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Identification of Environmental Issues on the Ecoregion of Volcanic and Fluvio-Volcanic Landform in Badung Regency

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ABSTRACT

Badung is one of the regencies in Bali province, which is formed by varied landforms with different characteristics. The objective of this study was to identify environmental issues that arise in volcanic and fluvio-volcanic ecoregions in terms of abiotic, biotic, and cultural aspects. The method used to determine the sample in this study was purposive sampling. Meanwhile, the methods used in data collection were surveys and interviews, then analyzed using an ecoregion concept approach and based on resources in the research study area. The research study approach uses a descriptive-analytical approach. The results showed several environmental issues in the research area, mainly caused by human activities, such as agriculture, nature tourism, and fishery. However, several issues were insufficiently coped. Among them, there is an incompatibility in the use of water springs and the accumulation of garbage around the springs in Sibangkaja Village. It might be due to the lack of awareness of the surrounding community towards household waste management. In addition, the handling of river pollution from liquid and solid waste in Sangeh Village has not been managed optimally.

1. Introduction

The environment is formed by several components including physical conditions such as land, water, solar energy, and minerals, which combine with living creatures such as plants, animals, and humans (Effendi et al. 2018). This environment needs to be managed so that the survival and welfare of living things are by the mandate of the Environmental Management Law Number 32 of 2009. Environmental management involves understanding the structure and function of terrestrial systems and the relationship between people and the environment. Environmental management is therefore concerned with identifying, observing, and tracking environmental changes, predicting possible changes, and attempting to optimize human interests and reduce environmental degradation caused by human behavior and activities (Živković and Veljković 2020). The environment is everything that is present around the organism and affects the existence of that organism. In other words, the environment is the conditions around living things that affect the growth and character of living things. The environment has three aspects: abiotic, biotic, and human (Mutakin 2018). The three environmental components are interdependent, and there is a reciprocal relationship between humans and other creatures with

natural factors. The environment has limitations to be processed and utilized so that over time it will show a decline in quantity and quality. Environmental problems are essential issues faced by the world, including Indonesia. Some strategic issues in environmental management in Indonesia include the water, energy, environmental, and social humanitarian crises (Rusdiyanto 2015). As one country with the highest biodiversity wealth, the threat of environmental problems due to the exploitation of natural resources tends to be large. To overcome this, it is necessary to use natural resources that must be used wisely by considering aspects of carrying capacity (Muta'ali 2015). The land is part of the landform, including environmental components (abiotic, biotic, and cultural). Hence, the environment affects the existing landforms.

Various types of human exercise are the fundamental reasons for environmental degradation. There is no denying that environmental problems born and developed due to human factors are much greater than the factors of nature itself (Herlina 2017). These resulting states of change are detrimental to every living being. The main causes of environmental deterioration are modern urbanization, industrialization, overpopulation, and deforestation (Chopra 2016). The impacts of human-environmental degradation are soil pollution, water pollution, air pollution, and ozone layer depletion (Archana et al. 2016). This impact also impacts humans because they live in it, so it is necessary to cultivate awareness in them. Currently, the government has also not empowered the community much in managing the environment. It is in line with the opinion of Wibawa (2019) that the community's involvement so far has only viewed the community as a piece of public information or limited to counseling so that an activity related to the environment runs without obstacles.

Bali island is famous for its cultural and natural beauty-based tourist destinations (Dipayana and Sunarta 2015). Bali is composed of several landforms, namely beaches, rivers, swamps, lakes, volcanic plains, and sedimentary plains that are sloping with a slope of 0–5% and an altitude ranging from 0–25 m.a.s.l (Sudamada 2013). Badung is one of the regencies in Bali Province, which has a natural beauty formed from several landscapes. The landscape there is composed of several landforms which are the result of the integration of various abiotic components such as climate, topography, and soil, interactions between organisms to form specific spatial patterns even under similar conditions, past and present settlement and land use patterns, dynamics of natural disturbances, and succession (Soeprobowati 2011). The changes in Badung certainly have a significant effect on the environment. The carrying capacity and capacity of the environment need to be considered. Within 15 years, the change in the use of rice fields in residential buildings amounted to 25% of the total area (Sumadyanti et al. 2016). Likewise, As-Syakur (2011) also reported that the Badung Regency is the largest administrative area on Bali island, facilitating land changes from non-residential land to residential land, which covers an area of 1,054.29 ha. This condition can certainly be a guideline in environmental management, in addition to paying attention to the characteristics of the stretch.

Badung Regency consists of various landforms. Some of them are volcanic landscapes located in the Sangeh conservation forest, the slopes of Gunungapi Buyan, and the foot of the Buyan-Batur Volcano. Meanwhile, the fluvio-volcanic landscape is situated in Sibangkaja Village and Sangeh Village.

Volcanic landforms are landforms whose rock constituents are volcanic rocks (Andini et al. 2012). Volcanic landforms are formed due to the process of volcanism. Pyroclastic material released by the volcano during eruption will form new land. The land produced by the formation will spread in the cone area up to the foot of the volcano (Kurnianto 2019). The sedimentation

process begins to activate due to a slope decrease. The surface material is dominated by gravel to coarse sand. The erosion process on this unit is smaller than its deposition. As a result, land use for agriculture and settlements began to be developed (Kusuma et al. 2019). Meanwhile, fluvio-volcanic landforms occur due to processes in the path of volcanic land-shaped springs that flow to lower places by carrying different residues. The difference depends on the vegetation aspect (Kurnianto 2019). This landform has the potential to provide clean water because it is composed of alluvial material capable of forming aquifers (Febriarta et al. 2020). This study aimed to identify the environmental problems in each aspect of the environment. The volcanic slope and the fluvio-volcanic plain are a single entity with a characteristic interrelationship. The development of settlements in Badung shows human activities, which, if not managed properly, will certainly impact the environment. The results of this study are expected to provide data on the ecoregion of volcanic and fluvio-volcanic landforms in the Badung Regency and can be used to support environmental management processes according to their conditions.

2. Materials and Methods

The method used to determine the sample in this study was purposive sampling. Purposive sampling is a process carried out to select and take samples correctly from a population based on their proportional importance and specific considerations so that they can use as a representative in the analysis. Furthermore, the data was processed and analyzed qualitatively to get a picture or description of each study object in the research study area. Meanwhile, the methods used in data collection were surveys and interviews. The survey was conducted to obtain primary data in the form of abiotic components such as slope, soil conditions, and water conditions, as well as biotic components in the form of flora and fauna species that dominated the location. Meanwhile, interviews were conducted to obtain data from cultural components such as social, economic, and cultural aspects of the surrounding community. In addition to primary data, secondary data was also used to support this research.

The data and information in this study were sourced from primary and secondary data and studies which were then analyzed using an ecoregion concept approach and based on resources in the research study area, in this case, Badung Regency. The research study approach used a descriptive-analytical approach. This approach was non-experimental and divided into descriptive and analytical parts (Nazir 2011). This descriptive research study was a study to find facts with the correct interpretation; it was related to analyzing secondary and primary data used in research studies.

Volcanic landforms result from volcanic activity, composed of volcanic material that has come out to the earth's surface (extrusion) or frozen in the earth’s surface (intrusion). In Badung Regency, there are three locations classified into volcanic landform ecoregions, namely: Sangeh Conservation Forest, the Slope of the Buyan Volcano, and the Foot of the Buyan-Batur Volcano. The research area is shown in **Fig. 1**. Meanwhile, the fluvio-volcanic plain is a laharictic plain morphogenesis derived from fluvial processes with main pyroclastic materials such as ash, sand, gravel, and chunks of rock carried by water during rain (Handayani et al. 2013). The deposition process that occurs is more intensive and the main material is medium to fine sand on the top. This landform is usually used for agriculture and more developed settlements (Nugroho et al. 2015). Two locations are identified as fluvio-volcanic plains: Sibangkaja Village and Sangeh Village.

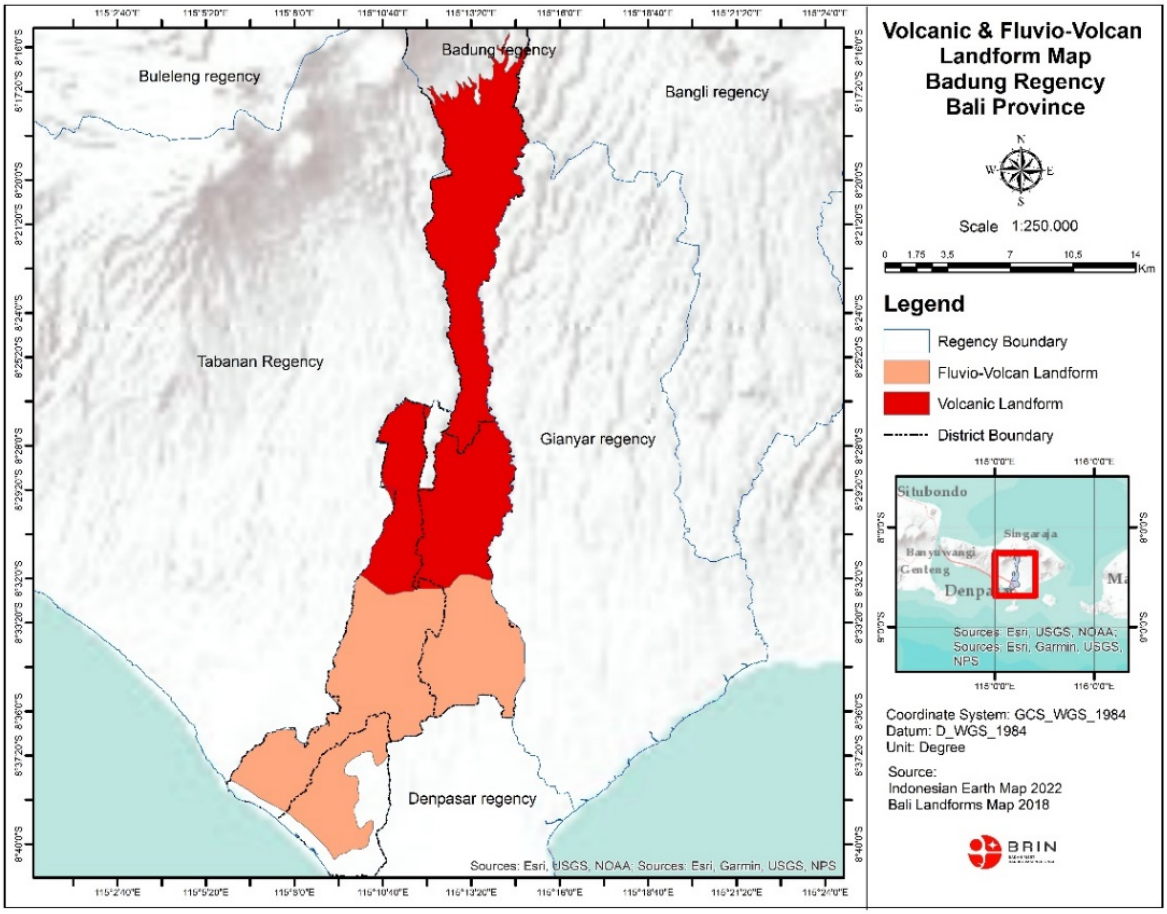

Fig. 1. Research location map.

3. Results and Discussion

Landforms are natural and cultural landscapes that emphasize the interrelationships between biogeophysical components and humans and all their activities to meet the needs of life (Hidayati 2020). Badung Regency has a variety of landforms ranging from volcanic to marine. Each landform has different characteristics, both in terms of abiotic, biotic, and cultural. The characteristics of volcanic and fluvio-volcanic landforms in the Badung Regency are shown in **Table 1**.

The Sangeh Conservation Forest is an area that was previously known as the Bukit Sari Sangeh Monkey Object, in which there is a temple relic of the Mengwi Kingdom in the XVII century. In its development, Sangeh became one of the oldest tourist attractions in Bali. The Sangeh Nature Tourism Park area was determined based on the Decree of the Minister of Forestry Number SK.203/Menhut-II/2014 dated 3 March 2014, concerning the Determination of the Sangeh Nature Tourism Park (RTK.21) with an area of 13.91 Ha in Badung Regency, Bali Province. The characteristics of the landforms of the Volcanic Plain of Sangeh Nature Tourism Park are located in the ecoregion unit at the foot of the Buyan-Batur volcano.

In the Sangeh Conservation Forest, several lands are used for gardens, plantations, and conservation forests. Traditional local villages assist in implementing BKSDA Bali management with 5 banjars/hamlets. These 5 banjars work together to manage each other. The management carried out by this traditional village is none other than because in the Sangeh Nature Tourism Park, there are 5 temples. A temple is a sacred place for Hindus that functions as a place of worship

Table 1. Characteristics of volcanic and fluvio-volcanic landforms in Badung Regency

No.	Location	Landform	Characteristic	
			Abiotic	**Biotic**
1	Sangeh Conservation Forest	Volcanic	- Height 276 m.a.s.l - Topography of the plains - Slopes 3-8% - Formed from volcanic material deposits - Dominant geomorphological processes of erosion and deposition - Tuff formations, lava, ash - Quarter formation age - Types of yellowish-brown latosol soils - Climate AW and Climate C - Wind speed 9.8-16 km/h, southeast and east - Solar radiation intensity 11.5-12.7 hours/day - Volcanic hydrological system - Water discharge >15 liters/second	- Dominant flora: nutmeg *(Dipterocarpus trinervis)* - Dominant fauna: long-tailed monkey *(Macaca fascicularis)*
2	Buyan Volcano Slope	Volcanic	- Height 763 m.a.s.l - Topography of mountain hills - Slopes 55% - Formed with material resulting from volcanic eruptions and volcanic structures - Formation of lava breccia, and tuff - Types of soil inceptisol - Soil moisture 67.5%	- Dominant flora: Teak *(Tectona Grandis),* Durian *(Durio zibethunus*), Sengon *(Albizia chinensis*), Jackfruit *(Artocarpus heterophyllus),* Elephant grass *(Penissetum purpureum*). - Dominant fauna: cows and pigs
3	Foothills of Buyan-Batur Volcano	Volcanic	- Height 332 m.a.s.l - Wavy topography - Slope 10% - Formed from volcanic eruption material - Types of soil inceptisol	- Dominant flora: rice, corn, palawija, chili, and oranges - Dominant fauna: goats and cows
4	Sibangkaja Village	Fluvio-volcanic	- Height 129 m.a.s.l - Topography of the plains - Formed from volcanic eruptions - Lava and tuff building formations - Types of soil inceptisol - Texture and structure of dusty mushy soil - Soil pH 5.1 - Soil Moisture 100%	- Dominant flora: banyan, palm, kluwuh, and bamboo
5	Sangeh Village	Fluvio-volcanic	- Height 276 m.a.s.l - Choppy plains topography - Formed from volcanic material - Formations of rock, lava, tuff - Water discharge 18.33 m^3/s	- Dominant flora: coconut - Fauna: catfish, tilapia, gurame, bawal

for Hyang Widhi Wasa in all His Presence (His manifestations) and/or Atma Sidha Dewata (Ancestral Holy Spirit) with yadnya ceremony facilities as the embodiment of the Tri Marga.

The Sangeh Conservation Forest has a unique natural panorama and quite cool air with a flat topography decorated with Nutmeg (*Dipterocarpus trinervis*) stands, which are very distinctive and dominate the area. In the west, the area has interesting natural scenery, green scenery inhabited by various flora and fauna, and the life of the long-tailed monkey (*Macaca fascicularis*) with a population of about 600 individuals divided into three groups, which is a very interesting sight. With the potential for nature tourism, several natural tourism activities that can be enjoyed in the area include enjoying unique natural panoramas and quite cool air, interpretation of nature and the environment, recreation, wildlife watching, educational and research tours for observation and research wildlife, especially long-tailed monkeys, historical tourism, including the history of temples from the Mengwi Kingdom in the XVII century, cultural tourism, spiritual tourism with Hindu religious ceremonies – Bali, attracting domestic and foreign tourists, and taking pictures (photo hunting).

The slopes of the Buyan Volcano are categorized as steep relief, where the selection of land cover types must be considered because of the potential for landslides. The dominant land cover types at this location are teak, sengon, jackfruit, durian, and elephant grass. Inceptisol soil type has moderate to high nutrient content and moderate to high soil productivity (Ketaren et al. 2014). The inceptisol soil is suitable for mixed farming because it has a high C-organic and does not require intensive management compared to irrigated rice fields (Saridevi et al. 2013). However, intensive use of agricultural land on inceptisol soils with inappropriate management can decrease soil fertility, marked by soil acidity, low organic matter, and nitrogen in the soil (Siswanto and Widowati 2018). In contrast, land management as community forest does not require much intensive treatment that can damage soil quality and trigger landslides. The utilization of elephant grass as feed for cows and pigs is also appropriate. The intercropping pattern of elephant grass and legumes such as sengon is one way to increase forage production while reducing nitrogen fertilization and reducing soil quality (Kaca et al. 2017).

In contrast to the slopes, the Buyan Volcano's foothills of Buyan Batur volcano have a wavy relief, so the intensity of landslides and erosion is somewhat reduced. From **Table 1**, it can be seen that the land use at that location is agricultural land for seasonal crops. Cultivation of seasonal crops on Inceptisol soil types can provide good yields because of the fertile character of the soil type. However, land use for the cultivation of seasonal crops can affect the soil quality because the cultivation of seasonal crops requires intensive management from planting to harvesting.

Sibangkaja village, Abiansemal sub-district, has a characteristic fluvio-volcanic plain, located at 129 meters above sea level with a topography of plains. There are large springs in this location, one of which has the potential to be Mambal springs. This spring results from material deposition from volcanic eruptions by river flows. The constituent material comes from the Buyan Volcano in the form of lava and tuff, which were then deposited by the river's flow. The Mambal Spring in Sibangkaja Village has an inceptisol soil type with a texture and structure in the form of dusty clay. The soil pH is 5.1 and the relative humidity is 100%.

Based on the survey conducted in the field, it can be seen that most of the land use in Sibangkaja village is in the form of mixed forest, paddy fields, shrubs, and settlements, with the dominant plant species being banyan, palm, kluwuh, and bamboo. The economic level in the area is relatively prosperous in terms of housing, facilities, and infrastructure development of Sibangkaja Village. Abiansemal District is a tourist destination in Badung Regency. It has a very

complex impact, especially on the environmental health aspect, as well as the increase in new densely populated settlements and the incidence of disease in environmentally-based communities because not all people can behave in a clean and healthy life (Lestari et al. 2021). Public awareness of waste management in Sibangkaja Village is still lacking, as seen by the large amount of plastic waste scattered near the springs, thereby reducing the cleanliness and beauty of the springs when viewed from the side of the road so that it looks unkempt and slum.

Sangeh Village is located in Abiansemal District, Badung Regency. This village is included in the ecoregion of the Buyan volcanic foot lands. This plain is formed from volcanic material, which is then deposited by river flows. The constituent materials consist of rock, lava, and volcanic tuff. The main rocks that make up the Buyan volcano consist of gravel, sand, silt, and clay with a mixture of the river, lake, and beach deposits (Suyarto 2012). One of the samples observed in Sangeh Village is Pancaka Tirta Spring. The location is at an altitude of 276 meters above sea level with a topographic type in the form of wavy plains with a water flow of 18.33 m^3/second. The condition of the springs is excellent, characterized by clear color, tasteless, and odorless. This indicator shows that the water quality in Pancaka Tirta Springs and its surroundings is still good and has not been polluted. The community uses this water source for various needs. For example, the community uses Pancaka Tirta Spring as a place of worship and tourism.

The results of field observations show that there are various kinds of community activities in the Badung Regency. These activities certainly have a tremendously positive and negative influence on the surrounding environment. Increased community activities are driven by various factors, such as meeting the needs of life and culture. Community activities not accompanied by an awareness of the environment will certainly negatively impact the environment in the short and long term. The decline in environmental quality will affect the ability of the environment to provide for human needs. Environmental problems can occur in the abiotic, biotic, and cultural aspects of the environment that can influence one another. The environmental problems arising from community activities in Badung Regency can be seen in **Table 2**.

Table 2. Environmental issues due to community activities in Badung Regency

No	Location	Landform	Activity	Environmental Issues
1	Sangeh Conservation Forest	Volcanic	Agriculture Nature tourism Place of Worship	- Fallen trees - The ape that attacked tourists
2	Buyan Volcano Slope	Volcanic	Folk forest	- Pollution by pig farms that cause odors and interfere with the worship process - Terracing design is less than optimal - Less water availability
3	Foothills of Buyan-Batur Volcano	Volcanic	Agriculture	- There has been an increase in land conversion into settlements - Decrease in land productivity
4	Sibangkaja Village	Fluvio-volcanic	Mixed forest Agriculture Settlement	- Pollution of springs by household waste - Mismatch of spring use - Lack of public attention to springs
5	Sangeh Village	Fluvio-volcanic	Agriculture Fishing	- Water utilization is less than optimal - Decreased water quality - Lack of visitor security facilities

Various human activities caused environmental problems that arise in each study area. Based on observations made in the Sangeh Conservation Forest on volcanic landforms, there are environmental problems in the form of fallen trees and aggressive behavior of monkeys towards tourists. Fallen trees are caused by natural factors that have a domino effect on the fall of other trees. It causes the tree population to decrease. Another problem is the aggressive behavior of monkeys in the Sangeh Conservation Forest, which tend to attack visiting tourists. Research by Wahyuni et al. (2015) described how the behavior of long-tailed monkeys is aggressive towards tourists related to snatching food from visitors who come and from managers. Based on observations, this behavior is dominated by adult male monkeys with a percentage of 22.84% and juvenile males with 13.88%.

Environmental problems on the slopes of Mount Buyan were caused by the smell of pig manure on the farm. Where there is a temple of worship around the farm, it has become a complaint of local residents because it interfered with the worship activities. Another problem was the high potential for landslides because the terracing design was less than optimal. According to (Sumiyanto and Noor 2010), cutting slopes to make terraces will reduce slope stability; the wider the terrace is made, the smaller the slope stability. Hence, the terrace needs to be made optimally to prevent landslides. This condition can be prevented by reducing the inclination angle or extending the slope. Thus the driving force of the shear stress does not exceed the repulsive force originating from the shear strength of the soil along the landslide plane (Haryadi et al. 2018). The sub-optimal terrace also impacts the lack of water availability because rainwater that falls directly and is not accommodated but directly flows downstream. The low ability of the soil to hold water will cause the soil water content to decrease rapidly. The decrease in soil water content will usually be followed by an increase in soil penetration resistance so that it will physically inhibit root growth (Wahyunie et al. 2012).

One of the environmental problems that occurred at the foothills of the Buyan Batur Volcano was the increasing conversion of land into settlements. The increase in land conversion into settlements is caused by the high birth rate of children, the high flow of urbanization, and the transfer of function from the use of the house itself (Mukti 2006). The high demand for land encourages people to convert land that initially functions as forests, gardens, and agricultural land into settlements. The high rate of land conversion can have a negative impact if it is not limited. Land use for agriculture has an impact on land productivity. Intensive soil management causes a decrease in soil quality so that it cannot provide maximum results. According to Wahyunto and Dariah (2014), land degradation usually begins with the conversion (transfer of function) of land use from forest land for other purposes. In agricultural land, land degradation mainly occurs due to accelerated soil erosion, use of agricultural machinery, and excessive use of agricultural chemicals.

The problem in Sibangkaja village, especially the Mambal spring as the sample location, was the garbage scattered around the spring. These wastes were household waste thrown away by the community around the springs, improperly disposed of garbage, or in particular garbage bins, thereby reducing the clipping's cleanliness and beauty. These activities will have an impact on health which will cause various kinds of diseases such as diseases caused by rats and diarrhea that comes from improper waste processing (Hasibuan 2016). The springs seem unkempt and rundown, so people are reluctant to use them, especially for bathing and washing, even though the water quality is still very good. The habit of throwing garbage into springs has been going on for a long time, so it is difficult for people to change their habits. Many people still think that waste

management in the area that is the scope of the EHRA (Environmental Health Risk Assessment) study is inadequate, and there is a need to improve services (Lestari et al. 2021).

Another issue of concern was the use of inappropriate springs. The use of spring water for washing motorbikes by the community was regrettable because this spring could be used for many more activities. The springs of the volcano area were widely utilized because they have good quality. This utilization fulfills the drinking water needs of the surrounding population and residents downstream (Fan et al. 2014). However, the activity of washing motorbikes near the springs will, over time, interfere with the water quality because of the soap content that will pollute the water in the Mambal springs. Smell and taste are very subjective properties of water because they are difficult to measure but can be identified, such as foul odor, gas odor, bitter taste, and sour taste (Herlambang 2006). In addition to inappropriate use, the lack of public attention to the springs makes the flowing springs wasted in large quantities; if they are not used for washing motorbikes, the springs are not used. According to Lestari et al. (2021), some people at water collection points at several springs still consumed water directly from the stored springs without boiling it first. They considered the quality of the water they took was equivalent to consuming bottled mineral water. This has the potential for diarrhea and other diseases.

The development of the spring as a tourist place and place of worship in Sangeh Village allows this location to be visited by many visitors. However, facilities to maintain visitor safety to prevent the risk of visitors falling into the pool were still minimal at this location. Therefore, the condition of the deep pool should be a consideration for the manager to pay special attention to the safety of visitors.

In addition, several other springs had not been used optimally by the community and were just left abandoned. This is a disadvantage considering that a break of slope formed a spring belt in this landform. The large potential of the waters in Sangeh Village made most of its residents work as fishermen in freshwater fish farming. Several cultivated fish include catfish, tilapia, carp, and pomfret. The fishery was one of the concrete steps to improve the community's economy and utilize existing resources. In addition, based on the survey, some people also chose to work as farmers. It was because the fluvio-volcanic plain is formed from material from volcanic eruptions and forms soil with andosol and alluvial classification. The two types of soil characteristics have high nutrient elements (Febriarta et al. 2020). The nutrient content makes the soil in this area fertile, so many agricultural activities are carried out.

However, these activities caused a decrease in water quality. Garbage disposal activities in fish ponds and excessive feeding cause a decrease in water quality which will later be channeled into irrigation canals. It was not following the concept of sustainable development, where in addition to improving the economy, natural resources must also be appropriately managed to become a good legacy for the next generation (Walukow et al. 2021). Suppose this pollution continues and is not controlled. In that case, it will cause water pollution starting from an increase in temperature, which will interfere with life in the water (Rani and Afdal 2020) to changes in the smell of pond water, which at a severe level will cause damage to aquatic flora, aquatic fauna, and the quality of the water itself.

4. Conclusions

Volcanic and fluvio-volcanic landforms have different abiotic, biotic, and cultural characteristics. Abiotic, biotic, and cultural are components of the environment. Changes influence

environmental conditions in the landscape, biodiversity, and human activities. Abiotically, volcanic landforms are formed from volcanic eruptions, while fluvio-volcanic landforms are formed from volcanic eruptions that pass through water flows. These landforms have different environmental problems according to the land use that dominates the area. Environmental problems in volcanic landforms in the Sangeh Conservation Area, the Slope of the Buyan Volcano, and the Foothills of the Buyan-Batur Volcano include the lack of visitor safety from monkey attacks in tourist villages, less than optimal land management, and the occurrence of a domino effect due to falling trees. Environmental problems in the fluvio-volcanic landforms in Sibangkaja Village and Sangeh Village are less than optimal use of springs and decreased water quality.

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