunami disaster, the sand deposits found at Baron Beach have a brownish color due to sand deposits from the river The coastal morphology is undulating to rough with medium to high relief. The slope of the beach is relatively sloping with a relatively narrow width and length of the beach. The coastline forms bays and pockets. The relatively flat coastal structure and the existence of river estuaries also increase the risk of a tsunami that can sweep away the surrounding area. In addition, the lack of disaster mitigation infrastructure and low awareness of local communities about tsunami disasters exacerbate this vulnerability [16]. Studies by Bappenas and various other studies show that comprehensive disaster mitigation planning is urgently needed to reduce the possible impact of tsunamis in these areas.

The land in the Baron Beach area is usually used as a tourist area and a place for fishermen's activities. In this area, settlements are very close to the coastline. Fishing

boats are placed on the beach surface without being moored tightly, so they are easily blown away if there are waves. Cover vegetation on the beach is very rare or even non-existent, so the risk of damage due to the impact of objects on the beach, in the event of a tsunami, will be greater experienced by buildings and residents' houses.

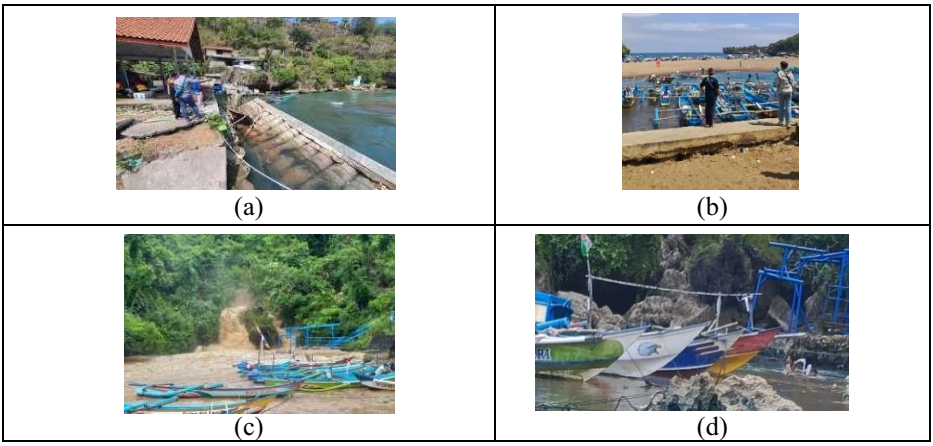

Fig. 2. Comparison of the situation of Baron Beach when (a) Talud collapsed in 2024 [15]. (b) Talud during normal situations. (c) River flow flooding in 2023 [13]. (d) river flow during normal situations.

3.1.3 Hydrological Disaster in Luweng Pego

Hydrological disasters in Luweng Pego include drought disasters. The drought in the Purwosari District area, precisely in Girimulyo village, has an impact on 2 hamlets, namely Macanmati Hamlet, and Kadjobo Hamlet. Gunung Kidul Regency is also included in the Gunung Sewu Karst area which is synonymous with a dry environment with many cracks in the soil. The triggers for drought are "Human activities such as mining and deforestation will further reduce water infiltration, while human activities such as agriculture and sanitation contribute to the decline in water quality" [17].

During the rainy season, most of the residents of Macanmati use the Hamlet Rainwater Harvesting Plant (PAH) which has been installed in residents' homes for generations. "Because of the rain that continued to fall last year, residents can meet their water needs through PAH. But on the other hand, we have to bear the consequences with a long dry season," explained Purwanto, a resident of Macanmati Hamlet [17]. In Giricahyo village, the same is true that the local community only relies on rainwater during the rainy season and experiences drought in the dry season [18], [19].

3.1.4 Hydrological Disaster in Seperangan Lake

Hydrological disasters in Seperangan Lake include flood disasters. The natural disaster on Monday (March 18, 2019) damaged several culverts in the Purwosari area, one of

which was in Njelok Parangrejo Girijati [20]. This damage causes air to overflow onto the asphalt road, causing inconvenience to road users. On the other part of the ring road in the Girijati guesthouse area, there are culverts that have collapsed, damaging the roadside drainage system. Eroded roads are becoming narrower, endangering the safety of road users. The road to Sandang also collapsed slightly due to strong air currents. Fortunately, there were no injuries in this incident. In Giritirto alone, around 45 houses and shops were flooded. There was an accident where a tree fell directly on a house. 17 market stalls in Giriasih Village and the Balai Giriasih complex, including the Korwil-bidik Purwosari office were also flooded. Three houses were also damaged by flooding [21].

(a) (b)

Fig. 3. (a) Karst Cave in Luweng Pego. (b) Seperangan Lake.

Table 1. Comparison of Hydrological Disaster Vulnerability in each Observation Site

No.	Observation Location	Types of Disasters Hydrology	Disaster Factors Hydrology	Mitigation Efforts
1.	Kalisuci	Karst Floods, Landslides.	The karst geological structure is highly porous, the rainfall is high, and the natural drainage is less efficient.	1) Strengthening the preparedness of tourism managers with the inauguration *of search and rescue* carried out with the Gunungkidul Nature Lovers Youth. 2) The creation of a guide pocket book, in addition to this book avoids the negligence of the guide in carrying out SOPs for *cave tubing*. 3) The making of posters and banners is made to show tourists the existence of potential disasters in Kalisuci. 4) Making leaflets containing more detailed information related to the danger of flash floods in Kalisuci. 5) The creation of *the Flash Flood* Early Warning System.
2.	Baron Beach	Floods, Coastal Abrasion, Tsunamis.	Steep topography, Landslide-prone karst areas, High rainfall, Overflow waves.	1) Construction of seawater retaining embankments. 2) Emergency early warning system in the form of sirens, loudspeakers, evacuation routes, and evacuation sites. 3) Management of coastal vegetation. 4) Infrastructure development.
3.	Luweng Pego	Floods, landslides.	Steep topography, Unstable soil type, High rainfall.	1) Land terraces. 2) Strengthening the soil structure with vegetation. 3) Good waterway manufacturing. 4) Reforestation and Reforestation. 5) Planting trees in landslide-prone areas to stabilize the soil.

4.	Seperangan Lake	Floods, landslides, droughts.	Dependence on seasonal rainfall, Poor natural drainage, Inefficient use of water.	1) Sustainable management of water resources. 2Educating the public about water conservation. 3) Build a reservoir to collect rainwater that can be used during the dry season. 4) Mapping disaster-prone areas for better planning.

3.2 Discussion

3.2.1 Vulnerability to Hydrological Disasters in Kalisuci

Kalisuci is located in Padukuhan Jetis Wetan, Pacarejo Village, Semanu District, Gunungkidul Regency, Special Region of Yogyakarta (DIY). Geographically, Kalisuci is at the end of a surface river system known as the Jirak Watershed. The Jirak watershed is dominated by vertical soil which has a high clay content [22].

Fig. 4. Map of Kalisuci Location

Vertisole soils have a low ability to absorb water, so when it rains, most of the water will flow into the river resulting in significant river discharge and potentially causing

flooding. The underground river flow in Kalisuci, Gunungkidul gets the name Allogenic River which means water from non-karst areas or surface rivers enters the underground river through the mouth of the cave. The water in underground rivers known as Allogenic Rivers is usually murky because it mixes with soil that is eroded from surface rivers. Geomorphologically, Kalisuci has a diverse topography, consisting of lowlands, hills, and mountains.

In addition, land use that is not in accordance with spatial planning can increase vulnerability to hydrological disasters. For example, the problem of converting forests into agricultural or residential land can increase the risk of floods and landslides. In Kalisuci, many forest lands have been converted into agriculture or settlements resulting in the loss of vegetation important to retain rainwater and prevent erosion.

Some types of hydrological disaster vulnerability in Kalisuci are floods, but the flood referred to here is a seasonal flood where flooding usually occurs only during the rainy season, when high rainfall large river discharge is hampered by a narrow karst cave mouth. As a result, the river level will rise and will not be able to accommodate the high water discharge. In the hilly areas in Kalisuci, it is vulnerable to landslide disasters, which is a type of fall. The solutional process of rocks by water that occurs continuously, can form cracks between rocks that cause rocks to be unstable. The instability of the rock in its position can cause collapses. In other cases, there has also been a drought disaster in this region. During the dry season, many farms fail to harvest and people lack clean water.

To reduce the vulnerability of hydrological disasters in Kalisuci, in increasing the capacity of the community in dealing with disasters, especially flash floods in the Kalisuci area by preparing an emergency response system through 1) Strengthening the preparedness of tourism managers with search and srescue training carried out in collaboration with Gunungkidul Nature Lovers youth, 2) Making a guide pocket book, in addition to this book avoids the negligence of guides in carrying out SOPs for cave rafting tubing, 3) The creation of posters and banners is made to show tourists the existence of potential disasters in Kalisuci, 4) Making leaflets containing more detailed information related to the dangers of flash floods in Kalisuci, 5) Making an Early Warning System for flash floods [23].

3.2.2 Vulnerability to Hydrological Disasters in Baron Beach

Baron Beach is located in Kemadang Village, Tanjungsari District, Gunungkidul Regency, Special Region of Yogyakarta (DIY). This beach is located about 40 km from the center of Yogyakarta City and is directly adjacent to the Indian Ocean. Baron Beach has a unique morphology in the form of a bag grid flanked by two steep cliffs, with a stretch of sand formed from the sedimentation process of organic matter that has been destroyed for millions of years. Geologically, the coastal area of Baron Beach is a coast with a typology of land erosion coast which is formed from the dissolution of carbonate rocks on the karst hills around the coast. The karst topography in the Gunungkidul area was formed due to the process of limestone deposition on the seabed which was then lifted to the surface and dissolved by rainwater to form domes and basins.

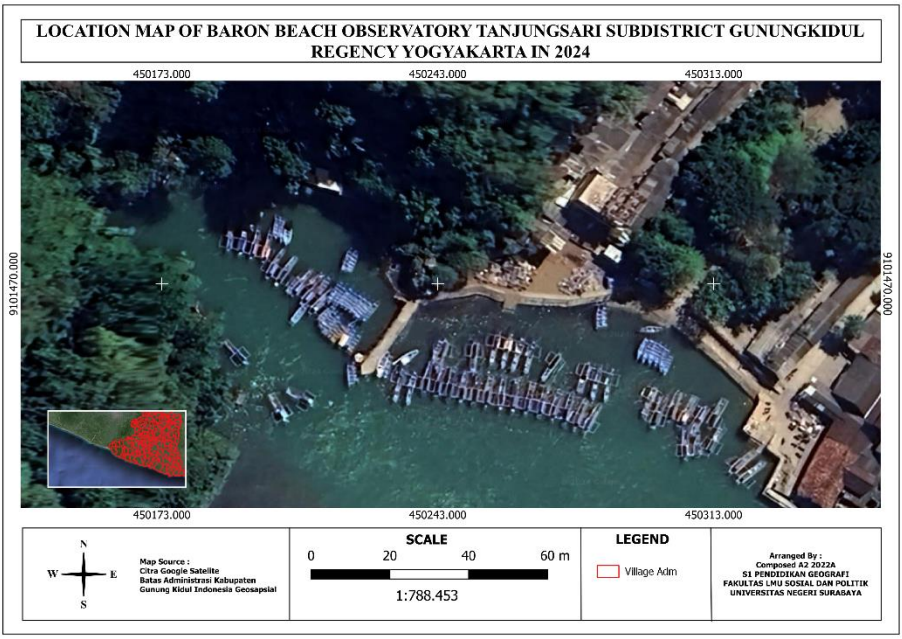

Fig. 5. Baron Beach Location Map

Strong wave activity hits the tip of the promontory which has a steep relief, causing abrasion. The impact of the waves and the repetitive solutional process deposited the material and formed a pocket grid in the bay with white fine material. The material deposited in the gisik is the result of limestone erosion [24]. Baron Beach has undergone significant changes in the coastline due to abrasion and accretion. In the 2010-2018 period, the area that experienced abrasion reached 2.75 ha, while the area that experienced accretion was 1.07 ha. These changes are mainly influenced by the movement of ocean currents at low tide which tend to lead to the coastline and accelerate erosion [14].

The existence of estuaries in karst areas is natural because of the existence of underground flows. Geomorphologically and hydrologically, karst areas are formed through the process of dissolving rocks by water and carbon dioxide in the atmosphere. Karst pores allow for the percolation of surface water which then joins underground flows. This process produces karst hills on the surface and cave passages and underground rivers. Water in karst aquifers flows through drainage channels in the form of caves or underground rivers until they reach the sea [25].

The vulnerability of hydrological disasters in Baron Beach, Gunungkidul can be explained through several main factors. First, intensive marine erosion and frequent high waves due to cyclones, linked to global warming, trigger sea level rise and weather anomalies that threaten coastal ecosystems. Second, significant sea level rise contributes to the vulnerability, causing flooding and damage to coastal structures. High waves caused by cyclones can also damage coastal structures and surrounding buildings, as

well as threaten the safety of residents. Furthermore, the geomorphological conditions of the beach, such as the slope and width of the beach ridges, affect the level of vulnerability. Beaches with beach ridges that tend to be convex or concave as well as many buildings along the coastline are more vulnerable to hydrological disasters [26].

Baron Beach in Gunungkidul Regency, Special Region of Yogyakarta, has a high level of vulnerability to hydrological disasters. Factors such as steep topography, erosion-prone limestone geology, high rainfall, and suboptimal land use contribute to this vulnerability. Some of the potential hydrological disasters that have the potential to occur at Baron Beach include floods, smash waves, tsunamis, and coastal abrasion. Coastal abrasion can occur in karst areas, one of which is at Baron Beach forming a residual land form resulting from the marine process. This residual land forms sedimentation in the form of sand and only a small part has silt content. This is because the weak current velocity only transports small sediment grains according to the amount of energy from the current. Baron Beach is included in the morphology of the bay which has a danger of waves due to wave reflections, including tsunami waves, and frequent rip currents. The occurrence of backflows is influenced by offshore topography which is generally found in coastal waters with low breaking wave height and in near-shore waters that experience wave dispersion due to wave refraction [27], [28].

One of the tsunami disasters that occurred in the coastal area of Gunungkidul was Baron Beach, directly facing the Indian Ocean in the south of Java Island. Here there is a subduction zone formed by the subduction of the Australian Indo-Continental Ocean Plate under the Asian Continental Plate. This subduction zone is active due to the constant movement of these plates, causing seafloor deformation that can trigger tsunamis. In addition, this area is one of eight seismic fissures that have the potential to experience large earthquakes. Even though it is in an active subduction zone, Baron Beach is included in several structurally shaped coasts, wave erosion coasts, land erosion coasts, and marine deposition coasts. Beaches that are formed structurally shaped coast, wave erosion coast, and land erosion coast with the characteristics of steep cliffs more than 30 meters high and clear topographic differences between land and water with a dominating cliff abrasion process. Of the three typologies, it turns out that they have relatively little vulnerability to tsunami disasters. This is due to the steep cliff topography that can dampen tsunami waves. Although in terms of beach typology that is relatively ecil to tsunami disasters, on the other hand Baron Beach is also still in an active subduction zone and directly facing the Indian Ocean [29], [30].

Baron Beach has a high level of vulnerability to flood disasters. The study used hydrodynamic models to predict potential flooding in this region showing that the most vulnerable areas are around river mouths and low-topographic areas [26]. In an effort to mitigate the tsunami disaster, facilities and infrastructure have been provided adequate tsunami disaster. As has been provided, an emergency early warning system in the form of sirens, loudspeakers, evacuation routes, and evacuation sites [31]. To reduce the risk of hydrological disasters at Baron Beach, several efforts can be made, including planting trees to reduce soil erosion and increase rainwater absorption, building disaster-resistant infrastructure such as dams and retaining walls to reduce the risk of floods and landslides, as well as increasing public education and awareness about the dangers

of hydrological disasters and ways to deal with it to reduce the risk of casualties and property damage.

3.2.3 Vulnerability to Hydrological Disasters in Luweng Pego

Luweng Pego is located in Tlogowarak Hamlet, Giripurwo Village, Purwosari District, Gunungkidul Regency. Luweng Pego is a stunning underground cave, hidden in the middle of a lush forest and surrounded by steep cliffs.

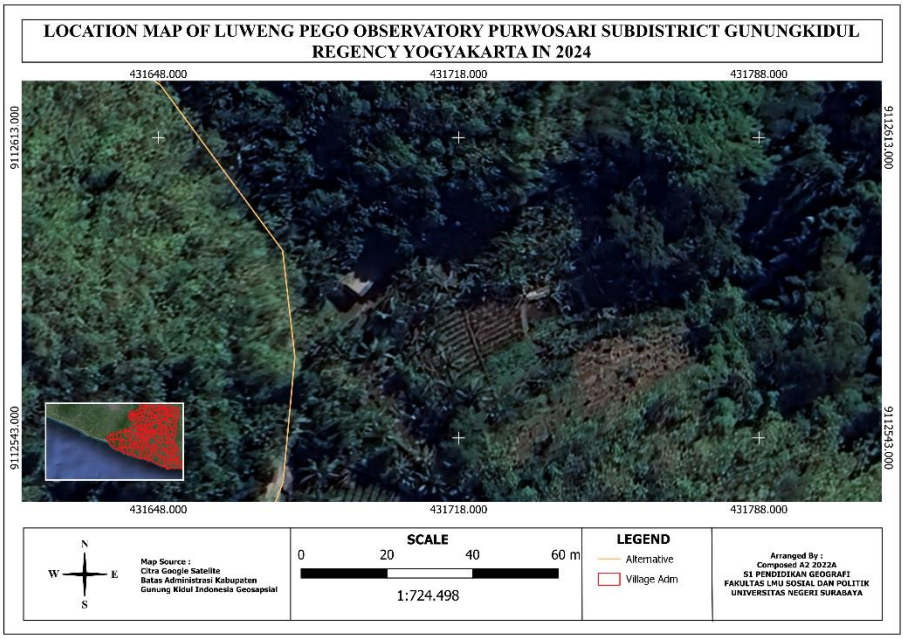

Fig. 6. Map of Luweng Pego Location

The geomorphological conditions around Luweng Pego describe a rugged mountainous area, where steep cliffs shade underground caves. Luweng Pego (Pego means smoke or steam in Javanese), because in the morning you can see smoke (water vapor) billowing from Luweng from a distance. Luweng Pego is classified as the Wonosari Formation, a geological formation formed from limestone in the Early to Middle Cretaceous period, around 145-100 million years ago, the limestone in this formation is grayish-white and formed from coral reefs and shallow marine sediments. This formation is widespread in various areas of the Special Region of Yogyakarta, including Gunungkidul Regency where Luweng Pego is located. The Wonosari Formation is famous for its limestone content that forms various caves, dolin, and other karst geomorphological phenomena. Luweng Pego is one of a number of caves formed in the limestone of the Wonosari Formation. In Luweng Pego, there are 2 types of land forms, the

first is macro karst in the form of polygonal karst and, micro karst in the form of cockpit karst.

Luweng Pego is located in a karst area with a steep and hilly topography that allows rainwater to easily drain into the cave and increase the risk of flooding. Before the 1990s, 90% of domestic water needs were met [32]. Luweng Pego is an underground river with a depth of 100 m underground. The limestone rocks that surround Luweng Pego are vulnerable to erosion and landslides because they are easily eroded by water. The high rainfall in this area, especially during the rainy season, also increases the potential for floods and landslides. especially on the river and Luweng [33]. Meanwhile, the use of land around Luweng Pego for agriculture and tourism has resulted in a reduction in land cover. As for preventing the occurrence of sustainable drought, the community should make more than one rainwater reservoir, as well as the use of intercropping systems in agricultural areas [34].

3.2.4 Vulnerability of Hydrological Disasters in Seperangan Lake

Seperangan Lake is located in Karangnongko Hamlet, Giripurwo Village, Purwosari District, Gunungkidul Regency, DIY. Geographically, it is located in the southwestern part of the Special Region of Yogyakarta, adjacent to the border of DIY and Central Java. The area around Seperangan Lake is mostly in the form of lowlands filled with agricultural land and residential areas.

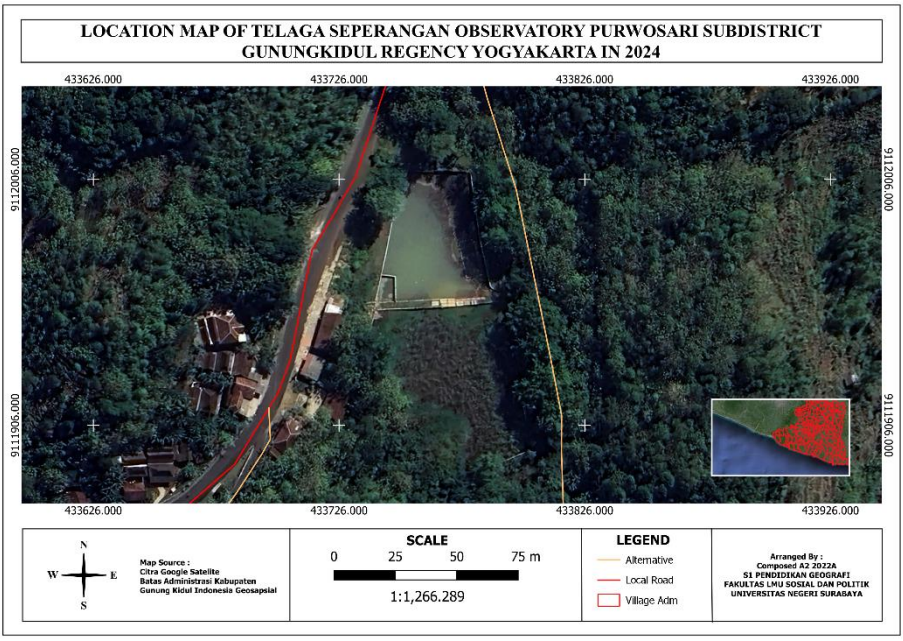

Fig. 7. Map of the location of Seperangan Lake

The geomorphological characteristics of Seperangan Lake show lowland characteristics with conditions that tend to be flat, accompanied by several small hills around it. Geologically, Seperangan Lake is located in the Badung Basin. The rock formations around Seperangan Lake include the Wonosari Formation which is a collection of limestone formed during the Early to Middle Cretaceous Period.

Vulnerability to hydrological disasters in Seperangan Lake, Yogyakarta refers to the level of sensitivity or exposure to the threat of hydrological disasters such as floods, landslides, or deterioration in water quality and drought. The area around Seperangan Lake, which consists mostly of lowlands covered by agricultural land and residential areas, is prone to flooding due to high rainfall and heavy flows. In addition, the slope of the land around Seperangan Lake can increase the risk of landslides, especially in the rainy season. The decline in water quality is also a problem, especially if there is water pollution by agricultural or domestic waste from residential areas around Seperangan Lake In addition, there are several factors that result in the rapid loss of lake water (1) Thin soil in the lake catchment area allows water to flow directly into the epikarst zone. (2) The vegetation around the lake decreases, the temperature rises and the wind speed increases, resulting in evaporation and the height of the lake being much higher. (3) Dredging the bottom of the well causes water to enter the underground river system. (4) Deterioration in lake water quality caused by the use of chemicals in household and agricultural activities [32].

In addressing the problem of potential hydrological disasters in the area, Destana from Seperangan Lake collaborates with various stakeholders, including the government, community organizations, and the private sector, to increase the disaster response capacity in the village by using a KRB map that shows the level of vulnerability of each area based on the results of analysis around Seperangan Lake which can help in identifying high-risk areas and provide important information for population mitigation and relocation efforts.

Strengthening institutional capacity is carried out through the establishment of the Regional Disaster Management Agency (BPBD) and Disaster Task Forces at the village and sub-district levels, increasing the capacity of human resources in the field of disaster management, and the establishment of the Disaster Management Communication Forum. Community education and preparedness are improved through socialization, simulation, training and the formation of Disaster Preparedness Groups at the village and sub-district levels. Law enforcement is determined through regional regulations on disaster management and spatial control.

4 Conclusion

Karst soils dissolved by rainwater can potentially become hydrological disasters. Research findings show that in addition to karst soils being useful for storing large groundwater resources, dissolution and carbonification that affect the morphological shape under the karst surface can result in hydrological disasters for communities and the environment, where limestone that is easily dissolved by water can cause floods, landslides, and droughts. A series of potential hydrological disasters were researched by

students and comparisons were carried out in several places with potential hydrological disasters, namely Kalisuci, Baron Beach, Luweng Pego, and Seperangan Lake located in Yogyakarta.

Considering that the potential for hydrological disasters, namely, in Kalisuci, Baron Beach, Luweng Pego, and Seperangan Lake located in Yogyakarta is still very concerning, the empowerment of hydrological disaster management must be an issue that is always studied and paid attention to by disaster practitioners and researchers in Indonesia. Some solutions to deal with this hydrological disaster problem, including BPBD Yogyakarta are encouraged to be able and willing to design hydrological disaster management procedures with various models that are reported to have a positive impact on increasing public awareness of hydrological disasters. Procurement of understanding related to the potential for hydrological disasters is also sought to be realized. In addition, it is also necessary to analyze the content of various studies that have studied hydrological disasters in Indonesia to see the extent to which these studies contribute applicative solutions in overcoming this problem.

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6 References

[1] E. Budiyanto Dan E. P. Lestari, "Jurnal Geografi Sensitivitas Mata Air Karst Goa Gremeng Terhadap Hujan Di Area Tangkapannya," *Jurnal Geografi Geografi Dan Pengajarannya*, Vol. 17, Jun 2019, Doi: Https://Doi.Org/10.26740/Jggp.V17n1.P63-70.

[2] I. N. Rachmi, "Karakteristik Air tanah (Geohidrologi) Karst Kajian Dan Studi Literatur Berbagai Mata Air Dan Sungai Bawah Tanah Daerah Istimewa Yogyakarta," Mei 2018.

[3] W. B. White, "Analysis Of Karst Aquifer. In:Alley, W.M. (Editor), Regional Groundwater Quality. New York : Van Nostrand Reinhold.," 1993.

[4] M. Suri Dan B. K. Susilo, "Identifikasi Dolina Karst Formasi Kalipucang Melalui Analisis Dem, Daerah Ayah, Kabupaten Kebumen, Provinsi Jawa Tengah," *Avoer 12*, 2020.

[5] R. Hayati, "Macam-Macam Metode Penelitian," Agu 2021, Diakses: 8 Juli 2024. [Daring]. Tersedia Pada: Https://Www.Myusro.Id/?P=1157

[6] L. L. Sitohang, B. Hariyanto, A. Kurniawati, S. P. Prasetya, E. Budiyanto, Dan N. H. Purnomo, "Head To The Field: Fieldwork As A Direct Experience Learning Tool In The Integrated Geography Course," *Technium Social Sciences Journal*, Vol. 50, Hlm. 71–78, Nov 2023, Doi: 10.47577/Tssj.V50i1.9869.

[7] R. O. Artrisdyanti, "Informan Dan Key Informan: Pengertian, Cara Menemukan, Dan Contoh," *Kompas.Com*, 8 Maret 2023.

[8] H. D. Lestari, "Karakteristik Sistem Aliran Airtanah Karst Gunungsewu, Kabupaten Gunungkidul, Daerah Istimewa Yogyakarta," 2018.

[9] Universitas Medan Area, "Mengetahui Pengertian Dari Analisis Data," 20 September 2023. Diakses: 8 Juli 2024. [Daring]. Tersedia Pada: Https://Uma.Ac.Id/Berita/Mengetahui-Pengertian-Dari-Analisis-Data

[10] L. Shano, T. K. Raghuvanshi, Dan M. Meten, "Landslide Susceptibility Evaluation And Hazard Zonation Techniques – A Review," *Geoenvironmental Disasters*, Vol. 7, No. 1. Springer, 1 Desember 2020. Doi: 10.1186/S40677-020-00152-0.

[11] Antaranews, "Bencana Banjir Lumpur Dengan Longsoran Kapur Di Kalisuci," 19 Maret 2019.

[12] U. Ha, "Pasca Banjir, Sampah Penuhi Cave Tubing Kalisuci Gunungkidul." Diakses: 4 Juli 2024. [Daring]. Tersedia Pada: Https://News.Detik.Com/Berita-Jawa-Tengah/D-3811764/Pasca-Banjir-Sampah-Penuhi-Cave-Tubing-Kalisuci-Gunungkidul

[13] M. Yuwono Dan A. P. Utomo, "Hujan Deras, Aliran Sungai Bawah Tanah Pantai Baron Gunungkidul Meluap." Diakses: 4 Juli 2024. [Daring]. Tersedia Pada: Https://Yogyakarta.Kompas.Com/Read/2023/02/16/092138078/Hujan-Deras-Aliran-Sungai-Bawah-Tanah-Pantai-Baron-Gunungkidul-Meluap

[14] A. A. Pratiwi, H. Setiyono, A. Anugroho, D. Suryoputro, J. Marwoto, Dan A. Satriadi, "Perubahan Garis Pantai Pada Morfologi Gisik Kantung Di Pantai Baron, Kabupaten Gunungkidul Daerah Istimewa Yogyakarta," *Indonesian Journal Of Oceanography*, Vol. 2, Hlm. 225–234, 2020, [Daring]. Tersedia Pada: Http://Ejournal2.Undip.Ac.Id/Index.Php/Ijoice/

[15] A. L. Irkhami Dan A. May, "Tanggul Di Pantai Baron Gunungkidul Ambruk Diterjang Gelombang Tiinggi, Jalur Evakuasi Tsunami Terputus." Diakses: 4 Juli 2024. [Daring]. Tersedia Pada: Https://Radarjogja.Jawapos.Com/Gunungkidul/654712335/Tanggul-Di-Pantai-Baron-Gunungkidul-Ambruk-Diterjang-Gelombang-Tiinggi-Jalur-Evakuasi-Tsunami-Terputus

[16] M. Akrom Mustafa Dan Yudhicara, "Karakteristik Pantai Dan Resiko Tsunami Di Kawasan Pantai Selatan Yogyakarta," *Jurnal Geologi Kelautan*, Vol. 5, No. 3, 2007.

[17] Dompetdhuafa, "Kekeringan Berkepanjangan Di Pedalaman Gunung Kidul," *Dompetdhuafa.Org*, Sep 2022, Diakses: 2 Juli 2024. [Daring]. Tersedia Pada: Https://Www.Dompetdhuafa.Org/Kekeringan-Berkepanjangan-Di-Pedalaman-Gunung-Kidul/

[18] E. Setiawan, "Pengeboran Sumber Mata Air Di Desa Giricahyo," *Kapanewon Purwosari*, Gunung Kidul, 19 September 2019. Diakses: 7 Juli 2024. [Daring]. Tersedia Pada: Pengeboran Sumber Mata Air Di Desa Giricahyo

[19] Dompetdhuafa, "Kekeringan Berkepanjangan Di Pedalaman Gunung Kidul," 2021, Diakses: 4 Juli 2024. [Daring]. Tersedia Pada: Https://Dmc.Dompetdhuafa.Org/Kekeringan-Berkepanjangan-Di-Pedalaman-Gunung-Kidul/

[20] Tim Ti Kominfo, “Beberapa Talud, Gorong-Gorong Dan Drainase Rusak Akibat Bencana Banjir Sepekan Yang Lalu,” *Kapanewon Purwosari*, Mar 2019.

[21] Kapanewon Purwosari, “Hujan Seharian, Beberapa Rumah Warga Giriasih Dan Giritirto Terendam Banjir,” Mar 2019, Diakses: 4 Juli 2024. [Daring]. Tersedia Pada: Https://Purwosari.Gunungkidulkab.Go.Id/Berita/Hujan-Seharian-Beberapa-Rumah-Warga-Giriasih-Dan-Giritirto-Terendam-Banjir

[22] A. Cahyadi, E. S. Pratiwi, Dan H. Fatchurrohman, “Metode-Metode Identifikasi Karakteristik Daerah Tangkapan Air Sungai Bawah Tanah Dan Mataair Kawasan Karst: Suatu Tinjauan,” 2017, Doi: 10.31227/Osf.Io/5u864.

[23] A. Cahyadi, S. Suprayogi, T. A. Trivianton, Dan B. Prabawa, “Peningkatan Kapasitas Masyarakat Dalam Manajemen Bencana Banjir Bandang Di Lokasi Wisata Minat Khusus Kalisuci, Gunungkidul Tommy Andryan Tivianton,” 2017, Doi: 10.31227/Osf.Io/4dmru.

[24] N. Suryani, “Strategi Pengembangan Dan Pengelolaan Wilayah Pesisir Berbasis Tipologi Di Wilayah Kepesisiran Kabupaten Gunungkidul Yogyakarta,” *Jurnal Azimut Edisi Khusus Smar*, Hlm. 1–8, Feb 2020.

[25] A. Nurzaman, R. Shaw, Dan M. S. Roychansyah, “Measuring Community Resilience Against Coastal Hazards: Case Study In Baron Beach, Gunungkidul Regency,” *Progress In Disaster Science*, Vol. 5, Jan 2020, Doi: 10.1016/J.Pdisas.2020.100067.

[26] A. S. Nugraha, “Dinamika Pantai Di Perairan Pantai Baron, Yogyakarta,” 2017.

[27] B. Mutaqin, A. Cahyadi, Dan G. A. Dipayana, “Indeks Kerentanan Kepesisiran Terhadap Kenaikan Muka Air Laut Pada Beberapa Tipologi Kepesisiran Di Propinsi Daerah Istimewa Yogyakarta Gilang Arya Dipayana,” 2012, [Daring]. Tersedia Pada: Https://Www.Researchgate.Net/Publication/311537888

[28] N. E. Naufalina, J. Marwoto, Dan B. Rochaddi, “Analisis Sebaran Sedimen Berdasarkan Ukuran Butir Di Perairan Pantai Baron, Kabupaten Gunungkidul, Yogyakarta,” *Indonesian Journal Of Oceanography* , Vol. 4, Hlm. 61–67, Mei 2022, Diakses: 8 Juli 2024. [Daring]. Tersedia Pada: Https://Www.Researchgate.Net/Publication/375759510_Analisis_Sebaran_Sedimen_Berdasarkan_Ukuran_Butir_Di_Perairan_Pantai_Baron_Kabupaten_Gunungkidul_Yogyakarta

[29] M. A. Marfai, A. Cahyadi, Dan D. F. Anggraini, “Tipologi, Dinamika, Dan Potensi Bencana Di Pesisir Kawasan Karst Kabupaten Gunungkidul,” *Forum Geografi*, Vol. 27, No. 2, Hlm. 151–162, Des 2013.

[30] A. M. Marfai, H. Fatchurohman, Dan A. Cahyadi, *Pesisir Gunung Kidul*. Gadjah Mada Universty Press, 2020. Diakses: 8 Juli 2024. [Daring]. Tersedia Pada: Https://Books.Google.Co.Id/Books?Hl=En&Lr=&Id=Ryh_Dwaaqbaj&Oi=Fnd&Pg=Pr15&Dq=Tipoogi+Dinamika+Dan+Potensi+Bencana+Di+Pesisir+Kawasan+Karst+Kabupaten+Gunungkidul&Ots=Zhyejtush3&Sig=Fexxbzhmqntbl6ua-Tr0t8ln0-Q&Redir_Esc=Y#V=Onepage&Q=Tipoogi%20dinamika%20dan%20potensi%20bencana%20di%20pesisir%20kawasan%20karst%20kabupaten%20gunungkidul&F=False

[31] J. Dwi Saptadi, M. Eko Arianto, Dan M. Rifai, "Studi Sarana Prasarana Keselamatan Dan Keamanan Wisatawan Pada Destinasi Wisata Pantai Parangtritis Dan Pantai Baron Tahun 2021," Vol. 7, No. 2, Hlm. 132–147, 2022, [Daring]. Tersedia Pada: Http://Formilkesmas.Respati.Ac.Id

[32] C. Rahmadi, S. Wiantoro, Dan H. Nugroho, *Sejarah Alam Gunung Sewu*. 2018.

[33] D. Kurniawan, "Cegah Banjir, Bupati Gunungkidul Terbitkan Edaran Bersih-Bersih Sungai Dan Luweng," *Harian Jogja*, 19 November 2023.

[34] F. Aprian, Y. Dwi Setianingsi, U. Muntia, K. Ari Susant, Dan S. Imam Wicakson, "Analisis Curah Hujan Sebagai Upaya Meminimalisasi Dampak Kekeringan Di Kabupaten Gunung Kidul Tahun 2014," *Khazanah*, vol. 6, 2014.