RESEARCH

Geoenvironmental Disasters



Exploring the role of social determinants in the risk reduction of landslide-prone settlements: a case study of Giripurno Village in Central Java, Indonesia

Santika Purwitaningsih^{1,2}, Pramasti Dyah Nhindyasari², Ahmad Priyo Sambodo², Amadeo Benvenuto Santosa³, Atina Salsabila Hilal³, Ayu Wulandari³, S. Aisyah Azka Nurul Fitriyah⁴, Ryan Andri Wijaya⁴, Junichiro Asano¹, Junun Sartohadi^{2,3*}, Muhammad Anggri Setiawan^{4,6}, Muhammad Sulaiman⁵ and Elok Surya Pratiwi^{2,7}

Abstract

Background The world population is still growing. The growing population caused a changes in the trend of selecting settlements location. Due to the limited flat land, people were starting to form settlements in a hilly or mountainous area which is prone to landslide. The community used to move from place to place to avoid landslides, however, it is no longer possible to implement those actions. While a lot of research has been conducted to assess the vulnerability and risk of settlements to disasters, there needs to be more research on developing settlements in landslide-prone area and their impact on disaster management.

Results High social influences can be found in the development of landslide-prone settlements of Giripurno Village. The community shows a high consideration on relatives in deciding their settlement location. Moreover, high consideration of kinship and social activity affects the arrangement of spaces in the house and directly affects the amount of space occupancy. Layout of houses in Giripurno Village were found to have large living room to accommodate family and community gatherings. Although high social dependences of one community can be beneficial in the disaster emergency response and recovery, it can also hinder the disaster mitigation effors by allowing development in an unsafe area, thus increase the risk of disasters.

Conclusion This paper discuss about how the social factors can relate to the disaster management with an emphasis on the development of settlements. This paper also highlight the aspects of space occupancy which is rarely being discussed in the disaster management related research. The result obtained by this study could provide important insight into the future disaster management in the landslide-prone settlements area.

Keywords Disaster management, Landslide, Settlements, Space occupancy, Space arrangement, Social factors

*Correspondence: Junun Sartohadi

junun Sartonadi

Full list of author information is available at the end of the article



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Introduction

The world population is still growing (Roser et al. 2013), including Indonesia (Badan Pusat Statistik 2021). The increase in population also increases the need for land for settlements (Tanjung et al. 2022; Wunas and Arifin 2020). In the previous era, residential land tended to be in flat areas. Easy access, safe areas, and low construction costs are considerations for building settlements in flat areas (Wunas and Arifin 2020). However, the increase in population also increases the demand for land for settlements (Ismael 2013; Putrie et al. 2019). The high demand resulted in the development of residential areas in hilly and mountainous areas (Tsabit and Pigawati 2021). Not infrequently, these residential areas are also in areas prone to disasters, one of which is landslides.

Development of residential areas in high elevations, many of which are prone to landslides. This phenomenon often occurs in areas that are pretty densely populated, such as on the island of Java, Indonesia (Wunas and Arifin 2020; Putrie et al. 2019). Many residential areas on the island of Java are located in hilly areas with a high level of landslide hazard (Koesuma et al. 2016; Utomo 2013; Zamroni et al. 2020). The high level of landslide hazard is a natural condition due to the steep slope factor in the high elevation area (Casagli et al. 2006; Schuster and Krizek 1978; Pawluszek 2019). However, the development of settlements has an impact on increasing the susceptibility of landslides. Changes in land use and water absorption are the main factors driving the increase in landslide susceptibility (Borrelli et al. 2013; Pan Gonzalez et al. 2014; Xu et al. 2011). This condition is concerning and needs attention because it can harm property and life.

A number of studies have been conducted in related to landslide. The studies include vulnerability (Galli and Guzzetti 2007; Ahmed 2021), susceptibility (Hong et al. 2018; Jazouli et al. 2019; Puente-Sotomayor et al. 2021), type and characteristics (Jacobs et al. 2017; Hungr et al. 2014; Zhuang et al. 2018). A landslide or mass movement is a natural process but can be a disaster when it threatens life and livelihood. Thus, solving the problem of landslides cannot be done with general research focusing on the mass movement itself. Specific research is needed, especially from a social perspective, namely the people who are threatened and affected by landslide.

Formerly, the mitigation strategy for settlements is by avoiding the landslide-prone area. In the past, when the number of population was still small, the community's response when they were affected by a landslide was to move to a safer place. However, due to the population growth and the infrastructure supporting settlements, most of which are built permanently, mitigation efforts through internal resettlement are no more applicable. Therefore, research on landslides, their risks, and mitigation is fundamental.

Currently, attention to landslides is more carried out in large-scale landslide events. As a result, small landslides should be noticed. However, even small landslides can cause significant disruption, especially, in areas with marginal development. Thus, mitigation also needs to be done to the scale of building houses on land prone to landslides. Settlement conditions, precisely the detailed building conditions, affect the condition of the land below. While there are many guidelines that emphasize building location, structure, materials, height, and age, the space arrangement aspect of a building is not rarely being highlighted, even said to be not very relevant (Carribean Disaster Management Agency 2016). Therefore, understanding the role of space arrangements toward landslide-prone settlements is necessary.

Furthermore, research on landslides in residential areas currently only focuses on causal factors (Mia et al. 2015), correlation with natural factors (Aditian and Kubota 2017), and technical modifications to reduce the risk (Illmer et al. 2016; Pourghasemi et al. 2018). Understanding the reasons for occupying landslide-prone land, the level of public understanding of the dangers of landslides still need a satisfactory answer. Therefore, this research aims to understand the physical appearance of settlements in a landslide area by emphasizing the space occupancy and space arrangements aspects. An understanding of factors that motivate people to live in a landslide prone area also become an attention. The result of this research will be an essential insight for future risk reduction of landslides on residential area.

Materials and methods

Study area

Indonesia is prominent as a country with numerous disasters. Based on the EMDAT data in 2021, Indonesia has placed the second country with the most disaster occurrences globally and was 1st among the developing countries (USAID, UCLouvain and CRED 2021). The number of disasters in Indonesia is dominated by meteorological disasters, such as landslides (Badan Nasional Penanggulangan Bencana Indonesia 2022). Amongst all provinces in Indonesia, Central Java Province has the highest experiences of landslides throughout the year (Badan Nasional Penanggulangan Bencana Indonesia 2022). Magelang District, the home of the famous Borobudur Temple, which is then set as a National Strategic Tourism Area of Borobudur Temple and Its Adjacent Area (Government of Republic of Indonesia 2014), has moderate to high landslide risk (Badan Nasional Penanggulangan Bencana 2021). The National Strategic Tourism Area of Borobudur Temple consists of Borobudur Village as the

center of the development and the other villages as the hinterlands. Some villages located in the Menoreh Hills which is very prone to landslide. Amongst all hinterland villages that are prone to landslides, Giripurno Villages has the highest landslide occurrences (BPBD Kabupaten Magelang 2023). Thus, we chose Giripurno Village as the location for this research (Fig. 1). Giripurno Village has six sub-villages: Parakan, Jombor, Gayam, Pokoh, Miriombo Kulon, and Miriombo Wetan. The Giripurno Village is part of the National Strategic Area of Borobudur Temple and Its Adjacent Area (from now on referred to as KSPN Borobudur), which impacts the status of the village as the buffer zone of the Borobudur Temple tourism.

Giripurno Village is situated within the Menoreh Hills, a region located on the northern side of the Kulon Progo Mountains (Fig. 2). The Menoreh Hills encompass an area formed by the geological activity of the Menoreh Volcano, one of the three volcanoes responsible for shaping the Kulonprogo Mountains during the Tertiary era (van Bemmelen 1949). The volcanic activity associated with Menoreh Volcano persisted until the Late Miocene epoch (Rahardjo et al. 1977; Harjanto



Fig. 1 Location of the research area. **a** Orientation of Central Java Province towards Indonesia, **b** orientation of Magelang District towards Central Java Province, **c** orientation of Borobudur Sub-district towards Magelang District, and **d** orientation of Giripurno Village towards Borobudur Sub-district



Fig. 2 Geological map of Giripurno Village

2011). The Medial-Proximal facies of the volcano can be found in the southernmost hills of the village. It consists of andesite breccia, tuff breccia, fragmental sandstone, clayey sandstone, and thin lava (Widagdo et al. 2018). On the northern side of the village, the hills represent the proximal facies of the volcano characterized by lava flows and volcanic breccia (primarily autoclastic breccia). After volcanic activity ended, the Menoreh volcano underwent tectonic events (uplifting and collapsing) coupled with magma intrusion in the Pliocene era (van Bemmelen 1949; Widagdo et al. 2018). These geological processes led to the formation of some normal and strike-slip faults that became repositories for both extrusive and intrusive igneous rocks (Widagdo et al. 2018). Consequently, the existing rocks surrounding the faults have been significantly altered and impaired, giving rise to an alteration zone located in the central region of the village.

The subsequent geomorphic process in the Giripurno Village involves landslides that have been happening since the tectonism period forming Menoreh Hills and continue to shape the landscape up to the present day. The recently occurring landslides are relatively smaller in terms of area and volume but are more destructive compared to the mass landslide processes that transpired during the initial stages of hills formation. This escalation in damage can be attributed to the increased population and human activities in the village. The occurrence of landslides is prevalent in the alteration zone, primarily due to their accumulation of thick and weak unconsolidated material resulting from the alteration process (Fig. 3). However, landslides can also occur beyond the alteration zone, particularly on steep slopes exceeding 30°.

Regarding the climate factors, the research location is also in a wet tropical climate system, where rainfall can reach more than 2500 mm/year (Sinugroho 2015). The steep slope conditions, complex geological and geomorphological conditions, and a wet tropical climate make Giripurno Village have high risk of landslides.

Land use in Giripurno Village is quite diverse, with the central dominance being the production forest area (Figs. 4 and 5). The primary commodities cultivated in Giripurno Village are cloves, cardamom, and ginger (Balkondes Giripurno 2017). Currently, the cultivation of coconut and avocado plants is also being developed. In addition to the area of production forest land, many residential areas have also developed in Giripurno Village. Clustered settlement patterns can be identified if interpreted from satellite imagery or remote sensing (Fig. 5). The condition of clustered settlements is associated with limited land in Giripurno Village. The residential area in Giripurno Village is in landslide material deposition that occurred in the past. Depositional areas can be seen from their relatively gentle slopes.

The diversity of Giripurno village is reflected in its political, geographical, and social situation. On the one hand, the determination of the KSPN Borobudur will provide fresh air for tourism development in Giripurno Village. Apart from taking advantage of natural conditions, some commodities can and are ready to be marketed to tourists and a broader market. However, on the other hand, the geographical conditions of Giripurno Village provide challenges in developing supporting facilities such as road infrastructure (Fig. 5). In addition, the threat of landslides also needs



Fig. 3 Landslide evidence in the alteration zone of Giripurno Village. a Soil creeps alongside the road. b Landslide deposits covering altered soil that was once surface soil



Fig. 4 Geographic and landuse of the Giripurno Village. **a** represents the steepness of the topography of the village, while **b** shows the two dominant land use types in Giripurno, namely production forest area and settlements. *Source*: direct survey, 2022



Fig. 5 Aerial Photograph of Miriombo Kulon Sub-Village. The Aerial photo shows the dominant landuse of production forest and clustered settlements—the clustered settlement due to the limited flatter land for settlement. Furthermore, the limited land with gentler slopes also makes road development challenging. *Source*: direct survey, 2022

to be an essential consideration in development plans. These factors make Giripurno village worthy of being a research area.

Research method

This research was conducted using a survey approach. Research based on a survey approach is usually carried out to know and understand a particular phenomenon that happened (Creswell 2014). In this case, the survey approach was conducted to obtain information on the space occupancy of each person in the landslide-prone settlements of Giripurno Village and to understand the community's considerations for settling in that area.

Data collection

This research's data collection process was conducted from June 2022 until November 2022. Two primary data were collected in this research. The first data is detailed information on houses in Giripurno Village. The information details consist of the coordinates of the houses, name of the owner, number of occupants, area of the house, number of stories, and experience of landslide. This data was collected using a questionnaire. The second data is the community's consideration in settling the landslideprone settlement area of Giripurno Village. The data on the community's consideration is qualitative. Thus, it was collected by using an in-depth interview method.

The research subjects for both data collection methods were selected through purposive sampling. Purposive sampling is a non-probability sampling that relies on the researcher's judgment in determining the sample or object involved in the survey (Creswell 2014). The researcher's judgment aimed to make the survey process more effective and efficient because it directly aligns with the research purpose (Etikan et al. 2016). In this study, a group of respondents with criteria of (1) being a native person and (2) having sufficient knowledge about the

physical and social conditions of the area were selected to obtain detailed information on the houses. Meanwhile, the criteria for respondents in understanding the community's consideration were divided into two categories of houses (houses that are affected by landslides and houses that are not affected by a landslide, the period for landslide occurrences is from 1982 to 2022-based on the result of questionnaire survey). From groups affected by the landslide, we selected the resident that (1) had their house badly damaged by a landslide, (2) had experienced a landslide more than once (in the range of period mentioned in the result of the survey), had their house damaged landslide, and had undergone a renovation with their own money. For groups not affected by the landslide, the criteria were created based on the current space occupancy for each person in the house. We divided the space occupancy by each person into five categories. They are: (1) > 10 sqm/person; (2) 10.1–20 sqm/person; (3) 20.1–30 sqm/person; (4) 30.1–40 sqm/person; and (5) > 40 sqm/person. We selected one person for each category.

Data organization

The detailed information on houses was compiled in an excel file. This file was then joined with the digital file of the base map to create a Geographic Information System shapefile containing detailed information about the houses in the Giripurno Village using ArcGIS Pro software. Finally, the interview result was recorded as a transcript in a Microsoft word file.

Data analysis

Space occupancy has a similar meaning to the living space of every person in a house. Space occupancy refers to a person's physical space in a particular area. Space occupancy can be measured in various ways, such as by the number of square feet or square meters a person occupies (Badan Standarisasi Nasional 2004; Spearpoint and Hopkin 2018). Space occupancy for every person in this research was calculated based on the formula below:

$$SO = \frac{A}{n}$$

where SO is space occupancy for the current time (2022) for every person in the selected house, A is the area of the selected house, and n is the number of occupants in the selected house. We applied several limitations in this step. Empty houses were excluded in this analysis to prevent distortion in calculating the space occupancy.

The results of in-depth interviews in the form of interview transcripts were then analyzed using the content analysis method. We categorized some keywords that matched the research purpose and then made a conclusion. We also add several pieces of information that can support our research findings.

Results

Respondents of the research

The respondents involved in collecting detailed information on houses in Giripurno Village were the leader of the neighborhood and the leader of sub-villages. Local leaders were selected because they are natives and have sufficient knowledge of the area in which they are assigned (Purwitaningsih et al. 2022). A total of 31 respondents participated in generating the database of houses in Giripuno Village. All respondents are their productive age (Fig. 6). While the leaders of sub-villages mentioned the house owner's name in the base map, the leaders of neighborhoods gave detailed information about the houses. As a result, a database consisting of 608 houses in the Giripurno Village was generated. Meanwhile, 18 people from all sub-villages become our respondents in understanding the community's consideration in determining their house layout and settling in the landslideprone area. Most respondents are also part of productive age groups (Fig. 6).

Spatial distributions of houses that is affected by landslide and houses that is not affected by landslide

Landslide occurs yearly in the Giripurno Village, especially in the rainy season. Of 608 houses that have been identified, 164 houses (26.97% of total house populations) were affected by landslides during 1982–2022 (Table 1). Based on the typology, more than 50% of houses affected by a landslide are permanent housing, and almost all affected houses have one story. The percentage of each typology of houses in the not-affected by landslide house category are 61.94%, 10.59%, and 27.48%, for permanent housing, semi-permanent housing, and non-permanent housing, respectively. Most of the housing in Giripurno Village is one-story housing.

Other than the physical condition of the house, our questionnaire survey result also allowed us to know the landslide distribution in the Giripurno Village residential area. There are two types of landslides in the residential area of Giripurno Village; they are slides, and creeps. There is no particular pattern of the slide occurrence distribution in Giripurno Village, as seen in Fig. 7. Most of the slides in the Giripurno Village is not significant in size, considering that they affected one or two houses in one event. Apart from the geological condition, the slides also most likely occurred due to the slope around the resident settlements with a value of more than 30 degrees, which then belongs to the unstable slope (Al-Hashemi and Al-Amoudi 2018; Nelson 2013). However, although it is insignificant



Fig. 6 Profile of respondents. Source: direct survey, 2022

Table 1 Typology of houses that is affected and not affected by landslide in the Giripurno Village

	Туроlоду			Total	Number of storys		Total
	Permanent housing	Semi permanent housing	Non permanent housing		One story	Two storys	
Affected by landslide	98	20	46	164	156	8	164
Not affected by landslide	275	47	122	444	419	25	444
Total	373	67	168	608	575	33	608



Fig. 7 Distribution of houses affected by landslides. It is also indicated the landslide distribution pattern in the village. The data were collected from June 2022 to October 2022. The map scale is 1:5,000

compared to landslides in other areas, the slide type of landslides in Giripurno Village mainly directly harm the residents' houses. The damages of slide type of landslide in the residential area of Giripurno Villages include damage to the house's structure, such as the breaking down of walls and roofs (Fig. 8a). It also damaged the utilities of the settlements, such as the road network (Fig. 8c), and loss of personal property, in this case, is part of the community's land. The most recent landslide occurrences with slide type in Giripurno Village happened in Miriombo Wetan Sub-Village and Miriombo Kulon Sub-Village (Fig. 8b). The recent landslide occurrences have greater impacts than the previous landslides. It disturbed the connectivity of the main road in Giripurno Village (Fig. 8c). Meanwhile, the creep type of landslides in Giripurno Village tend to be concentrated in one area, namely Miriombo Kulon Sub-Village, Neighborhood Group number 5 (Fig. 7). The creep occurrences in Giripurno Village were indicated by cracks on the walls (Fig. 9a) and floors (Fig. 9b) mentioned by the respondents. The creep is also pointed out with some cracks in the road near the affected neighborhood (Fig. 3).

Based on the geomorphological condition of the village, the residential area in the Giripurno Village is located in the depositional zone, specifically, the temporary depositional zone. A temporary landslide depositional zone is where the material that a landslide has displaced is deposited (Kharismalatri et al. 2019; Strauch et al. 2019). This material may include rocks, soil, and other debris



Fig. 8 Examples on landslide occurrences in the Giripurno Village. **a** Houses in Miriombo Wetan sub-village were buried by landslides originating from a nearby slope. The left and center images depict the landslides that damaged the walls and the roof of the house. The image on the right depicts the landslide deposits that buried part of the house. **b** A recent landslides happened in Miriombo Wetan sub-village. The top photo shows part of house yard on a high slope were collapsed onto the objects below. The bottom photo shows landslide debris filling the road and disturbing the nearby house. **c** A landslide happened in Miriombo-Kulon Sub-Village. The landslide disturbed the connectivity of road connections by filling the road with debris. *Source: Local disaster risk reduction community, 2022*

that the landslide has moved. These zones are typically located near the base of a slope or hillside where the landslide has occurred. In the case of the Giripurno Village, the temporary landslide deposition zone that nowadays developed as the settlement area was the deposition zone of an ancient landslide. Thus, it will threaten the village once the depositional zone starts actively.

Space occupancy of each person in the landslide-prone settlements

The amount of physical space a person occupies in a particular area is known as space occupancy. In a settlement area, the space occupancy of each person can vary depending on a variety of factors, such as the size of the individual's home or dwelling, the number of people living in the dwelling, and the number of personal belongings and furniture that the individual has (Suryo 2017).

In addition, the space occupancy of a person in a settlement area can also be affected by the layout and design of the area and the availability of public spaces and shared facilities (Suryo 2017). Therefore, we excluded the number of personal belongings and furniture in calculating the space occupancy for each person in a dwelling.

The houses in the residential area of Giripurno Village are generally significant. The average area of the houses in Giripurno Village is 79 sqm. The minimum house area in Giripurno Village is ten sqm, a permanent one-story house. Meanwhile, the maximum house area in Giripurno Village is 500 sqm, a two-story permanent house. The average number of occupants in the Giripurno Village settlement is four people. However, several houses were occupied by only one person, and several were occupied by more than eight people (Additional file 1).



Fig. 9 Indication of creeps in the neighborhood group number 5 of Miriombo Kulon Sub-Village. **a** Shows cracks on the wall in the resident's house, and **b** represents cracks on the floors. The yellow line indicates the part of the building in normal condition, while the red line indicates the abnormality in the part of the building due to creeps. *Source*: direct documentation, 2023



Fig. 10 Space occupancy for each persons for houses that is affected by landslide. It shows that most the houses has more than 10.0 sqm space occupancy rate. *Source*: direct survey, 2022

Based on our analysis, slightly over than 90% of all houses affected by landslide have a space occupancy for each person of more than 10.0 sqm/person (Fig. 10). Approximately 37.80% of the affected houses have a space occupancy between 10.1 and 20.0 sqm/person. Forty-one out of 164 houses have space occupancy between 20.1 and 30.0 sqm/person. Around 11.59% of the affected houses have 30.1–40.0 sqm/person space occupancy. The remaining 16.46% are houses with more than 40 sqm/ person space occupancy. The average space occupancy of each person in the affected houses is 26.80 sqm/person. The minimum and the maximum number of space



Fig. 11 Space occupancy for each persons for houses that is not affected by landslide. It shows that most the houses has more than 10.0 sqm space occupancy rate, only 9.2% of houses has less than 10.0 sqm of space occupancy *Source*: direct survey, 2022

occupancy of each person are 4.8 sqm/person and 102.0 sqm/person, respectively (Additional file 1).

Similar to the houses that are affected by the landslide, slightly more than 90% of all houses that are not affected by landslide have a more than 10.0 sqm space occupancy for each person (Fig. 11). Forty-two points five-seven percent of the non-affected houses have space occupancy around 10.1–20.0 sqm for each person. One hundred and twelve houses (approximately 25.23%) have space occupancy of around 20.1–30.0 sqm for each person. Around 10.59% of the not-affected houses have space occupancy of 30.1–40.0 sqm for each person. The 12.39% remains in houses with more than 40.1 sqm of space occupancy for each person. The minimum space occupancy per person is 7.0 sqm/person, while the maximum is 135 sqm/person. Therefore, the average space occupancy of each person in the not-affected houses is 27.79 sqm/person.

Community's consideration for settling in a landslide-prone settlements

Space arrangement inside the Giripurno Village houses

A house's space arrangement refers to how the various rooms and spaces within a home are arranged and organized. The space arrangement includes the placement of furniture, the layout of rooms, and the overall flow of the house. In this research, we limited the definition of a house's spatial arrangement to the layout of rooms. There are five basic rooms commonly found in a house to support the basic needs of people's life. They are the living room, dining room, bedroom, kitchen, and bathroom. The spatial arrangement in the Giripurno Village settlement house is the same as the primary space requirements in the house building. However, several houses put other spaces, such as a prayer room, spare room, and an expansive terrace. Most house in the settlement of Giripurno Village has an expansive living room. This wide living room is intended to accommodate families when religious holidays come and accommodate residents during group activities.

Yes, during Eid many families get together, residents also sometimes hold yasinan and gather residents at home. Yes, it's meant to be a gathering place too (Interviewee 9, male, 66 years old, Pokoh Sub-Village) Moreover, some respondents said they have a spare room(s) in their house that serves as a guest bedroom when relatives come over. In addition, some houses also have an expansive terrace which is utilized to serve guests (Fig. 12).

Yes, because I am originally from East Java, I have a lot of relatives, so automatically, if there are big days, such as holidays maybe, or there is an interest in celebrating or holding an an event, such as thanksgiving, automatically the two rooms are all filled.. (Interviewee 16, female, 40 years old, Miriombo Kulon Sub-Village)

Reason behind the decision of staying in a landslide-prone settlements

The community might consider many factors in deciding the place of their settlements. These can include the availability of natural resources, such as water and fertile land for farming, and the location's climate and weather patterns (Źróbek et al. 2015). The community may also consider factors such as the proximity to other settlements or trade routes (Smersh et al. 2003) and potential threats such as hostile neighboring communities or natural disasters (Olusola et al. 2019). Additionally, the community's cultural and social values may play a role in their decision-making process (Rapoport 1969).

In the case of Giripurno Village, most of the residents built their houses on the site based on the inheritance from their predecessors. The current villagers get the land as an inheritance from their parents, their parents



Fig. 12 Example of house that has large terrace. The wide terraces are intended to accommodate guests on daily basis or on special occasions which is not limited to be held in the Village Officer's houses. The house in this pictures are located in Parakan and Miriombo Wetan Sub-Villages. *Source*: direct survey, 2022

get the inheritance from their ancestors, and so on. Thus, most houses in the Giripurno Village settlement do not have legal and procedural permits, and there are many kinship relations within the village settlement.

The land belongs to the parents. Grant from parents. It used to be an area for growing coffee and langsep*) here. (Interviewee 6, male, 70 years old, Gayam Sub-Village)*)langsep= a fruit native to Java

Even though many villagers are aware that the area where they live now is prone to landslides, the residents are still willing to live in the area and are reluctant to move.

If there is a relocation plan, if it's far from here, we don't want it, because we're already settled. It's hard to move from here. In the past, the owner around that house also did not want to be relocated. Even though it will only be moved around the Winong spring. (Interviewee 4, male, 53 years old, Miriombo Wetan Sub-Village)

There are economic factors that motivate the residents to survive living in landslide-prone areas. However, dominantly, social factors in the form of closeness to relatives are the things that underlie residents to survive in the landslide-prone settlements in Giripurno Village. In addition, the feeling of comfort and being accustomed to being a supporting factor for residents to continue living in the area even though there have been several relocation directives from the Government.

Discussions

The simplest definition of space occupancy or living space is the amount of space a person occupies to move freely. This aspect of space on an individual scale can be calculated by dividing the area of a house by the total number of people in a house (Spearpoint and Hopkin 2018). A further definition of space occupancy is the space for human movement after deducting space for furniture (Suryo 2017). This study uses the first definition, which is simpler considering the research scale of a village. Our research found that the space occupancy for each person in the Giripurno Village is more than 20 sqm (26.80 sqm and 27.79 sqm for houses affected by land-slides and houses not affected by landslides, respectively).

Discussions about space occupancy are primarily associated with urban settlements; no specific guideline or research mentions space occupancy or living space in disaster-prone settlements in hilly areas. In Indonesia, the Indonesian Nasional Standard number 03-1733-2004 concerning Procedures for Planning Residential Environments in Urban Areas mentioned that the required space occupancy is nine sqm/person (Badan Standarisasi Nasional 2004). A study by the Residential Research and Development Center of the Ministry of Public Works (Pusat Litbang Permukiman) mentioned that the minimum space occupancy for one person is 11.89 sqm (Suryo 2017). In Hong Kong, the average space occupancy for a private house is around 15.6 sqm per person (Liu et al. 1999). In the United Kingdom, the minimum space occupancy for a private house is 21.34 sqm per person, higher than in Hong Kong (Liu et al. 1999). The finding of this study shows that the space occupancy rate in Giripurno Village is much higher than the results of other

studies related to space occupancy.

Meanwhile, in urban settlements, there are minimum criteria regarding space requirements to avoid the emergence of an unhealthy residential environment; the case is different in a landslide-prone settlement. The high level of space occupancy represents the large size of the house. In a landslide-prone area, large houses are typically heavier and more massive than smaller ones, so they exert more force on the ground and can destabilize the soil (Sarker and Rashid 2013). This can increase the susceptibility of landslides. Additionally, large houses often require more resources to construct and maintain, which can strain the local environment and economy. Furthermore, large houses may not be appropriate for the local climate or terrain, and high impervious cover can lead to excessive surface runoff. All these factors can negatively impact a landslide-prone area's safety, well-being, and sustainability. Thus, in the future, it is essential to consider the limitations of the size of a house and the space occupancy for each person in a landslide-prone area.

The high space occupancy in Giripurno Village is related to the design of the house, which is influenced by the social characteristics of rural people who like to gather and socialize with one another. The size of the house, which tends to be large, is caused by the size of the living room, which is vast, and the presence of spare space. In addition, the ample occupancy space is also accompanied by a wide terrace. The large living room and terrace are intended to accommodate relatives who visit and for community group meetings. The existence of spare rooms in several houses is also intended to accommodate family members who come on certain days. This fact illustrates that social factors play an essential role in the construction of houses in terms of design, size, and materials, as stated by Weisman (1992) and Tousi (2020). A house is a manifestation of sociocultural expression (Shrestha 2000), which can reflect beliefs, family and kinship systems, social organization, and relationships between individuals (Rapoport 1969). The arrangement of space in the house is also influenced by norms, culture, and community psychology, which shape the expectations, values, and beliefs of the people who live

in a particular community (Rapoport 1969; Triatmodjo 2010). For example, certain cultures may place a high value on family unity and togetherness, which can lead to the design of houses with large, open living areas where all family members can gather. Other cultures may value privacy and individuality, which can result in the design of houses with smaller, more private spaces for each individual or family. Additionally, the psychological makeup of a community can also influence the arrangement of space in a house, as certain psychological factors, such as the need for security or the desire for social connections, can affect how people design and use the space in their house can also reflect a community's social structure and organization (Rapoport 1969).

The community's attitude of gathering and socializing is a double-edged sword in disaster risk reduction efforts. On the one hand, this character can be a tremendous social capital in landslide risk reduction efforts, but it can also worsen the risk of landslides. On the other hand, the preference to gather and socialize reflects high social ties. This can help disaster management and post-disaster rehabilitation efforts become faster and easier (Nakagawa and Shaw 2004; Mathbor 2007). On the other hand, however, the character of gathering and socializing can also increase exposure to disasters. In this case, the habit of gathering and socializing has alluded to the spatial aspect manifested in spatial arrangements in most houses in disaster-prone areas. While in the urban settlements, the habit of gathering and socializing is accommodated by the existence of public spaces (Carr et al. 1992; Yulistuti and Purwoningsih 2018), in peripheral areas such as Giripurno Village, public space planning is still uncommon. In the future, the provision of public spaces to accommodate rural communities' gathering and socializing habits adapted to the character of disaster-prone areas and community preferences can be considered.

We also found that social attachment still strongly influences settlement development in landslide-prone areas of Giripurno. The existence of settlements that continue to develop in landslide-prone areas of Giripurno Village manifests the tendency to live due to inheritance from their predecessors. The existence of early settlements that were very long before the formal establishment of the state and formal spatial arrangements gave the existing settlements a gray status. The land tenure officially belongs to the community. However, space acquisition for settlements was made through an unofficial and nonsequential procedure. As a result, the construction of houses in unstable or unsafe areas becomes unavoidable. Page 14 of 16

Moreover, building houses in peripheral areas are often not based on clear guidelines, adding to the higher vulnerability of buildings to disasters. From this phenomenon, it is essential for stakeholders in the future to strengthen the space utilization control system in overcoming cases of space utilization that have existed for a long time. Control of space utilization must also be accompanied by increased awareness of disaster risk; otherwise, the problem of occupancy of disaster-prone spaces will continue to occur.

Conclusions

Social factors still play an essential role in developing settlements in disaster-prone marginal areas. The influence of social factors is not only found in determining the location of living. However, it is also found in the house's design process, including the room arrangement. In addition to having a positive impact as a driving force for response and post-disaster recovery, social factors in developing settlements in disasterprone areas can increase the risk. Social influence and/ or social attachment to settlement development in the disaster-prone area can increase exposure to disaster, thus leading to increased vulnerabilities. The social attachment also can lead to a lack of flexibility and adaptability, making it difficult for residents to respond to changing conditions or hazards. Therefore, instilling knowledge about the risks of living in disaster-prone areas is essential. Moreover, this research found that social factors strongly influence the size of a house in a landslide-prone area which can lead to a higher risk of future disasters. While the standard of housing size and space occupancy within the disaster-prone area remains to be discovered, establishing one is essential to ensure future sustainability.

Recommendations

In order to derive detailed information on houses in Giripurno Village, this research conducted a questionnaire survey with local leaders as the respondents. The information from the local leaders could cover approximately 89% of the house in the settlement area of Giripurno Village. However, in understanding the community's considerations in constructing their house and staying in the landslide-prone area, this research utilized sampling data derived from the purposive sampling technique. As a result, although the respondents have covered all the criteria the researcher decided, the house's physical coverage needed to be higher. Therefore, for future similar research, adding more respondents is preferable.

Supplementary Information

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Additional file 1. Table S1. Space occupancy (sqm/person) of houses affected by landslides. Table S2. Space occupancy (sqm/person) of houses not affected by landslides.

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Author contributions

SP conceptualizes the draft and the methodology, conducts formal analysis & investigation, collects the resources, writes, reviews, and edits the original draft, and makes visualization. PDN makes validation and investigation, collects the resources, writes, reviews, edits the draft, and is responsible for project administration. APS conducts validation & investigation, collects the resources, writes, reviews & edits the draft, and makes visualization. ABS, ASH, AW, AANFS, and RAW conduct validation and investigation, collect the resources and make visualization. JA conceptualizes, writes, reviews, edits, supervises the draft writing. JS conceptualizes, writes, reviews, edits, supervises the draft writing, and is responsible for the project administration. MAS and MS supervise the draft writing. ESP writes the draft. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to privacy of the research subjects but are available from the corresponding author on reasonable request.

Declarations

Informed consent

Informed consent was obtained from all subjects involved in the study.

Competing interests

The authors declare no competing interests.

Author details

¹Department of Architecture and Civil Engineering, Toyohashi University of Technology, Toyohashi, Japan. ²Research Center for Land Resources Management, Universitas Gadjah Mada, Yogyakarta, Indonesia. ³Department of Soil Science, Universitas Gadjah Mada, Yogyakarta, Indonesia. ⁴Department of Environmental Geography, Universitas Gadjah Mada, Yogyakarta, Indonesia. ⁵Department of Applied Civil Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia. ⁶Research Center for Disaster Management, Universitas Gadjah Mada, Yogyakarta, Indonesia. ⁷Department of Geography, National Taiwan Normal University, Taipei, Taiwan.

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