Geomorphological hazard at some area of the Outer Dieng Volcanic Complex post explosive eruption era

M A I Wardoyo, R Prayuda, Y Susena, F A W Baradi, A Ashari, L F Imamah
Department of Geography Education, Faculty of Social Science
Universitas Negeri Yogyakarta, Jl. Colombo No.1 Yogyakarta, 55281, Indonesia

Email: muhammadасrori.2017@student.uny.ac.id

Abstract. Dieng area as an important and productive area needs the support of various aspects in encouraging regional growth and development. This region also has been experiences many disasters year by year. Disasters due to volcanism are events that cause many losses, especially casualties in the past. Discussions about potential disasters in the Dieng area should not only be limited to volcanism and earthquakes as hazards caused by endogenous processes. The Dieng area is an old landscape. As an old landscape that is heavily influenced by exogenous factors from a wet tropical climate, other potential hazards in the form of geomorphological hazards also need attention. In fact, there are some geomorphological hazards that occur due to the complexity of the landforms of this area, there are various processes that often occur such as mass movement and erosion and these processes usually have a negative impact on social and economic life. This paper aims to analyze the various types and levels of geomorphological hazards that exist outside of the Dieng Volcanic Complex. This region has experienced major eruptions in the past. At present, in the post-explosive era, it is necessary to know whether geomorphological hazards are limited to eruptions or if other hazards are a bigger threat. The terrain survey method or geomorphological survey is a field observation method used to achieve research objectives. The interpretation of remote sensing images, literature research, and documentation provides support in the form of additional data to complement the primary data from the observation. The results obtained show that the area of the Dieng Volcanic Complex after the explosive eruption era, which is largely composed of volcanic landforms, which physically dominates the denudation process. The denudation process is what causes mass movement and erosion to emphasize that there is a very high potential geomorphological hazard in this research location. This research area is also a productive agricultural production area. Although it cannot be separated from criticism because of its negative impact on the environment, because in the use and management of land carried out by the community it affects mass movement and erosion. Therefore, information on geomorphological hazards is very important to be provided and updated continuously in the interest of ensuring effective and sustainable disaster management.

1. Introduction
The Dieng area is one of the most important highlands in Central Java. This area is socially and culturally known as part of the development of the oldest cultural site in Java. Degroot [1] mentions it as the cradle of Javanese civilization, in its environment with the Borobudur zone in past developments in Central Java. Meanwhile, Lavigne et al [2] mentioned it as the residence of the gods. Physically this area is a volcanic complex ([2], [3], [4]). With the potential for natural and socio-cultural panoramas, the Dieng
area is currently developing as an important tourist destination. The number of visits to this region in 2013-2017 has increased from 703,974 to 1,585,477 people [5]. Apart from being a tourist destination, the Dieng area is also a productive agricultural production area. While not ignoring criticism because of its negative impact on the environment, the use of agricultural land in the Dieng area is also large with potatoes as the main product. As a volcanic complex area, this area also has a large potential source of geothermal energy [6].

Dieng area as an important and productive area needs the support of various aspects in encouraging regional growth and development. One that needs attention is the disaster aspect. Information regarding potential hazards and disaster risks is very important to be provided and kept updated in the interests of ensuring effective and sustainable disaster management. From time to time this region also experiences many adverse disasters. Disasters due to volcanism are events that cause many losses, especially casualties in the past. The eruption incident in Sinila Crater in 1979 which triggered the release of poisonous gas in Kawah Timbang which caused the death toll of 149 people of Kepucukan Village, is an example of an eruption that caused disaster in the past. According to Aziz in Ridlo [7], there are three of the 11 craters in Dieng that are considered very dangerous because they often emit poisonous gas. The three craters are, Weigh, Sinila and Sikendang. This incident is an example of an incident that has always been a reminder and learning until now. Data from the Center for Volcanology and Geological Disaster Mitigation show that in the last five years the types of potential hazards that have become a threat to this area are volcanic eruptions, bursts of toxic gas, landslides and potential lava floods.

Discussions about potential disasters in the Dieng area should not only be limited to volcanism and earthquakes as hazards caused by endogenous processes. Dieng area is an old landscape. Harijoko et al [4] show that the oldest part is at least 3.6 million years old on Mount Prahu or 2.53 million years on Mount Bisma. Meanwhile, the youngest part alone is 90 thousand years old on Mount Pakuwaja or 70,000 years old on Mount Seroja. As an old landscape that is heavily influenced by exogenous factors from a wet tropical climate, other potential hazards in the form of geomorphological hazards also need attention. Geomorphological hazards in the form of mass movement and erosion are also common in this region. Based on data from the Center for Volcanology and Geological Disaster Mitigation during 2019, 249 disasters occurred and most of them were landslides, totaling 166 events. Meanwhile, erosion is a very massive problem with the rate of erosion in Dieng reaching 463.86 tons/ha/year. Based on the Erosion Hazard Classification according to Hammer (1981), the Erosion Danger Level (EDL) value obtained is in the very high category [8]. In the past, the Dieng area has experienced explosive eruptions. However, at this time, this region is entering a new era where geomorphological hazards are also a threat that is no less important and needs to be informed.

This study aims to analyze the various types and levels of geomorphological hazards that exist outside the Dieng Volcanic Complex. This region has experienced major eruptions in the past. At present, in the post-explosive era, it is necessary to know whether geomorphological hazards are limited to eruptions or if other hazards are a bigger threat. This study also aims to produce alternative information to support land management by land conditions so as not to cause mismanagement. Alternative information about potential hazards is also needed to support the spatial planning of the area. At this time Dieng residents mostly work in agriculture and tourism. For optimal agricultural and tourism management, detailed and actual information on geomorphological hazards is required.

2. Method
This research uses descriptive-exploratory research. Descriptive research is a research process that is more directed at revealing a problem or situation as there are facts, sometimes given interpretation and analysis. This method is used to explain the symptoms encountered in detail regarding field conditions. The approach used in this study is a geographic approach, namely a spatial approach. The spatial approach in this study is used to be able to identify and describe several geomorphological phenomena and their distribution to assess potential geomorphological hazards in the study area. This research also includes geographic themes, namely location, and place in the discussion. Geographical themes used
are mainly location and place. Following previous research Ashari in 2019 [9], the theme is used to provide an overview to strengthen arguments and clarify the discussion regarding the spatial aspects of geomorphological conditions in the research area, which reflects which geomorphic phenomena are in the study area, the existence of these phenomena, and their distribution patterns.

Primary data collection in this study employs an observation method which was carried out by directly checking the conditions in the field. At the same time, interpretation of remote sensing images, literature research and documentation is carried out to improve secondary data collection results. Observations were made using two methods, namely digital observation (image interpretation) using Geographic Information System (GIS) software and field observation. The location of the sample was determined purposively in each field unit in the study area. The use of tools, namely drones, aims to take aerial photographs of several terrains. Interpretation of remote sensing images is used to obtain additional data or secondary data regarding regional geomorphological data, regional infrastructure, and landform distribution data. In some samples in the field that have been determined, the process of observation and field measurements will be carried out. Each sample location will be selected or purposively determined in each terrain unit in the research area. Terrain units represent changes in the geomorphological conditions of an area. Geomorphological data obtained from ground surveys can also be used as a verification control for image interpretation data, because field survey results are often more realistic and accurate. Interpretation of remote sensing images is used to obtain additional data or secondary data regarding regional geomorphological data. observing in terms of terrain and relief that are difficult to reach, therefore the use of remote sensing images is very important to help complete and obtain geomorphological data from the area due to accessibility, terrain, and affordability factors. Various landform data taken using remote sensing interpretation is determined as a control to emphasize the geomorphological data in this research obtained from Landsat images. Geomorphological data obtained from direct field observation together with geomorphological data obtained using remote sensing image interpretation will complement each other and strengthen the discussion.

Other secondary data collection uses literature and documentation. The literature study was carried out to obtain secondary data used, among others, the book from Van Bemmelen and the article from Harijoko. These guidelines are used to strengthen primary data in land-based data analysis. The landform data in question is in the form of landform characteristics and potential geomorphological hazards. Further strengthening of secondary data collection is by using documentation to obtain secondary data from various documents containing maps in the research area such as RBI maps and geological maps. This method is used to provide geological information as well as existing land use in the area to be studied or observed. The entire series of field data collection in the study area is listed in table 2.1. The table 2.1 below shows the relationship between data types, data collection methods, instruments, and data sources in this study.
### Table 2.1 Field data collection techniques

| No | Data            | Methods of collecting data          | Instrument/data source                  |
|----|-----------------|-------------------------------------|----------------------------------------|
| 1  | Landform        | Observation                          | GPS, observation sheet, digital camera, Drone |
|    |                 | Imagery Interpretation               | Landsat Imagery, Google Earth           |
|    |                 | Literature Study                     | Harijoko et al and Van Bemmelen         |
| 2  | Slope           | Observation                          | Observation sheet, Yallon, abney level, roll meter |
|    |                 | Documentation                         | *Peta Rupa bumi Indonesia* or RBI map (Indonesian Topographical map), Google Earth |
| 3  | Relief unit     | Observation                          | Observation sheet, Yallon, abney level, roll meter |
|    |                 | Documentation                         | RBI map                                |
| 4  | Rock type       | Observation                          | Observation sheet, geological compass, GPS |
|    |                 | Documentation                         | Geological Map                         |

**Figure 2.1 Research Procedure**
In this research, the main points of emphasis are survey and geomorphological mapping. In addition, field survey activities and geomorphological mapping are carried out as the first step in conducting field analysis in order to identify and analyze the geomorphological hazards of the research area. The data analysis technique used in this research is descriptive analysis with a spatial approach to the location aspect. When using this analysis, the spatial conditions between each unit of the eruption trail part of the Dieng Volcanic Complex must be considered. The use of descriptive analysis with due observance of spatial aspects is obtained from literature studies from reference books and image interpretation which checks field conditions. The field survey was conducted by combining a comprehensive analytic geomorphological survey method and a synthetic terrain survey method. The use of descriptive analysis through the place aspect aims to identify geomorphological hazards after field identification and measurements are carried out, the use of these aspects of the area aims to determine the geomorphological hazards in each area with other areas. The analysis begins by identifying geomorphological conditions. When identifying geomorphological conditions and hazards, the emphasis of the analysis on geomorphological processes, types of landforms and land use distribution in the study area are the main steps taken to obtain relevant and detailed discussion of the surrounding terrain conditions.

This study also uses the same steps as previous research which refers to Ashari [9]. Topographic analysis and classification in the research area related to geomorphic hazard potential is carried out in several stages, namely: (1) detecting terrain related to land forms, geology, soil, hydrology, and vegetation / land use processes, to collect terrain data, (2) the second step describes and delineates the main reliefs, (3) details the terrain based on land form units, and (4) Step 4 is to select and describe the terrain features associated with the geomorphological hazard potential. For a clearer and more complete discussion, the four steps can be continued in step. Step (5) is part of the terrain assessment phase, which is a continuation of the terrain analysis and classification. This stage includes assigning terrain features to geomorphological hazards.

3. Results
3.1. Research Area

The research area covers all areas outside the eastern side of the Dieng Volcanic Complex which administratively includes the Tieng Village, Sikunang Village, Campursari Village, Sembungan Village, Maron Village, Seranggede Village, and Mlandi Village. The five villages cover two sub-sub-districts, namely Kejajar and Garung sub-districts, Wonosobo regency, Central Java. On the southwest side of the research area which is the area of Watumalang Sub-district using secondary data sources listed in previous research from Ashari in 2019. Astronomically this area is located at 372515 mT to 384411 mT and 9191594 mU to 9203216 mU at UTM zone 49 coordinates (Figure 3.1). This research location also has a total area of 90.2 km². The research boundary when viewed physiographically this area is bounded to the north by volcanic landscapes and denudational mountains, namely the Dieng Volcanic Complex, in the eastern part it is bordered by the Sindoro Volcano, as well as parts of the Serayu Mountains in the south and west. Furthermore, administratively this research area is limited to the north and west by Banjarnegara Regency, the south is bordered by Watumalang and Mojotengah sub-districts, and in the east, it is limited by the central side of Kejajar Sub-district.
From a geomorphological perspective, the study area includes several volcanic groups (Volcanic Complex) consisting of Mount Bisma, Mount Seroja, Mount Sidede, Mount Sikunir, Mount Prambanan, and Mount Pakuwaja, so this area is generally grouped into five sub-units of shape. The landform consist of volcanic cones, volcanic slopes, volcanic foot, volcanic footplain, and volcanic fluvial plains because the average volcano in this study is a type of stratovolcano even though it is currently in a denudational phase. However, if you look at it in more detail, this research area also includes several landforms, including volcanic cones, volcanic slopes, creators, and caldera.

The geological conditions of the study area based on the information on the geological map of the Dieng Volcanic Complex, Wonosobo Sukhyar, et al [10] have various geological conditions, starting from young dieng surface deposits in the form of alluvium deposits in the valley area between the Volcanoes of Mount Bisma and Mount Seroja and the Cebong Lake. which consists of breccias, sand, and unconsolidated layers showing that the area has flat or sloping morphology. The sedimentary layers of the Dieng volcanic rock which are included in this area are andesite lava and andesite biotite which occupy the northern side of the study area. In general, Sikunir, Prambanan and Pakuwaja volcanic rocks are in the form of andesite and clastic lava deposits from a series of young Dieng volcanoes. There is a lava deposit on the east side of the study, namely the Sikunir lava deposit which can be assumed that an
eruption occurred and there was a flow of lava movement that headed east. Meanwhile, the material composition of the Adult Dieng Volcanic Rocks, which are generally in the form of andesite and clastic lava, is found in Bisma, Seroja, and Sidede Volcanoes. Dieng volcanic rocks which are included in this area are the lower part of andesite lava and andesite quartz and volcanic clastic rocks, with a relatively lower silica content compared to the younger part. The andesite lava deposits from Bisma and Seroja volcanoes dominate the constituent materials in the study area. The climate is based on BPS data from Wonosobo Regency [11] from the three sub-sub-districs in the study (Garung, Kejajar, and Watumalang) which have high average rainfall numbers (Table 3.1).

**Table 3.1 Rainfall in Garung, Kejajar, and Watumalang**

| No | Sub-Sub-distric | 2014 Rainfall (mm) | Rainy days | 2015 Rainfall (mm) | Rainy days | 2016 Rainfall (mm) | Rainy days | 2017 Rainfall (mm) | Rainy days |
|----|----------------|--------------------|------------|--------------------|------------|--------------------|------------|--------------------|------------|
| 1. | Kejajar        | 3157               | 212        | 2136               | 177        | 4141               | 244        | 3578               | 252        |
| 2. | Garung         | 3014               | 190        | 3212               | 159        | 5147               | 312        | 3433               | 218        |
| 3. | Watumalang     | 2389               | 245        | 2456               | 197        | 4043               | 305        | 2590               | 223        |

The peak of rain in the three sub-sub-districs has the same character, which occurs at the end of the year, more precisely in November and December, and the lowest rainfall occurs in the middle of the year, more precisely in July and August. Aspects of air temperature in this research area, namely the sub-districs of Kejajar, Garung, and Watumalang are following the state of the mountainous area, the temperature in this area ranges from 14° C to 27° C, but in the dry season the temperature can reach 14° C or less. In the geomorphological context, this high rainfall is a factor that affects the rate of geomorphic phenomena and an important factor that determines the development of the landscape in this area [9]. Seeing from the climatic factors of the data and also seeing from the viewpoint of the landscape of the research area which is a highland and morphological factor in several volcanic cones in the study area also encourages the formation of orographic rain so that the Dieng Volcanic Complex Area has high rainfall, many with great intensity.

Hydrological conditions are characterized by river flow systems with radial and dendritic flow patterns, radial patterns are shown in several rivers that have not been affected by high denudation, and dendritic patterns show characteristics of denudational landforms. Another hydrological condition was found in the spring belt on bending the slopes in the Outer Dieng Volcanic Complex area. In this research area, springs are the main source of water to meet daily needs such as logistics and are used to support the survival of the surrounding community. The use of these springs is by using a pipeline to the springs and distributed to the community. Springs are a source of livelihood for water needs in the study area due to several factors, one of which is the relief condition, which is hilly to mountainous, is a factor that hinders the ease of access to groundwater. The use of these springs is also based on the quality of clean and clear water rather than surface water such as rivers. Land uses include forest, rice fields, gardens, settlements, moor, and shrubs. Land use in the form of forests is still found in the volcanic cones in the Dieng Volcanic Complex. The most dominating land use in this research area is the moor, which is very unfortunate because a lot of this moor is on slopes with steep slopes, clearing land devoted to the use of moor in areas with steep slopes will increase the potential for disasters such as landslides. Settlement areas in the study area are very rare. The settlements located in the research area are in an area where the slope is not that steep and there is main accessibility. The residential area is uneven because the Wonosobo community is more centralized in urban areas. Based on data from BPS Wonosobo Regency (2019), the majority of the population in the research area, namely Kejajar, Garung, and Watumalang Sub-districs are farmers and traders, although there are other jobs such as civil servants and private employees, these jobs are only on a minor scale.
3.2. Geomorphological Study of Research Areas

Geomorphology is a complex and detailed scientific study when translating about the phenomenon of physical conditions on the earth's surface, which includes the form of rivers, hills, plains, beaches, dunes, and many others. Geomorphology examines landforms and the processes or factors that shape them. The forms, processes, and interrelationships between landscapes are at the core of understanding the origin and development of landscape forms. In geomorphology, shape or form has three aspects - composition (chemical and physical properties described by material property variables), configuration (size and shape described by geometric variables) and mass flow (by mass flow variables such as discharge rate, precipitation flow rate and evaporation). Referring to Verstappen [3], geomorphological studies are very complex and based on many aspects of landform, genesis, processes, and the environment while other scientists like Huggett explained, in geomorphological studies, there are several aspects discussed in the study, the aspects in question are structural and process aspects. [12].

The aspect of the study used to discuss a research on geomorphology in this area refers to previous research, namely the Ashari research in 2019 [9]. This includes forms of dynamic geomorphological studies related to short-term processes and changes, forms of static geomorphological studies related to actual landforms, forms of environmental geomorphology studies related to landscape ecology, and forms of genetic geomorphology studies related to relief development in the long term.

Discussion about genesis, the research area is largely formed in volcanic landforms. The origin genesis of volcanoes in this area can be characterized by several volcanic cones with river flow patterns classified as radial patterns. As mentioned above in all parts of the study area, when viewed from a geomorphological perspective, there will be found parts that characterize the origin of this research area being a volcanic area, and of course, the study area will include several volcanic clusters (Volcanic Complex) consisting of Mount Bisma, Mount Seroja, Mount Sidele, Mount Sikunir, Mount Prambanan, and Mount Pakuwaja, in general, the morphology of this area is grouped into five landform units, namely volcanic cones, volcanic slopes, volcanic foothills, volcanic foot plains, and volcanic fluvial plains, but is viewed in more detail using images, there is a landform unit in the form Guungapi cone, volcanic foot slopes, creator, and caldera see Figure 3.2. This is because the average mountains in this study are Stratovolcanoes, even though they are currently in the denudational phase. Information regarding the genesis aspect of the volcanic complex in the study area is increasingly clarified in the results of image interpretation with evidence that there are several landforms such as volcanic cones that form a volcanic complex cluster in the study area.
Figure 3.2 The Geomorphological Map of Outer Dieng Volcanic Complex Research Area

The process that dominates the volcanic landforms in the current research area is denudational. Indonesia's tropical climate is one reason that the denudation process has developed in mountainous areas, so that it has characteristics such as air temperature and high rainfall. Denudation is a form of a weathering process on the earth's surface that generally occurs in structural and volcanic landforms. As described by Huggett [12], weathering is the breakdown of rock by mechanical disintegration and chemical decomposition. When exposed to lower temperatures and pressures on the earth's surface and in contact with air, water, and organisms, these rocks begin to decay. Weathering tends to weaken the rock and make it more permeable so that the rock is more susceptible to erosion by erosive agents, and removal of the surface layer of the rock will speed up the weathering process.

Based on the results of the geomorphological survey regarding field conditions, various geomorphological processes have taken place in the current research area. Exogenous processes that dominate and are strong have resulted in the occurrence of several geomorphic phenomena such as erosion and mass movement processes. Geomorphological processes in the form of erosion are found in the research area in various types, namely, in the form of splash erosion, sheet erosion, furrow erosion, and trench erosion, the erosion process of some of these erosions is a factor that causes the valley floor to widen and deepen. This erosion process is also accelerated and exacerbated by human-influenced...
activities, especially in land management. Human activities such as land reclamation for agriculture and mooring on steep mountain slopes will significantly impact the acceleration of erosion. Soil solum that has become thin is a parameter of the fast rate of erosion. The soil erosion will continue and can be said to be massive if there is a parent soil material called regolith has appeared in several places to the surface because the topsoil has been lost.

There is a geomorphological process besides erosion that is found in the research area, the process is a mass movement consisting of various types, namely slides (rotational and translational), falls, and creeps. Fall and Slide are the most common types. Fall is the downward movement of a mass of rock and soil from which it is free falling. Fall is more common, especially in landscapes with steep rocky slopes and towering cliffs. While slides are a form of mass movement that occurs on a wide scale. This movement occurs because of the mass transfer along with the landslide (slide) plane which moves by sliding from its original place. The two subtypes are rotational and translational slides. Creep mass movement is a very slow plastic deformation of soil or rock. They occur due to pressure exerted by the weight of the soil or rock bodies and usually occur at depth, under weathered layers [12]. The high intensity of rainfall, volume, and length of rainy days will affect the mass movement events. Various geomorphological processes such as erosion and mass movement is a natural cycle which when studied using the context of geomorphological hazards can be a threat or danger to living things around the area.

The result of geomorphological survey and observations in several sample locations using geospatial technology and documentation as a way to assist data collection shown in Table Geomorphological survey results and observations in several sample locations Table 3.2 and Geomorphological Map of Outer Dieng Volcanic Complex Research Area Figure 3.2.

Table 3.2 Geomorphological survey results and observations in several sample locations

| No | Location   | Coordinate                  | Elevation (masl) | Erosion Type     | Soil            | Rock Type       | Slope Shape | Slope | Slope Length | Land Use | Mass Movement Type |
|----|------------|-----------------------------|------------------|------------------|-----------------|-----------------|-------------|-------|--------------|----------|------------------|
| 1  | Mlandi I   | 49-379606 9195829           | 1221             | Splash, sheet    | dusty clay      | Lahar / sediment| Concave     | 45%   | 30 m         | Moor     | Creep            |
| 2  | Mlandi II  | 49-379505 9197209           | 1335             | Splash, sheet    | dusty clay      | Lahar / sediment| Concave     | 60%   | 35 m         | Moor     | Fall             |
| 3  | Mlandi III | 49-379113 9197946           | 1501             | Splash, trench   | Sandy loam      | Pyroclastic     | Concave     | 90%   | 55 m         | Moor     | Fall, slide (translational & rotational) |
| 4  | Sembungan I| 49-379302 9199297           | 1770             | Splash, trench   | Sandy loam      | Lahar           | Concave     | 30%   | 7 m          | Bush, Tour| Fall             |
| 5  | Sembungan II | 49-379246 9199685         | 1967             | Splash, sheet    | dust            | Pyroclastic     | Concave     | 38%   | 11 m         | Moor     | Fall             |
| 6  | Sikunang   | 49-379453 9200765           | 2154             | Splash, sheet,   | Sandy loam      | Lahar / sediment| Concave     | 38%   | 11 m         | PLTU, Moor| Fall             |
| 7  | Tieng      | 49-382067 9201126           | 1950             | Splash, sheet    | dusty clay      | Pyroclastic     | Straight    | 12%   | 30 m         | Moor     | Slide (rotational) |
| 8  | Seranggede | 49-383461 9198128           | 1421             | Splash, sheet,   | dusty clay      | Lahar / sediment| Concave     | 40%   | 10 m         | Bush    | Slide (translational & rotational) |
| 9  | Maron      | 49-381366 9195904           | 1229             | Splash, sheet    | Sandy loam      | Lahar / sediment| Concave     | 34%   | 16 m         | Tour, tea garden, tobacco | Slide (translational & rotational) |
3.3. Geomorphological Hazards in the Outer Dieng Volcanic Complex

The study of geomorphological hazards in this research area includes mass movement and erosion. The strong climatic influence along with the terrain of the old outer Dieng area causes various geomorphological phenomena that can affect and threaten the safety of living things. This research area has regional characteristics that have reached the denudational phase. This is reinforced because the outer region of Dieng is an area that has been eroded by high exogenous factors so that the constructive nature of endogenous factors such as tectonic and volcanic factors is no longer dominant. The many types of geomorphological hazards in the study area indicate that the relationship between high climatic factors that affect the area. These symptoms are the main source of this research location having various kinds of geomorphological phenomena that can cause disasters to live things, especially the people around the outer Dieng, therefore it can be called a geomorphological hazard. There are several types of mass movements identified through geomorphological surveys that are often encountered in the field. These include, among others: falls, slides, andcreeps.

Taking from the main point the characteristics of the landforms and the ongoing series of geomorphic processes, geomorphological hazards in the outer Dieng originate from denudational processes by the climate in the form of mass movement and erosion. The length of the rainy day, the high intensity of rainfall, and the volume, greatly influence the mass movement events. This mass movement occurred in various parts of Mount Bisma, Mount Seroja, Mount Sidede, Mount Sikunir, Mount Prambanan, and Mount Pakuwaja, both in volcanic cone units and in other volcanic units. This mass movement in outer Dieng occurs in various types. The process of mass movement found during terrain survey were of various types, namely slide (rotational and translational), fall, and creep.

This slide type mass movement occurs because of the old mountain, the high level of weathering, and the type of soil that has high aggregate as seen in the table of measurement results that the average area that has the form of slide type mass movement has clay and loamy soils. Both types of soil are classified as the last phase soil or can be said to be old and have very small soil particles so that the soil porosity is low. This type of slide occurs around the eruption of Mount Bisma because Mount Bisma is one of the oldest volcanoes in the Dieng Volcanic complex. Harijoko et al [4], state that the oldest part in the Dieng Volcanic Complex area is at least 3.6 million years old on Mount Prahu or 2.53 million years on Mount Bisma even the youngest part is 90 thousand years old on Mount Pakuwaja or 70,000 years at Mount Seroja. Of course, on Mount Bisma it is very possible to have a slide-type mass movement. Steep slope coefficient is the main factor related to the slide-type mass movement. In the field, the slides are dominated by very steep slopes, with a slope of 12% - 90%. The slide mass movements that were found consisted of rotational and translational slide types. While rotational slide mass movement with the composition of the material does not change much and is generally influenced by rotational motion, it is called a slump. This rotational slide-type has bedrock in the form of debris slump, earth slump, and rock slump. Meanwhile, translational slides are a type of mass movement that is influenced by translational motion with the composition of the material changing a lot. The basic rock types of translational slides are rapids, ice sliding, debris slide, earth slide, debris block slide, earth block slide, rock slide, and rock block slide. The adult Dieng rock formation contributes to the large mass movement of the slide type because when viewed from the type of material it is composed of, it is lava andesite.

The basic material in the Seroja Volcano, namely the Tieng, Seranggede, Maron area, which is andesite lava as a material has low porosity, make a lot of mass movement in this area especially the slide-type mass movement. The result of the terrain which has low porosity is that the infiltration in this area is not too much so that the rainfall will be responded to by the soil as runoff and cause or tend to cause slide mass movement. Even in Ashari's previous research [9], the Bisma Volcano can have several types of mass movement that are more varied, of course, this factor is caused by the terrain which is composed of Dieng volcanic material in the Bisma volcano and material from the Jembangan volcanic material in the fold belt. In this area, you can find the mass movement of the slide, creep, and fall types. Old volcanic rock material is one of the causes, this is confirmed by Hadmoko [13] who explained that based on landslide data throughout Java between 1981 and 2007, from this data it can be analyzed that
Erosion is common in this research area and erosion mainly occurs on slopes of 30°-40° in weathered soil areas caused by the foundation material of an old terrain, such areas were usually in a denudational state. The steeper slope of the case on a steeper slope above 4o landslide events is reduced because the steeper location material is relatively more stable and is supported by less land use by the community. Similar discoveries have occurred in the Seroja volcanic area which is composed of several old volcanic materials such as clastic pyroclastic debris consisting of pyroclastic breccias and agglomerates with the basic material in the form of andesite lava and even experiencing many landslides. In the field, it shows that the slides in the Seroja Volcano area occur at a slope of 12% to 40% with a height ranging from 1200 masl to 1950 masl. There is also a slide event at a 90° slope with an altitude of 1500 masl in the Bisma volcano crater.

Besides the slides, there are also creep and fall type mass movements. On the other side of the Vulkan Bisma, there are many creep and fall type mass movements. The lithology factor of volcanic products which has greater permeability and porosity is very likely to have an effect on the existence of the creep and fall type mass movement coupled with the increasingly steeper slope so that creep and fall can exist. Creep is a mass movement that moves at a slow speed. Creep has a small amount of water and is often found in the fold zone [9]. In the study area, creeps were identified on upland agricultural land at the foot of the Bisma Volcano. Creep is found on a 45% slope with a height of 1221 masl. While a fall is a fall or mass of rock that moves through the air, including free-fall, jumping and rolling over boulders and scrap material without much contact with one another. Fall was identified in Vulkan Bisma, Vulkan Seroja, Vulkan Sidede, and Vulkan Pakuwaja. Fall is often found in upland agriculture with a slope of 30% to 90% and an altitude ranging from 1300 masl to 2150 masl.

Another very influential factor in mass movement is rainfall. In certain seasons, such as the rainy season, mass movement often occurs. Along with the peak of the rainy season, the intensity of mass movement also increases. In the outer area of the Dieng volcanic complex, which is based on mountainous areas and highlands, of course, has relatively high rainfall, the strato volcanic cones these areas play a very important role in the formation of orographic rainfall. Due to higher rainfall, there will be more water infiltration, causing a lot of mass movement to occur. Apart from the rainfall factor, Humans are a very influential factor in the mass movement, for example, land use. land use greatly affects the movement of the masses if it is not properly regulated and managed. From year to year, the population growth rate will increase and along with the development of life there are human needs which cause people to use more land, in the outer area of the Dieng volcanic complex or this research area, many people use the land even including lands that are prone to landslides. Land use activities by the community have also triggered landslides and various other types of mass movements.

Widespread land degradation occurs due to potato cultivation activities, landslide impacts during the rainy season in many residential points and roads along the Garung-Kejajar sub-sub-distric, flooding that occurs due to disruption of watersheds due to landslides, and drought during the dry [14]. According to Ashari [9], moor, then rice fields, and then forest are the forms of land use that occur the most landslides, especially in the moor. there is a lot of lands uses in this area which has led to mass movements in the Watumalang area. The land use includes moor and slope cutting which is used for road construction. Agriculture in the moor in this study area is found on steep slopes such as the middle slopes to the top of the mountains. the improper use of upland land resulted in an increase in the potential for large mass movements.

In the field conditions, when the geomorphological survey was carried out, there was another geomorphological hazard besides mass movement. Erosion is common in this research area and erosion is also one of the Geomorphological hazards besides mass movement. However, it is emphasized that this research only identifies the appearance or presence of erosion and observes the type of erosion in the field. Calculating the rate of erosion and determining the level of erosion hazard has not been carried out in this study. The phenomenon of erosion can also trigger various forms of threats to living things, both loss of property and damage to infrastructure and public facilities. According to Arsyad [15], an erosion event is an event of moving or transporting land or part of the land from one place to another using natural media such as water and wind. If there is erosion, soil or part of the soil from one place will be eroded and transported which is then deposited in another place. In fact, the factors that influence
mass movement and erosion are almost the same and interrelated, erosion can also be caused and influenced because it is the result of interactions between climatic factors, topography, vegetation, and human intervention (management) of land [15].

There are variations in the types of erosion types found based on the results of the terrain survey in the research area. This erosion includes various types namely splash erosion, trench erosion, furrow erosion, and sheet erosion. However, splash and sheet erosion are the dominant types of erosion types or are often found in the study area. Several variations of this erosion are explained according to Nursa’ban [16], splash erosion is erosion that occurs at the beginning of rain because this erosion is caused by the influence of rainwater. The rainwater causes an impact or collision because it gives certain energy when it falls (kinetic energy), this energy can release soil particles. The release of soil particles from the soil mass due to splash erosion is very dependent on the type of soil being eroded. This spark erosion can be found in every field and research location. Splash erosion is the initiation or cause of other erosion such as sheet, furrow, and trench erosion. The erosion found in each study area shows that the outer Dieng area has a high rainfall intensity. This is supported by the rainfall data of BPS Wonosobo Regency [11] from the three sub-sub-districs in the study, namely Garung Sub-distric, Kejajar Sub-distric, and Watumalang Sub-distric which have a high average number of rainfall. The average rainfall in 2014-2017 in the three sub-sub-districs reached approximately 3,253 mm. Of course, the high rainfall is influenced by factors in the research area which is a plateau and is included in the volcanic complex. The high rainfall has a high influence coupled with the slope conditions, land use. The high intensity of rain causes an increase in the destructive power of soil particles, namely soil aggregates so that there is a lot of splash erosion in each location that has been identified, this is in accordance with research [9].

Of course, splash erosion will stop if the raindrops are no longer able to penetrate the thickness of the water layer, this is when the sheet erosion process begins. Sheet erosion is a continuation of splash erosion and can be found clearly over a relatively uniform surface area. Next is a continuation of sheet erosion. Sheet erosion is the research area can be found in the mean sample locations of the outer Dieng volcanic complex. Sheet erosion is continued erosion of the predominant splash erosion in this area, the average sheet erosion occurs on several slopes from sloping to steep. The next erosion is groove erosion starting from the presence of surface runoff concentration. This erosion often occurs on land on the slopes of mountains to form grooves. Erosion also greatly affects the activities of increasing the socio-economic needs of a place. The more the population continues to increase and coupled with the use of land to meet economic needs, the negative impacts on the environment often occur. The natural vegetation change in the research area is the use of moor. As has been explained above, the moor is a land use that is very vulnerable to mass movement and erosion. Planting plant species in the moor also greatly influences the type and magnitude of erosion. The average types of crops cultivated in this region include corn, chilies, potatoes, tobacco, and various other types of crops. As only in the research of Khadija et al [17], in the Kalaya River Basin, Morocco. Degradation of vegetation cover is still a very common problem in many locations in Morocco, in fact, it directly affects the annual amount of land loss, this is due to side effects and negatives such as population growth, technological advances, and an increase in the forest-economy. The degradation of natural vegetation has reached surprising levels and has even caused various natural disasters such as erosion. The impact of forest and land degradation has made the Dieng Plateau area save a lot of potential disasters [14] including toxic gases caused by the volcanic activity of the Dieng volcanic complex [18].

According to Nursa’ban [16], if the distance reaches hundreds of meters, what happens is not channel erosion but surface runoff erosion. When the size of the groove is very large, it cannot be removed just by regular plowing, or the channel is directly connected to the main drain, then the erosion that occurs has met the category of trench erosion. Subsequent erosion is trench erosion which is found in several locations with 30-90% slopes. This is certainly relevant to Ashari’s research [9] at Watumalang that the results at a slope of 30° or more show that the erosion rate of the channel and trench erosion type is getting bigger and growing. It can be said that the steeper a slope will increase the result of erosion that occurs in an area. The effect of a steep slope will accelerate the runoff rate. When the surface runoff rate is high, it will certainly increase the strength of the runoff to erode the land that is passed. This is
confirmed according to Guerra et al [19], which explains that the dominant hillside processes are associated with gravity and flowing water. Other influences such as human activities also play an important role in the hillside process, due to land-use change and logging of natural vegetation. Especially in tropical areas, where rainstorms and other extreme weather are very likely, the signs of erosion are clear, erosion in tropical areas is usually higher and filled with sediment due to deposition. Although mass movement and erosion are natural phenomena, human activities often accelerate the erosion process. Erosion can occur naturally, due to the angle of inclination and rainfall, and other factors as described above. Humans are a major and important role in this geomorphological process, they present various modes of events and causes and effects as a very influential role in nature today. According to Andriana [8], Dieng is an area that must be protected from production activities and other human activities that can damage its protective function. According to the Wonosobo, Level II Sub-distric Regional Regulation Number 1 of 1996 concerning the Regional Spatial Plan for the Wonosobo Level II Distric, the Dieng Plateau is part of a protected area. In Regional Regulation No. 1 of 2004 [20] concerning Regency Spatial Planning. Banjarnegara, Dieng Plateau Area is also a Protected Function Area. The Dieng Plateau area is a protected area that should be protected from production activities and other human activities that can damage its protection function. However, in fact, this area is used by humans to meet their needs by utilizing large-scale land for planting seasonal crops, namely potatoes, because potatoes are a superior commodity for farmers in the Dieng Plateau. Various natural events caused by the use of human land in this area, among others, cause geomorphological hazards that can cause losses to life around the outer area of the Dieng volcanic complex, the potential geomorphological hazards, both erosion, and mass movement in the outer area of the Dieng volcanic complex, are certainly reinforced by the denudation process by climatic influences. The outer Dieng area, which is part of the Dieng volcanic complex, has various variations in the age of the landform unit, which makes the phenomena of mass movement and erosion in this area very varied. The outer area of the Dieng volcanic complex, if viewed from genesis, has a lot to do with volcanic events, but these events played an active role in the past, but this volcanism does not play a role as a trigger for geomorphological hazard at this time but the results of the denudation process such as mass movement and erosion.

4. Conclusion
The Outer area of the Dieng Volcanic Complex, is one of the most vulnerable areas and currently facing geomorphological hazards caused by the denudation process in the form of erosion and mass movement. The Outer area of the Dieng Volcanic Complex, if viewed from genesis, has a lot to do with volcanic events, but these events played an active role in the past there will be found parts that characterize the origin of this research area being a volcanic area like a geological system in this place. However, volcanic activity as in the past does not pose a geomorphological hazard in the present era, but the results of the denudation process such as mass movement and erosion. Due to the sharp climatic influence and slow endogenous processes that create new problems, namely the denudation process, this kind of process is the main cause of damage or can be called a geomorphological hazard. The varying ages of volcanoes and the strong weathering of the rocks exacerbate this situation and encourage geomorphological disasters to become more severe and life-threatening. Based on the research results as described above, the outer area of the Dieng Volcanic Complex is faced with environmental degradation problems which are getting worse over the years. The main cause besides the denudation and relief process is the conversion of forest land to cultivation land and in some areas, it has turned into settlements. Conservation behavior that is built by the community and the government is very much needed, this is because the natural vegetation of the study area if reforestation or reforestation is not carried out, will continue to be eroded by the factor of land clearing as cultivation land or residential land. Humans should be aware to protect and provide positive treatment to their surroundings because of the environment human can survive.
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