MULTI-HAZARDS ANALYSIS BASED ON LANDSCAPE APPROACH IN THE AREA OF YOGYAKARTA NEW AIRPORT SITE PLAN

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ABSTRACT

Landscape of Kulon Progo coastal area is very attractive with abundance natural resources and adequate accessibility. On the other hand, this landscape provides a challenge for the new airport development planning. This area is composed by mountains, hills, coastal areas, and flood plains which potentially results in various hazards. All potential hazards may become disaster that could potentially lead to damage and loss to various vital infrastructure and vulnerable elements. An integrative and comprehensive study regarding multi-hazards that may occur is necessary. Development planning should be integrated with disaster risk assessments, so the research on multi-hazards in the site plan of the new airport of Yogyakarta is very important.

This research has three main goals: 1) to identify the relationship between landscape characteristics with the potential hazards that may exist, 2) to identify the type of hazards in each unit of landforms in the study area, 3) to identify the potential multi-hazards in the study area. This research used survey method, i.e. by landform analysis through image interpretation and compilation of supporting data to generate a multi-hazards map.

The preliminary finding of this research indicated that landscape has a specific characteristic and it is correlated with one or more potential hazards. Some coastal hazards occur in fluvio-marine landform are tsunami, storm surge, and windstorm. In fluvial landform the hazard than commonly found is flood and wind storm. Earthquake may happen in both landform types. The multi-hazards type in the research area can be divided into two types, i.e. (i) collateral multi-hazards, such as earthquake that trigger tsunami, and (ii) simultaneous hazards, indicated several hazards occur in the same time but no correlation among them. For example, flood, wind storm, and storm surge happen in the same time triggered by hydrometeorological phenomena. The output of this research are multi-hazards map and integrated analysis report regarding multi-hazards analysis based on landscape approach.

Keywords: Multi-hazards, Landscape, Yogyakarta New Airport Site Plan

INTRODUCTION

Indonesia has the geography, geology, hydrology, and demographic which potential to occur as disaster. It could be caused by natural factors, non-natural factors and human factors. Located in a ring of fire lines, Indonesia is extremely vulnerable to natural multi-hazards. Disaster historical data shows that Indonesia is vulnerable to natural multi-hazards such as floods, landslides, tsunamis, earthquakes, volcanic eruptions, droughts, forest and land fires, tidal waves, and land subsidence.

Various types of disasters cause a huge loss of property and lives. National Disaster Management Agency (BNPB) revealed the catastrophic trend in Indonesia increased significantly. The losses reach more than Rp10 trillion per year, exclude losses due to large-scale disasters such as the earthquake and tsunami in Aceh and Mentawai, and Merapi Volcano eruption in 2010 (Susanto, 2012). Sutopo (2012) states that "Ten cataclysmic events such as earthquake and tsunami in Aceh and Nias, earthquake in Yogyakarta, and others caused losses up to Rp 105 trillion." It excludes the toll of casualties. A plan to reduce negative impact of a disaster is conducted a thorough study of the multi-disaster threat in a region based on the characteristics of its landscape. A comprehensive study is intended as the basis for spatial planning that can be a reference for the regional development planning in disaster-prone areas.

Studies and exertion to minimalize the negative impact of disasters in a region require innovative approaches to accommodate various types of hazards. Multi-hazards level assessment of disasters in a region is possible to be applied proportionally by quantitative and qualitative approaches. A qualitative approach is more emphasis on the events that have occurred, whereas a quantitative approach refers to probabilistic calculation of the potential threat. At the same time emerging challenges in formulating a standard method to assess the level of multihazard, because disparity of hazard is not relevant to compare.

The study of physical condition of the region by landscape approach analysis is required to assess the hazards in a certain area. It also can be applied to identify the susceptible area of disasters, because for each occurrence of certain natural disasters will occupy a specific landscape unit. Thematic approach based on the landscape unit is an effective way to estimate multihazards level in a certain region.

Special Region of Yogyakarta (DIY) is known as a city of tourists and students. DIY has the second rank after Bali in tourism sector development. The assessment is based on several factors: first, the diversity of the objects. There are 8 tourist destinations such as the beaches, cave tours, cultural tours, sightseeing craft, museum tours, religious tourism, MICE (Meeting, Incentive, Conferencing and Exhibitions) and tourism village. Second, object specification supported by a harmonious combination of physical objects and non-physical objects. These factors strengthen the competitiveness of DIY as the primary destination is not merely for domestic tourists, but also for foreign tourists. To support all the potential of Yogyakarta, facilities related to transportation is necessary.

On August 7, 2012 International Yogyakarta Airport Master Plan located in Kulon Progo has been inaugurated. The international airport has been planned to replace the current airport (Adisucipto) that has been deemed unable to accomodate the surge of passengers in the future. The inauguration of this Master Plan involves several agencies: the Directorate General of Civil Aviation (DJPU), DIY Provincial Officer, Air Force, and the Directorate General of Railways. Through the Minister of Communication Nr: KP 1164 year 2013 decided that the new airport is located in Temon Subdistrict, about 50 km from the city of Yogyakarta to the south coast which comprises four villages namely Palihan, Sindutan, Jangkaran, and Glagah (Figure 1).

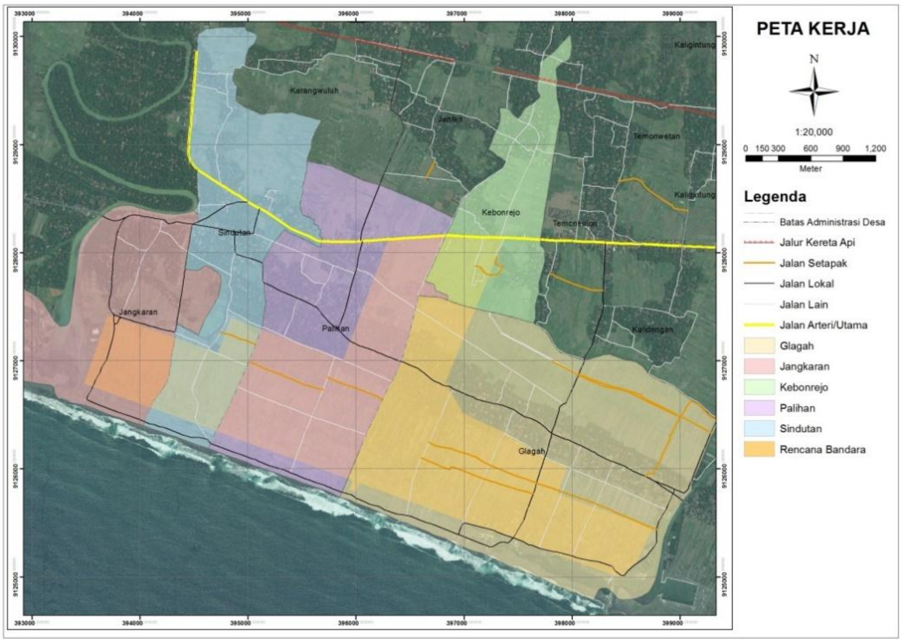

Figure 1. Research Area

The new airport construction site is located face to the tectonic plate zone (subduction zone) between the Indo-Australian Plate with Eurasia plate. This condition consequences a high potential threat of earthquakes and tsunami. In addition, this area landscape lies on the coastal region dominated by sandy material with low-lying topography, hence highly vulnerable to the potential threat of tidal waves, flooding estuaries, and typhoons. As the location of the new airport, the variety of hazards potential that exist in these area are important to be investigated as an input in spatial planning to consider the appropriate mitigation.

Research problem

Formulated problems expected to be answered in this research based on dinamic condition of tectonic arrangement and landscape expose in development area of new Yogyakarta airport are:

1) How is the relationship between landscape condition in the research area and the emerging hazard potential?
2) What type of hazards could potentially occur in each landscape unit in the research area?
3) How are multi-hazards potential in the research area, are they interconnected (collateral) or simultaneous?

Objective

This research has two main objectives, for practical scientific and institutional strategic. The aim of practical scientific research activities are as shown below.

1) To determine the relationship of landscape characteristics in the research area with the hazards potential.
2) To identify the type of disaster in each landscape unit in the research area.
3) To analyze multi-hazards potential in the research area and the hazard characteristics.

Acknowledgement

The authors would like to acknowledge Director of Graduate School, Universitas Gadjah Mada and Magister of Geoinformation and Disaster Risk Management for the research funding. We also acknowledge the Local Disaster Management Agency (BPBD) of Kulonprogo Regency for the invaluable supports during primary and secondary data collection.

Theoretical Framework

Based on the Constitution of the Republic of Indonesia Number 24, 2007 about Disaster Management, disaster risk is defined as the potential loss caused by disasters in a region and a period of time which can be death, injury, illness, life is threatened, the loss of secure sense, displaced, damage or loss of property, and disruption of community activities. Every person is obliged to carry out disaster management activities, which one of the objectives is to reduce the disasters risk.

Assessment of disaster risk-oriented spatial have three main characteristics (Greiving, 2006), namely (i) must be oriented on multi-hazard, (ii) only the risk which relevance spatial considered in the analysis, and (iii) only collective of risk that threatens the society will be relevant, not the individual risk.

Geographically, the study area is an alluvial coastal plain directly face the plate collision Subduction zone in the Indian Ocean. Based on the monthly rainfall data for the past 25 years, research areas is located at the climate area Aw according to the Koppen classification. Verstappen (1983) stated that the direction of the east wind that blew on this research area approaching 325° NE. Viewed from the standpoint of the geomorphology landscape, the location of the study area is located in the two environments. They are the coastal environment with units of land form beach ridges are covered by sand dunes and the coastal environment with landforms unit (beach) which had the beach cusps morphology.

The other physical factors are water waves, tides and the currents. All of them are an important variable to the dynamics of coastal landforms. These variables work together to form patterns of water circulation nearby the coast affecting the erosion and cliff coast line, the formation of the sea floor topography, coastal sediment movement and deposition mechanism at the beach. The intensity of the beach area uses for a variety of human activities, directly or indirectly. These uses can lead to change in the pattern of coastal landforms. Construction of the seawall, groins and breakwater, port development, and the reclamation can change the topography of the beach directly, the indirect effect is to trigger a change in the location of the area eroded and deposited on the beach.

In some cases the occurrence of earthquake damage, the local site effects play a role in causing the damage. The level of damage is not only influenced by the distance to the earthquake epicenter and its magnitude, but also the extent of damage was also heavily influenced by the local geological conditions (Mosidi et.al, 2004). In some earthquake damage, such as the 1985 Mexico earthquake, Kocaeli in 1999, Kobe in 1995, Loma Prieta in 1989 and Northridge in 1994, the damage would occur in a remote location from its epicenter (Tuladhar et al, 2004; Hasancebi and Ulusay, 2006).

Based on macro seismic observations data, the effect will cause a very strong earthquake in a soft condition and wet soil than in the hard and dry soil. The level of earthquake damage will be more severe in the alluvial plains than in a bedrock outcrop (Hasancebi & Ulusay, 2006). Sediment layer with a certain thickness potentially cause resonance in case of multi reflection seismic wave propagation between the sediment layer and bedrock (Tuladhar et al., 2004).

Disaster risk can be described as a function of the threat / danger (hazard) and vulnerability (vulnerability), which can be combined with the ability to cope with disasters (coping capacity). Simply, the risk can be written as follows: R = f (H, V, C), in order: R is risk, H is the danger, V is vulnerability, and C is the ability to cope with the disaster. Currently, disaster risk assessment not only includes one type of risk, but it also begin to be combined with a wide range of disaster risk generated by various types of threats / multi hazards. Estimations of the integrated disaster risk assessment is called multi risk assessment.

Thematic approach to the units of analysis based land system mapping information is explicitly presented in the image and / or a base map, allowed to create multi-level predictive potential hazard in a landscape. Landscape approaches for identifying the hazard is a comprehensively approach which considering ecological impact, economic efficiency, and quality of aesthetics (Tavora & Turetta, 2016). Land system mapping unit at scales of 1:50,000 will be lowered on a larger scale by differentiating the mapping unit. The larger scale of derivatives will provide better classes detail (see illustration on Figure 2).

These data could be multi hazards spatial data and non-spatial data. The data should be made in a spatial database that can be integrated with the land unit. Integration method is made by overlaying the data with the system of multi-prone land unit. This analysis will exist as a tabular database that serves as a data base of multi risk disaster.

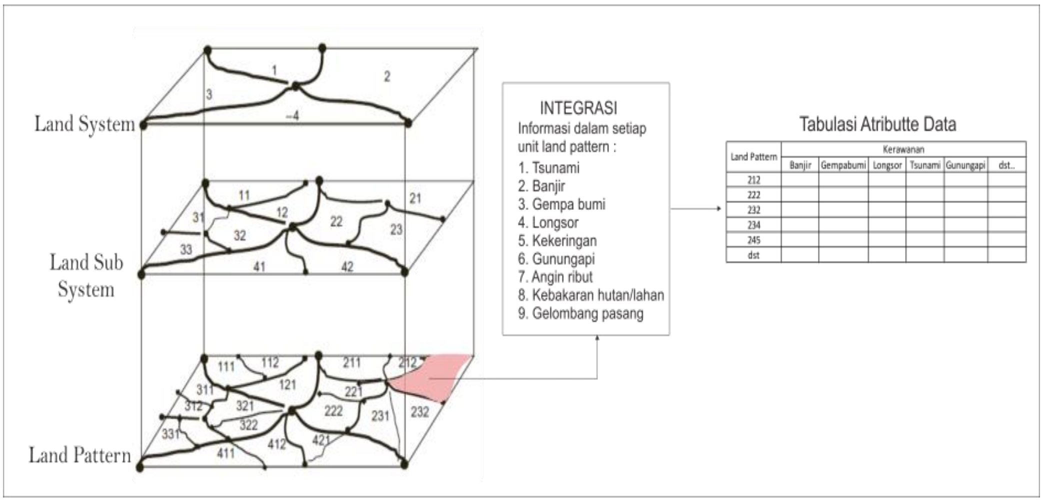

Figure 2. The illustration of integrated data on Land Pattern/Facet

Materials and Methods

The research employs quantitative and qualitative method to attain objectives. The research initially following three phase of activities, i.e. first, data acquisition; second, data analysis, and third, data compilation and classification for creating complete report. The details of material and methods used in this research are depicted in Table 1. The research setting is to conduct two phase fieldwork activities. First phase or pre survey phase will concern to collect primary and secondary data, while the second phase or post survey shall concern to examine and cross-check the results of the analysis.

Table 1. Rationale between Research Objective and Method

Objectives	**Research Questions**	**Expected Outcome**	**Data collection method and Material**
Determine the relationship of landscape characteristics in the research area with the hazards potential	What the landform unit exist in the research area?	Types of Landform unit	▪ Field observations; ▪ Check list ▪ GPS ▪ Camera ▪ Tentative geomorphology map
	How many landform unit are exist in the research area?	Number of Landform unit	
	What the relationship between landscape characteristic in the research area and the emerging hazard potential	Specific relation between landscape characteristic and hazard potential	
Indentify the type of disaster in each landscape unit in the research area	What type of hazard could potentially occur in each landscape unit in the research area?	Information related type of hazard that specifically occur in every landscape unit	▪ Landform analysis ▪ Geomorphology analysis ▪ Geomorphological map
Discover multi-hazards potential in the research area and the hazard charachteristics	How the multi-hazards potential in the research area, are they interconnected (collateral) or simultaneous?	Information related multi hazard and the characteristic of the hazard	▪ Multihazard analysis ▪ Multihazard maps ▪ Report

RESULTS AND DISCUSSION

The research area is located in Temon, Kuloprogo Regency, Yogyakarta Special Region, which genetically can also be referred to coastal landscape. The area is geologically sign on quarter landscape units. Based on the interpretation and analysis, it is found that the study area consists of three major landform units, namely: alluvial landforms (formed by fluvial processes), marine landforms (formed due to marine processes), and aeolian landforms (formed by wind processes). In addition to these three major landforms, research areas are also formed by the geomorphological complex processes or a combination of two or more processes, i.e. fluvio-marine processes, marine and aeolian processes, as well as fluvial, marine, and aeolian processes.

Geological formation has important rule in order to reflect the characteristics of a region. Based on Geological map, the study area is composed by various geological formations, i.e. 1) **Wates Formation** that has two layers, alluvium sediment and marine sediment. Wates formations are in low-lying areas around the Serang River, which may be called the coastal alluvial plain. Based on the deposition process sequence, Wates formation can be divided into two units, namely: (W1) originates from alluvial deposits at the top, which is composed by clay material, silt with a little fine sand and littoral clay deposits mixed silt at the bottom and (W2) originates from marine deposits composed of clay with lenses of marine sand containing marine Mollusca fossils. Wates formations forms the alluvial plain landform with 40 meters of thickness, occupies along the coast in the research area, ranging from Serang River to Bogowonto River. 2) **Sand dunes** with a thickness of 40 meters laying above Wates Formations. Sand dunes material composed by fine to coarse grained sand, mostly contains iron minerals and the rest are other mineral. Sand dunes is a complex landform unit consist of sand dune itself and beach ridge.

Geomorphological characteristic emphasize on the genesis, development process and its relationship to the environment. Based on the landforms unit map, it can be seen that the research area consist of young beach ridge, mature beach ridge, old beach ridge, beach ridge-swale complex and sand dunes, as well as the plains of fluviomarine. In general, the research area consists of two main landform units, namely fluviomarine plains and marine-aeolian origin landform (Figure 3).

Figure 3. Landform Map in Research Area

Fluvio-marine plain is a landform unit formed by marine activity and fluvial activity, which was once a shallow sea zone and the former lagoon or littoral zone (Santosa, 2014). Through the long and continuous process this lagoon covered by alluvial deposits brought by the Bogowonto River. In the dry season, the outlet of Bogowonto River frequently covered by sand and other sedimentary material, thus forming a lagoon. This landform is characterized by a flat morphology with slopes of 0-3%, with a horizontal layered structure at the top and a patterned cross maze in the layer below as a result of the deposition process of marine and fluvial processes. Fluvio-marine plains in the northern part have looked like the alluvial plain, where fluvial sediment making up the top and littoral clay and silt sediment containing fossils at the bottom. In the southern part is dominated by clay and sand sediment littoral containing marine fossils. This landforms unit occupy the center space of the study area, which extends from west to east on the north of old beach ridge unit which is the transition area to the coastal mainland in the past.

The southern part of the study area consists of landforms unit that formed by the marine and aeolian processes, sequentially toward to the coast include: beach ridges, the complex beach ridge, swale, and sand dunes, as well as the beach. Beach ridge unit material is originated from the activities of old Merapi Volcano. The main constituent material of this area is fine to coarse grained sand containing iron ore. This beach ridge is one of landforms unit produced by the marine process. Landform unit consist of complex beach ridge, swale and sand dune are formed by marine-aeolian activities. Beach ridge landforms at most places are used as settlements, while sand dune usually grow and develop over the beach ridge with elongated patterns and alternately with swale, which can act as a drainage basin. This landforms unit consist of the same material as the old beach ridge and young beach ridge, are fine to coarse grained sand. The source of young beach ridge material is from the present Merapi Volcano, transported by fluvial processes up to the Indian Ocean, and flung back by the wave forming younger beach ridge. Just as the old beach ridge, the young beach ridge is also the landforms produced by the marine processes, which was also composed by fine grained sand up to coarse sand material within iron ore.

Based on the landforms analysis performed, it is known that some specific potential hazards occur in several types of landforms. In general, the potential hazard that commonly found in a fluvio-marine landforms is coastal hazards type such as tsunamis, tidal waves, hurricanes, erosion and tidal flooding. In fluvial landforms the common potential hazards are floods and typhoons. As for the potential of earthquakes hazard can occur in all types of landforms, both in the fluvio-marine landforms and the fluvial landforms. The analysis also showed that there are two types of multi-hazards that could potentially occur in the study area, i.e. multi-hazard which are collateral, for example, the earthquake followed by the tsunami and the next one is a multi-hazard which are simultaneous, for example is floods, hurricanes, and tidal waves often occur simultaneously but there is no correlation each other. Their occurrence are influence by hydro-meteorological phenomena that occur simultaneously. In more detail, each type of potential hazard commonly found on each landform unit is presented in Table 2.

Table 2. Landforms and Hazard Potential Types

No	Landform Unit	Hazard Potential
1	Beach Ridge	Extreme weather, Flood, Earthquake
2	Mature Beach Ridge	Tsunami, Earthquake
3	Young Beach Ridge	Tsunami, Storm Surge, Marine erosion
4	Old Beach Ridge	Flood, Earthquake,
5	Alluvial Plain	Flood
6	Coastal Alluvial Plain	Flood
7	Sand Dunes	Tsunami
8	River Basin	Flood
9	Fluvio-Colluvial foot slope	Flood
10	Colluvial foot slope	Extreme weather

A spatial oriented disaster risk assessment has three main characteristics (Greiving, 2006) namely (i) multi hazard oriented, (ii) only spatially relevant risks are included in the analysis, and (iii) instead of individual risk, only collective risks which threaten community are considered relevant. This statement shows that the study of multi-hazard is very important in the context of disaster management. At present, the study of disaster risk does not focus only on one type of risk, but also combined with multi-risk caused by multi hazards. The comprehensive assessment of various hazards type is known as multi hazards assessment.

Based on the varied geological and geomorphological phenomena in the area, disaster risk caused by multi hazards is also varied. The analysis of the source of hazards should be done comprehensively in order to obtain a comprehensive multi hazards assessment. The result of the assessment will be combined with landform unit as the basis to be prepared in addressing the multi hazards analysis, in order to obtain multihazards map as thematic information (Figure 4). In the end, it is expected that the information regarding multihazards in the new airport site plan can be used as the input for risk analysis, in order to prepare a disaster plan for the new airport area.

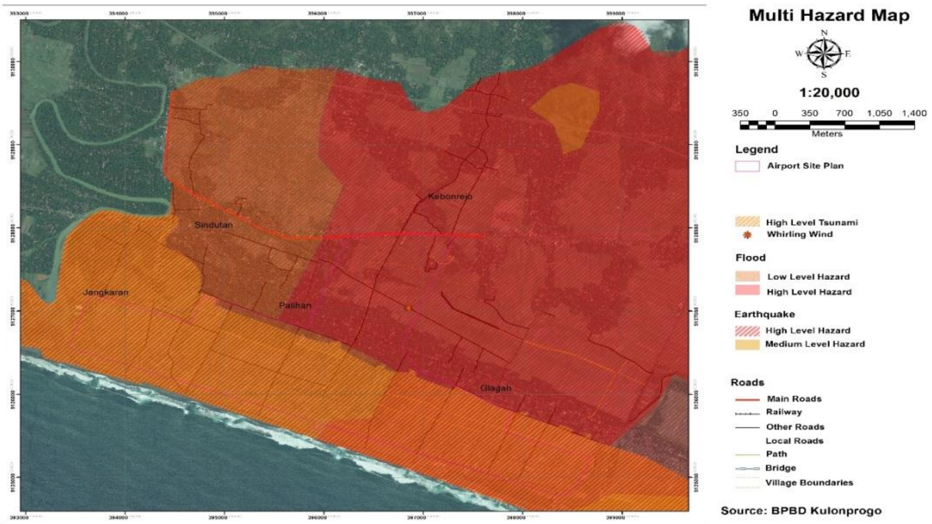

Figure 4. Multi-hazards Map in Research Area

CONCLUSIONS

1. The preliminary finding of this research indicated that landscape has specific characteristics and correlation with one or more potential hazards. In fluvio-marine landform, some coastal hazards commonly happens are

tsunami, storm surge, and windstorm. In fluvial landform, the hazard commonly found are flood and wind storm.
2. Earthquake hazard may happen in both landform types.
3. The multi-hazards type in the research area can be divided into two types, i.e. collateral multi-hazard (e.g. earthquake and tsunami) and simultaneous hazards (e.g. flood, wind storm, and storm surge, triggered by hydro-meteorological phenomena).
4. The multi-hazards map and its analysis is expected to be used as the input for risk analysis, in order to prepare a disaster management plan for the new airport area.

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