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Identification and Classification of Anthropogenic Landform in Parangtritis Hills Landscape

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ABSTRACT

Human activities alter the Earth's morphology into anthropogenic landforms, both in urban and rural areas, including Desa Parangtritis. These interventions create new characteristics in the landscape, such as pseudourban formations on plains and morphological changes in hills, posing environmental risks if not managed properly. This study uses a comparative descriptive spatial analysis method, comparing variations between anthropogenic and natural landforms. Digital Elevation Model (DEM) data and orthophoto were utilized to delineate and identify anthropogenic landforms. The results indicate that the hillsides in Desa Parangtritis are divided into structural and solutional landforms, each with varying levels of human intervention. The solutional landform falls under a "Slightly Modified Landscape" phase, while the structural landform has undergone significant anthropogenic intervention. Agrogenic land use dominates, with mixed gardens and fields as primary uses, while urbanogenic and traffic interventions are closely related to infrastructure development. The transformation of hills into anthropogenic landforms in Parangtritis reveals a strong human influence, not only forming pseudoterraces for agriculture but also altering land configuration through excavation and leveling, thus placing it in a "semi-natural landscape" phase. These interventions increase the risks of erosion and landslides and reduce infiltration capacity. The study demonstrates that landform changes due to anthropogenic intervention in the hills of Desa Parangtritis require careful conservation planning to protect the environment and minimize the negative impacts of human activities in the area.

KEYWORDS

Anthropogenic
Human Intervention
Landform
Keyword_4
Keyword_5

1. Introduction

Human activities have an influence in changing the morphology and modifying the shape of the earth's surface. The existence of anthropogenic processes provides changes in the shape of the current landscape (Lóczy, 2010). Changes in shape due to human activities either directly or indirectly will form anthropogenic landforms (Szabó, 2010; Tsermegas, 2015). Anthropogenic landforms are different from natural geomorphological features, as they have a strong human influence and are able to transcend natural geomorphological processes (Mandarino et al., 2021). Urban geomorphology is a study that addresses human activity as a process of physical change, where humans are able to modify natural landforms and transform them into anthropogenic landforms (Del Monte et al., 2016; Diao, 1996). Thus, many researchers are focusing on this field as a new branch of geomorphology that investigates natural landform changes due to human influence (Brandolini et al., 2017, 2021).

As the understanding of the impact of human activities on geomorphology grows, research reveals that landscape transformations due to human intervention have become more prominent since the start of the Anthropocene, a period in which natural processes began to be dominantly influenced by human activities (Zerboni & Nicoll, 2019). Humans, with practices such as urbanization, agriculture and mining, create topographic imprints that alter natural geomorphic processes and lead to clearly visible anthropogenic landforms (Tarolli, 2017). Human activities, such as infrastructure development and agricultural activities, cause changes in erosion and sedimentation that affect

landscape stability and ecosystems (Tarolli & Sofia, 2016). Further research shows that such interventions not only alter physical appearance, but also have lasting effects on ecosystem functioning and geomorphological processes globally (Harden, 2014). These studies emphasize the importance of understanding and managing anthropogenic changes to landscapes to maintain geomorphological and ecosystem balance.

Anthropogenic landscape classification systems are more developed in urban areas, but in reality human intervention does not only occur in urban areas, but also penetrates into rural areas (Adzima et al., 2020), including in this case Parangtritis Village. Parangtritis Village has been transformed into an anthropogenic landform, where humans play an important role in modifying the current natural formation. According to research by Lin et al. (2019) Parangtritis Village has been able to be referred to as a pseudourban, where rural areas that have shown an urban appearance, especially in plain regions. These human interventions give different characteristics to the appearance of the earth's surface. If the intervention is not well planned, it will have a negative impact on the surrounding environment. Therefore, careful planning and conservation approaches are needed to ensure that human intervention does not damage the balance of ecosystems in the Parangtritis Village Hills area and prevent long-term adverse impacts on the environment and surrounding communities.

2. Method

The study area is focused on the hillside in Parangtritis Village. The hillsides in Parangtritis Village are included in the Baturagung escarpment (Figure 1). The Baturagung escarpment is the boundary between the Baturagung Mountains and the mid-zone depression. The Baturagung escarpment is geomorphologically quite steep, as it has a slope of up to 100%. Based on the Geological Map of Yogyakarta Sheet, the hillside in Parangtritis Village has constituent materials from the Nglanggran Formation and Wonosari Formation. The existence of the Baturagung escarpment affects the groundwater configuration, which is important in determining slope stability and water flow patterns in the area (Rodhi et al., 2016).

The research utilized two types of data, namely Digital Elevation Model (DEM) and orthophoto. DEM is used because it can represent the relief of the earth's surface in three dimensions. DEM data is obtained from the Geospatial Information Agency and can be downloaded for free on the page https://tanahair.indonesia.go.id/. DEMNAS is an integration of elevation data that includes IFSAR, TERRASAR-X and ALOS PALSAR. The spatial resolution produced by DEMNAS is 8.26 meters. DEM data is used to delineate natural landforms in the hills of Parangtritis Village. While the existing orthophoto of Parangtritis Village was obtained from the Parangtritis Geomaritime Science Park (PGSP). The orthophoto was used to obtain land use information in the study area. With a spatial resolution of 7.5 cm. Anthropogenic interventions have evolved, so for the classification of anthropogenic interventions the following classification can be used: urbanogenic, traffic, agrogenic, tourism, and sport. In addition, the process of intervention has been added, namely excavation, planation, and accumulation (Szabó, 2010). Anthropogenic interventions were generated from verified detailed land use delineations. The field survey process used the transect method. Field observations were conducted purposively on the identification of anthropogenic interventions. Based on this, the analysis technique used in this research is comparative descriptive spatial analysis by comparing variations in anthropogenic landforms with natural landforms.

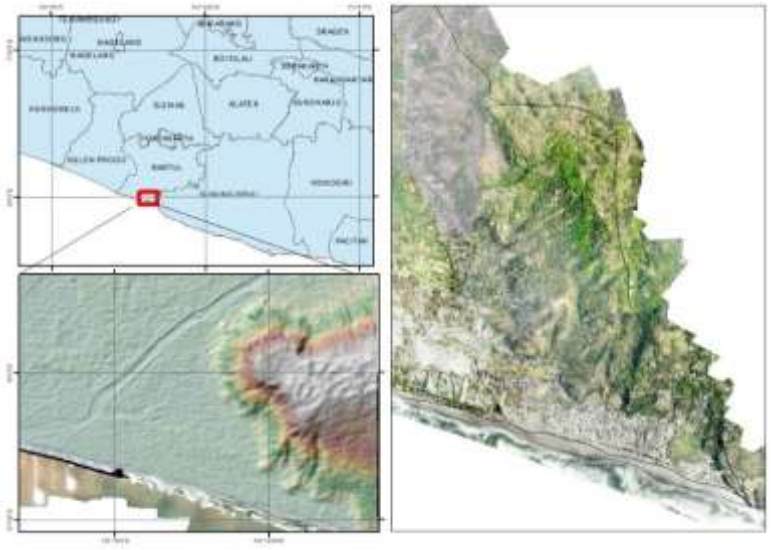

Fig. 1. Study Area

3. Results and Discussion

3.1. Genesis Landform

Parangtritis Village is genetically unique due to massive past tectonism activity. Based on Van Bemmelen (1970), Parangtritis Village is included in the Southern Mountains unit. The first morphogenesis association mentioned is Structural. The hilly area in Parangtritis Village is divided into 3 morphogenesis, namely structural, solutional, and hillslope process. Geomorphologically, the Baturagung Hills are controlled by the structural fault process that occurs due to endogenous forces from within the earth (Santosa, 2016). The endogenous power occurs due to the collision of tectonic plates. This landform can be recognized by the striking topographic difference between the fault line and the surrounding area (Saputra et al., 2016). Pramono (2007) explained that the Southern Mountains in Parangtritis Village are divided into two parts, namely the Baturagung Range and the Gunung Sewu Plateau. The Baturagung Range is a mature stage block mountain that turns into an escarpment. The rock formation that composes the Baturagung is the Nglanggran Formation which consists of andesite breccia, andesite lava, and sandstone. These rock types are scattered around the hills. The Gunung Sewu Plateau, which is included in the Southern Mountains series, is a hilly area that resembles a cone and is of mature stage. This unit is composed of limestone and has formed a karstification process. It is located at the top of the hills that extend from Parangtritis to the east. Then, the hilly area of Parangtritis village which consists of Structural and Karst develops into a hillslope process (hereinafter referred to as the slope process). The slope process based on Van Beek et al. (2008) consists of three main aspects, namely rock mass movement, slope stability, and erosion. The impact of slope processes is very important and is currently amplified by the influence of human activities in the form of land use change, deforestation, and even greater by the effects of climate change. When examined further, hillslope processes provide smaller erosional formations in the form of valleys or cuts and residual formations in the form of ridges. Examples of evidence of erosional formations in the hillside process are the springs of Sendang, Glapan and Bito, each of which is the headwaters for the river (Gunawan, 2001).

3.2. Landuse Identification

In general, the landforms in the study area fall into the Baturagung Hills. The study area falls into the solutional and structural process origin landforms. A landform is classified as anthropogenic if it is subjected to interventions that can change the morphology, type of process, and intensity of the process. This anthropogenic landform is identified based on detailed land use that has indications of

human intervention. The largest land uses in the study area are mixed gardens (178.06 ha), dryland forests (150.50 ha), fields/plantations (36.28 ha), and built-up land (13.62 ha).

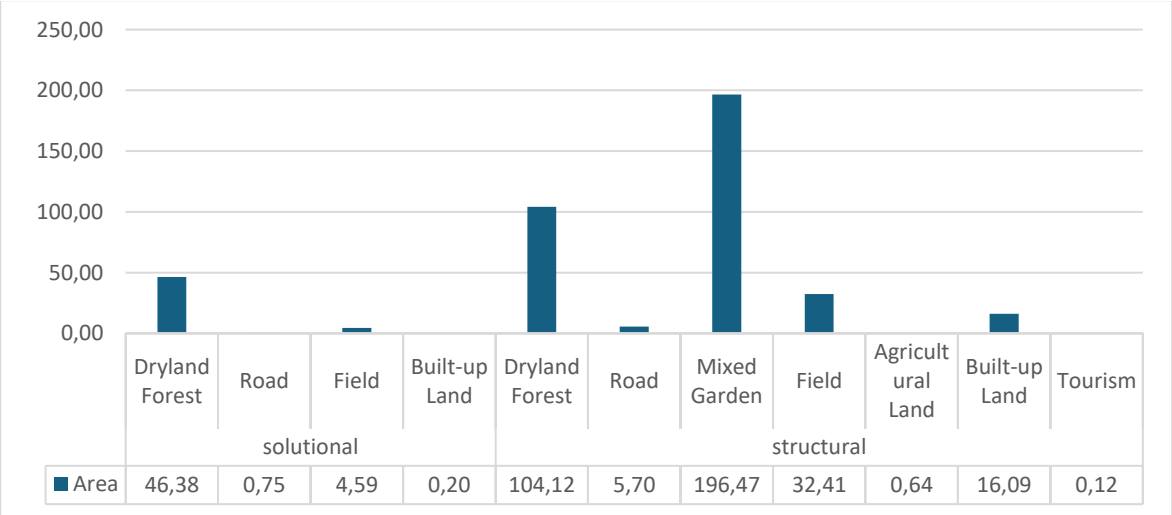

Fig. 2. Land Use Area in Parangtritis Hills

Land use on solutional and structural landforms is quite varied. Land use in the solutional landforms is dominated by dryland forest (46.38 ha). Other land uses identified are roads, fields, and built-up land. Fields are the second largest land use (4.59 ha). Fields are indicated by the presence of indications in the form of terraces on the hills. The existence of built-up land in the solutional landform is one of human intervention. The built-up land is in the form of semi-permanent buildings that support Japanese cave nature tourism at the top of the hills. Land use in the identified structural landforms are mixed gardens, dryland forest, fields, built-up land, roads, tourism, and ponds. The appearance of mixed gardens is dominant because it is associated with built-up land and has a diverse vegetation appearance.

Based on the identification of land use, anthropogenic landforms from the intervention can be identified, such as agrogenic, tourism, urbanogenic, and traffic. Agrogenic is identified from agricultural activities. This type is divided into two types, namely fields, mixed gardens. Tourism is classified from tourism activities. Urbanogenic is identified from urban activities in the form of residential buildings. Finally, traffic is identified from infrastructure for transportation, such as roads. The distribution of Landforms of Anthropogenic Process and Intervention Origin can be seen in Figure_.

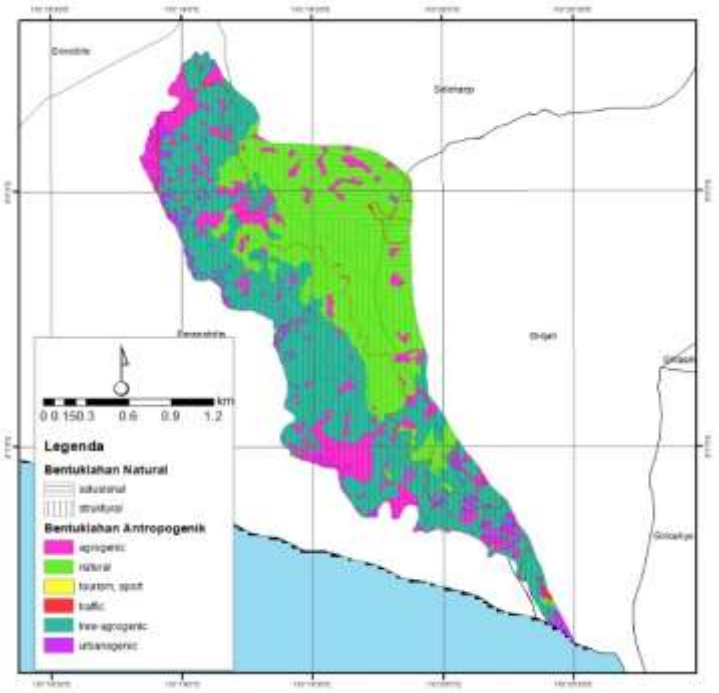

Fig. 3. Distribution of Anthropogenic Landform in Parangtritis Hills

3.3. Anthropogenic Intervention on Solutional Landform

The solutional landforms are dominated by natural landforms that have not received human intervention. The area of natural landforms is 46.38 ha of the total solutional landforms (51.92 ha). However, there are anthropogenic landforms in the form of agrogenic, traffic, and urbanogenic. Agorgenic intervention is an agricultural activity that can change the shape of the surface (Szabo, 2010). Agrogenic intervention in the solutional landform has a form of practice in the form of annual crops, such as beans, cassava, and corn (Figure 4c). These agrogenic interventions are associated with natural landforms. Agogenic interventions on hills are managed with minimal techniques. So that the process that occurs is accumulation and planation with the aim of enriching the soil layer. Minimal land management techniques, such as crop rotation and limited land use, are also important to maintain soil fertility and reduce the risk of degradation. Gerasimova & Savitskaya, (2020) showed that these techniques can maintain soil fertility while protecting ecosystems.

Traffic interventions are obtained from road construction in the form of asphalt, and soil. This intervention is obtained through the association process between road construction and slope cutting (Figure 4a). The tourism intervention is to support natural tourism in the form of Japanese caves. The process of tourism intervention in the solutional landform is obtained from the planation process on a relatively flat morphology (Figure 4b). With these conditions, anthropogenic intervention in the Solutional Hills Peak is still included in the Slightly Modified Landscape phase, where there are only minor human activities, so it still has the ability to self-regulate in a short period of time. The results of stakeholder interviews also show that in the hills there was a reforestation program called the National Movement for Forest and Land Rehabilitation (GNRHL). This makes the conditions in the hills still quite preserved.

Fig. 4. (a) Slope Cutting for road construction; (b) Tourism intervention in the form of semi-permanent building with a planation process; (c) Agrogenic Intervention Appearance

Tabel 2. Land Use and Anthropogenic Intervention Distribution in Solutional Landform

Penggunaan Lahan	agrogenic	natural	tourism, sport	traffic	urbanogenic	Total (Ha)
Dryland Forest		46,38				46,38
Road				0,75		0,75
Field	4,59					4,59
Built-up Land					0,20	0,20
Total (Ha)	4,59	46,38		0,75	0,20	51,92

3.4. Anthropogenic Intervention on Structural Landform

Structural landforms have quite a lot of intervention. This is indicated by the natural landform which is only 104.12 ha or 27.1% and the rest has anthropogenic intervention. Agrogenic intervention dominates in structural landforms. This type of agrogenic intervention is divided into two types, namely mixed gardens and fields / fields. The morphological appearance of tree agrogenic intervention, especially in mixed gardens, is formed by pseudoterrace. The appearance of psuedoterrace in mixed gardens can be seen in Figure 5a. This pseudoterrace is formed from a human-made terrace and modified by geomorphological processes, so that its shape is reconstructed. Terraces themselves are a conservation strategy in locations that have steep slopes. However, this strategy cannot be applied in all conditions. Poor planning can increase geomorphological processes, such as erosion and landslides. The process of pseudoterrace formation shows that the natural adaptation of geomorphological systems to anthropogenic changes still requires monitoring. Other studies have shown that pseudoterrace stability can be influenced by biological factors such as the presence of soil-retaining vegetation. Plants with deep roots, such as agroforestry trees can make a significant contribution to maintaining slope stability and reducing surface runoff, which is one of the main causes of erosion. In addition, lack of maintenance on terraces, such as failure in weed control and structural improvement, can accelerate geomorphological degradation, impacting overall land productivity (Arnáez et al., 2015).

Fig. 5. (a) Tree-agrogenic appearance Pseudoterrace; (b) Urbanogenic Intervention Appearance

Urbanogenic intervention is characterized by the presence of settlement areas, such as building construction, cutting and compaction of the land surface for construction. Urbanogenic interventions have implications for morphological changes due to excavation and planation. This process leads to increased surface runoff and reduced infiltration as the land changes from natural to artificial (Ghosh, 2013). Urbanogenic interventions are also associated with traffic interventions. Traffic intervention is found in road land use. Traffic intervention on structural landforms occurs through associated processes, including excavation (slope cutting), planing (leveling), and paving with/or without concrete or asphalt. These transformations not only change the physical morphology, but also affect the intensity of surface flow due to the expansion of impermeable land. Other studies have also shown that urbanization increases the frequency of surface runoff, regardless of variations in slope or soil characteristics. This impact is consistent across different climatic regions, suggesting that the expansion of impermeable surfaces disrupts natural hydrological systems and increases erosion, ultimately damaging the overall ecosystem (Vietz et al., 2014). In addition, there are also tourism, sport interventions. An example of tourism, sport intervention is religious tourism in the hills. The intervention has an excavation process in the form of cutting slopes to support tourism so that visitors can be safe when visiting the location. This is very important to create a safe experience for visitors without damaging the landscape and natural sites. One form of intervention that is often carried out is slope excavation to improve accessibility and safety. It also requires geological risk analysis to prevent hazards such as landslides (Ansari et al., 2014; Kiernan, 2013). With these intervention conditions, the structural hillside falls into the semi-natural landscape phase because its function and appearance are still characterized by the dominance of natural appearance with some human intervention processes.

Tabel 3. Land Use and Anthropogenic Intervention Distribution in Structural Landform

Land use	agrogenic	natural	tourism, sport	traffic	tree-agrogenic	urbanogenic	Total (Ha)
Dryland Forest		104,12					104,12
Road				5,70			5,70
Mixed Garden					196,47		196,47
Field	32,41						32,41
Agricultural Land	0,64						0,64
Built-up Land						16,09	16,09
Tourism			0,12				0,12
Total (Ha)	33,05	104,12	0,12	5,70	196,47	16,09	355,55

Parangtritis Village is a tourism area that has been planned and regulated in the Bantul Regency Spatial Plan. The development of tourism will accommodate an increase in the types of interventions, not least in hilly areas, especially with the construction of the Southern Cross Road Line (JJLS) which cuts through the hills. Intervention does not always mean destructive because it has several positive values, including in education, development, and tourism (Kubalikova et al., 2019). Through the right spatial planning approach, these interventions can support the ecological, social and economic functions of an ecosystem or landscape (Li et al., 2020). Thus, planning that integrates

aspects of tourism and environmental sustainability has the potential to increase multi-dimensional benefits for Parangtritis Village.

4. Conclusion

Parangtritis Village has a unique morphology due to the influence of tectonism, has different land uses on solutional and structural landforms influenced by anthropogenic interventions. The solutional landforms are mostly natural, but there is minimal agrogenic activity as well as traffic and tourism interventions. On structural landforms, interventions are more diverse, with agrogenic, tree agrogenic, urbanogenic, tourism and traffic interventions significantly altering the topography. Such interventions, such as tree agrogenic pseudoterraces and slope-cutting traffic will change the shape of the surface and have impacts on soil conservation, erosion and water infiltration.

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