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DETERMINING THE LOCATION OF LAND SUBSIDENCE OBSERVATION POINTS BASED ON LITHOLOGICAL DATA AND LAND COVER CHANGES IN LAMPUNG PROVINCE

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ABSTRACT

Land subsidence is a phenomenon that always occurs due to natural factors as well as human actions. Land subsidence has an even impact on all fronts. Land subsidence occurs continuously, therefore it is necessary to observe the phenomenon of land subsidence periodically using the GNSS method, which requires a benchmark that serves as a reference point for observation. With the need for a new benchmark devoted to observing land subsidence, it is necessary to do spatial modeling which is useful for finding out the suitability of the location where the subsidence observation point will be made. Spatial modeling was carried out using land cover data and lithology type to then be given weight and score and determined the soil movement vulnerability class into three, namely low class, medium class, and high class. The results of the spatial modeling of subsidence vulnerability show that the area12292.60 square kilometers is low grade, 20230.64 square kilometers represents medium class and 540.32 square kilometers is high class. Based on these results, the planning of the location of new observation points was carried out in areas with moderate to high levels of vulnerability with a total of 87 points scattered throughout the cities in Lampung.

***Keywords**: Land Subsidence; Lithology; Land Cover.*

A. INTRODUCTION

Lampung Province is one of the provinces with fast growth on the island of Sumatra, this is an indirect impact of its strategic location as the entrance from Java to Sumatra. Based on data from the Central Bureau of Statistics, the province of Lampung has a projected population of 17,042,402 people in 2020 spread across several districts and cities in the province of Lampung (Zaenudin et al., 2018).

The rapid population growth encourages land use change so that the reduction of green areas which are very useful for life as an example of its function is as a water catchment area. The water catchment area functions as a reservoir for rainwater which will be infiltrated into the ground so that it is useful for the stability of the volume of water below the soil surface. Given the large population projection of Lampung province, the use of clean water sources will increase inversely with the smaller number of water catchment areas. The use of clean water sources for daily living needs in Lampung province based on data from the Central Statistics Agency of Lampung Province in 2012 amounted to 49.7% of a total of 2,009,410 households in Lampung province (Setyadi & Rustadi, 2020; Zaenudin et al., 2018).

It is feared that the use of groundwater sources continuously will result in a decrease in the volume of water in the aquifer, which causes a decrease in the groundwater level and a decrease in the water reserves in the aquifer layer (Sudarto, 2012).

Decreasing groundwater levels and decreasing water reserves in aquifers can cause subsidence. Subsidence that occurs slowly is known as land subsidence (Andreas, Zainal Abidin, Gumilar, et al., 2019). Natural land subsidence occurs regionally, namely covering a large area or occurs locally only in a small part of the soil surface, this is usually caused by cavities below the soil surface and usually occurs in calcareous areas (Abidin et al., 2016; Andreas, Zainal Abidin, Gumilar, et al., 2019). In the study of land subsidence in an area, there are various methods to find out information on land subsidence, namely the flat slice method and GNSS observation (Widodo et al., 2019; Yuhanafia & Andreas, 2017). For GNSS observations a bench mark is required which is useful as a point of observation of the land subsidence phenomenon which can be done periodically. With not many benchmarks specifically designated as control points for land subsidence observations, it is necessary to make land subsidence observation points spread across the island of Sumatra in general and specifically for the province of Lampung.

This study aims to determine the location for the construction of a benchmark point for land subsidence observations. Land subsidence has a direct negative impact around the affected area, such as causing flooding and tidal flooding in the coastal zone, damage to buildings and houses, as well as infrastructure such as bridges and roads, and can even cause explosion of the gas pipe (Fiantis, 2017; Setyadi & Rustadi, 2020; Sophian, 2010). The magnitude of the impact of land subsidence on life on the surfacesoil is not in line with the handling and handling of the consequences of the subsidence. This research will provide information about some of the causes of land subsidence as well as planning the location of the observation points of the subsidence itself, making it easier to monitor the land subsidence phenomenon and can be used for decision making related to the land subsidence phenomenon.

Land subsidence can occur without realizing it due to its slow motion, therefore this study was carried out in sequence to estimating areas that are likely to experience the land subsidence phenomenon in Lampung Province by using spatial analysis, namely the scoring method based on several factors such as changes in land cover, groundwater use and soil types which are useful for providing an understanding of the relationship between community life patterns in managing land and other activities related to the phenomenon of land subsidence and determine a suitable location as a place for land subsidence observation points in Lampung province to be made in accordance with the required factors and parameters such as how likely the land subsidence phenomenon is to occur in the area and land designation so that the observation point made is not on private land and is minimal multipath.

B. MATERIALS AND METHODS

Land subsidence is defined as land subsidence relative to a particular reference area which is considered stable. Land subsidence can occur slowly or also occur suddenly. Many subsidence events range from a few centimeters per year. Sudden changes in land surface are usually followed by real physical changes and can be known immediately the size and speed of subsidence. However, for land subsidence that is slowly known after a long event, the amount of subsidence can be determined by a periodic mechanism. Natural land subsidence occurs regionally, namely covering a large area or occurs locally, namely only a small part of the land surface. This is usually caused by a cavity below the soil surface, usually occurring in chalky areas (Andreas, Zainal Abidin, Anggreni Sarsito, et al., 2019; Nurhamidah et al., 2018; Yuhanafia & Andreas, 2017).

There are several data and parameters used in conducting spatial analysis in this study:

1. Land Cover

   Land cover describes vegetation and artificial constructions that cover the land surface. Land cover is an important component in supporting the life system in an area, the better the type of land cover or forest vegetation, it can be assumed that the area has a high biodiversity value. Changes in land cover, whether caused by human activities or changes naturally, are considered as one of the factors that affect environmental quality, biodiversity in supporting life in an area (Bates & Jackson, 1987; Hu et al., 2019; Yuwono et al., 2018). Land cover conditions affect the causes of land subsidence. So it is necessary to identify the land cover in the study area. The types of land cover that have the most influence on land subsidence include industrial areas, ports, fertilizing land, offices, educational and sports facilities, as well as health facilities and luxury housing.

A review of the effect of building loads on the rate of land subsidence is carried out by conducting a geospatial analysis of the land cover conditions. To provide an assessment of the effect of building loads on land subsidence, it is necessary to determine a value as the loading scale.

2. Use of Groundwater

The development of the population and the increase in the standard of living have resulted in the need for clean water to increase, to meet the basic needs of water, the excessive extraction of groundwater, the number of pump wells is one of the causes of accelerating the subsidence of the land surface so that without realizing it, the land we are standing on is getting lower and lower. To prevent land subsidence due to pumping, that is, by knowing the condition of the soil structure at the pump location so that the maximum amount of water pumped discharge can be set and the distribution of pump wells in an area. If the total amount of groundwater withdrawal from an aquifer system exceeds the average recharge amount, there will be a continuous decrease in the groundwater table and a reduction in groundwater reserves in the aquifer. If this happens, then this condition is called over exploitation, and groundwater mining occurs. (Rahn & Onak, 1991; Whittaker & Reddish, 1990).

The use of water resources for industrial activities is generally used for the production process, cooling, waste disposal. Industrial estates tend to choose to use groundwater because PDAMs are unable to meet industrial demand. Besides that, the industrial location which coincides with CAT is a driving force for it them to take advantage of the existing potential. Besides the lower cost, the continuity is more guaranteed (Hutabarat, 2017).

The industrial area is the area that uses groundwater the most for the production process. Groundwater abstraction occurs because of the influence of higher population growth, this results in a greater need for water. The great need for water encourages people to find a substitute for river water, which is the main source of clean water, starting to be polluted by various kinds of wastes (Al Akbar et al., 2015; Sophian, 2010). One of the causes of the reduction in the volume of groundwater is due to its use for household purposes which occurs in fairly dense residential areas.

3. Lithology

Lithology is a description of rocks in outcrops based on their characteristics, such as color, mineral composition and grain size, synonymous with petrography (Bates & Jackson, 1987; Treman, 2016). lithology as a description of rock in outcrop based on its characteristics such as color, mineral composition and grain size. Lithology is a physical characteristic of rocks. Rock itself is a combination of similar or different minerals such as granite, marble, shale or an inseparable body of mineral matter such as obsidian or solid organic matter such as coal. From a geological point of view, rocks don't have to be hard and compact. Mud, sand, and clay including rock (Al Akbar et al., 2015; Yastika et al., 2017). Based on the physical condition of rocks in relation to the ability of rocks to store groundwater, there are two types of layers that can store groundwater, namely aquifers (aquifers) and aquicides (aqiclude). Aquifer is a layer that can store water and drain water in an economical amount, for example sand, gravel, sandstone.

Whereas aquicludge is a layer that is able to store water, but cannot drain a significant amount, for example clay, shale, fine tuff, silt. By using these parameters, a scoring process is made. Model (system) scoring or Weighted Linear Combination (WLC) is used to represent the level of closeness, connection, or severity of a certain impact on a phenomenon spatially. Each input parameter such as land cover, groundwater use and rock type will be scored and then added together to obtain a level of association. The end result of the scoring system is to classify the level of association of the output parameters (Bates & Jackson, 1987; Isnaeni & Farda, 2020; Sudarto, 2012).

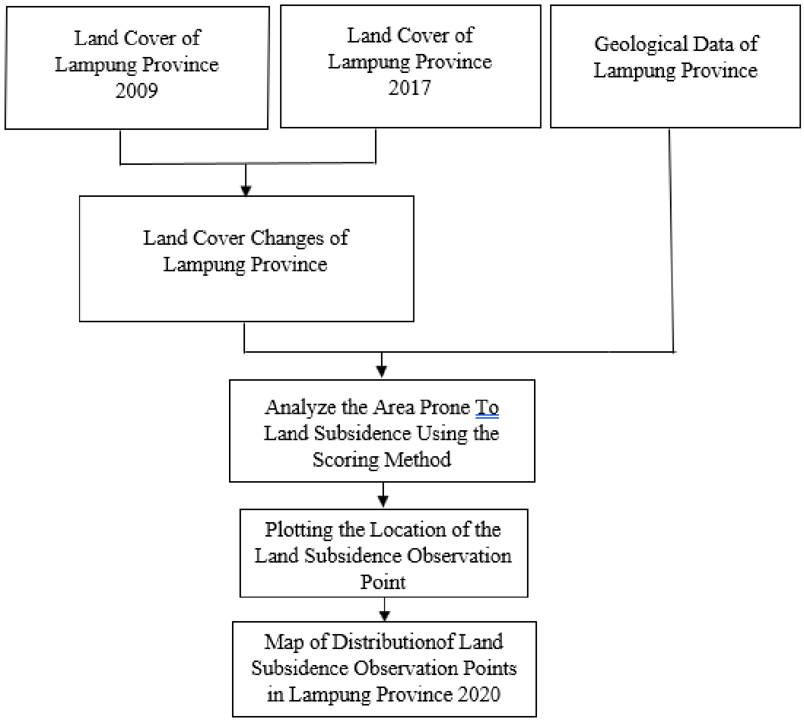

Figure 1. Data and data analysis technique with GIS

C. RESULTS AND DISCUSSION

1. Map of Potential Land Subsidence

Analysis of the potential for the land subsidence phenomenon was carried out using the scoring method based on changes in land cover, groundwater use and types of sediment composing rock with the respective weight values of 40% for land cover, 40% for groundwater use and 20% for sedimentary rock types. The results of this analysis can be seen in Figure 4.6 which is a map of the potential for land subsidence in Lampung province in 2020 which is divided into 3 vulnerable classes, namely low, medium and high classes.

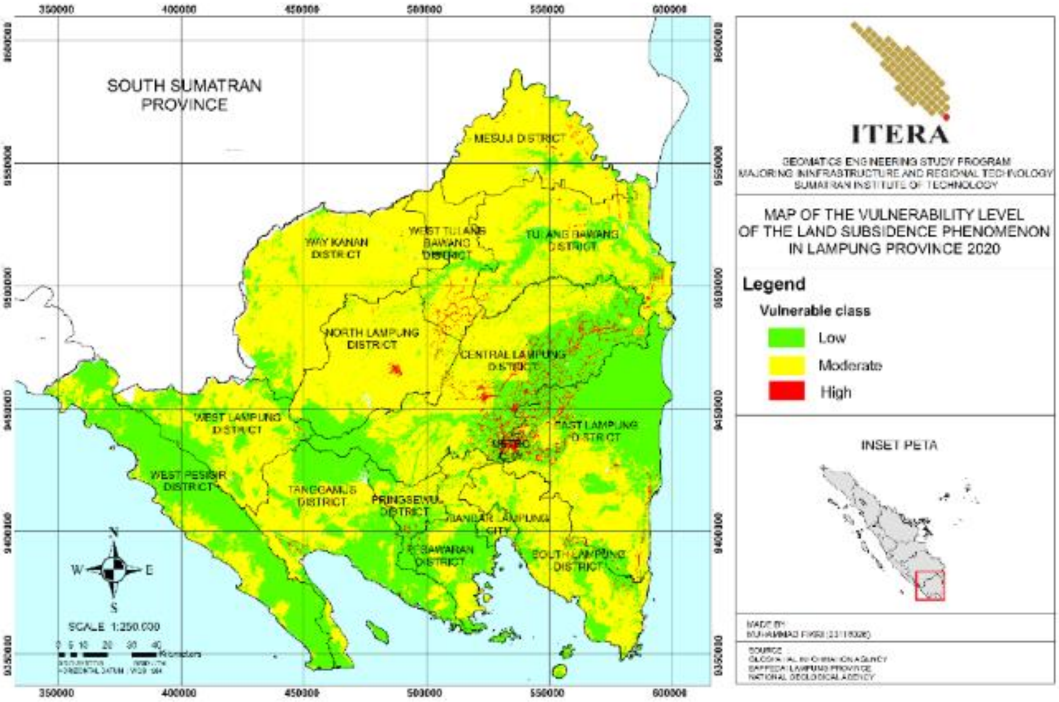

Figure 2. Map of the vulnerability level of the land subsidence phenomenon in Lampung province 2020

Based on Figure 7, it can be seen that the distribution of potential vulnerable classes to the land subsidence phenomenon which is depicted in different colors based on the weight value generated from the weighting process that has been carried out. The city of Bandar Lampung is an area with the majority of the middle class (yellow) to the high class (red) because the area is urban and densely populated, besides that there are industrial areas such as terminals, ports and factories which result in the possibility of a fairly high land subsidence phenomenon.

Table 1. The percentage of land subsidence vulnerable class in Lampung province 2020

Class	Area (km²)	Percentage (%)
Low	12292,60	37,12
Moderate	20230,64	61,19
High	540,32	1,63
Total	33063,56	100

Based on table 1, it can be seen that the area in the medium class has an area of 20230.64 km² with a percentage of 61.19% and is the class with the largest area followed by the low class with an area of 12292.60 km² with a percentage of 37.12%, and the smallest is the high class area of 540.32 km² with a percentage of 1.63%.

2. Location of Land Subsidence Observation Points

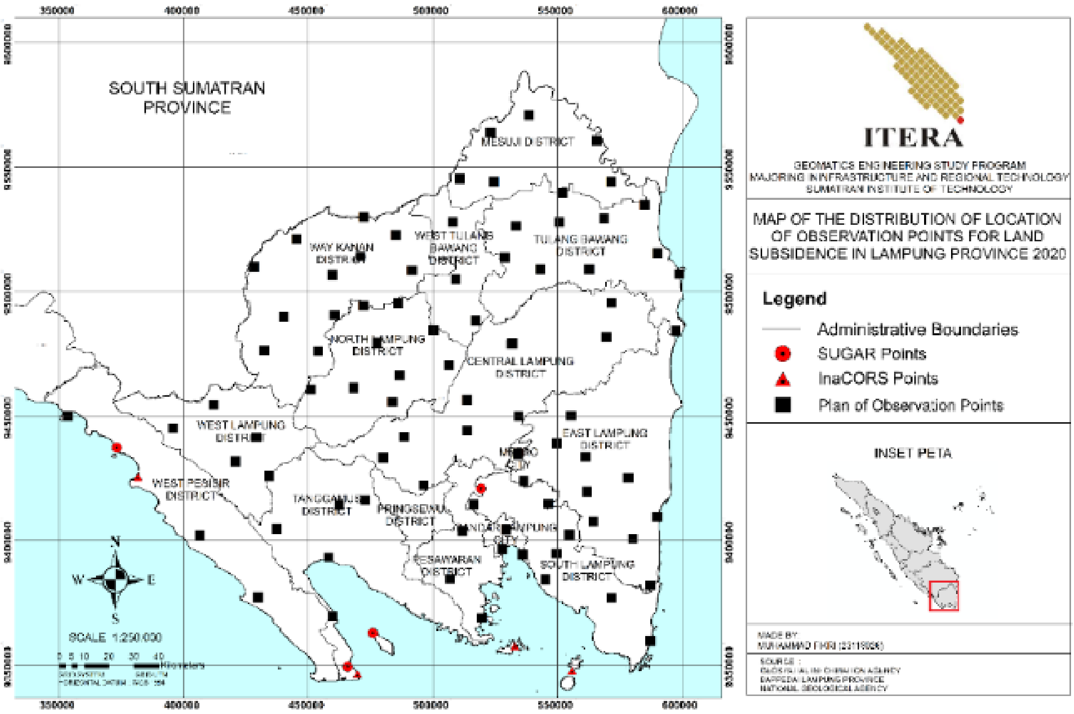

Figure 3. Map of the distribution of location of observation points for land subsidence in Lampung province 2020

The locations of observation points are scattered in all regencies / cities in Lampung province. The areas with the most observation points are Way Kanan Regency with 12 observation points, Central Lampung Regency with 10 observation points, East Lampung Regency with 10 observation points, Tulang bawang Regency with 9 points, North Lampung Regency 9 observation points, Mesuji Regency 8 observation points, South Lampung regency 7 observation points, West Lampung district 5 points, Tanggamus district 5 observation points, Tulang Bawang Barat district 3 points, Pesisir Barat district with 3 observation points, Pesawaran district 3 points and Bandar Lampung city with 3 observation points, Metro city with 1 observation point with a total of 87 observation points of land subsidence which are determined based on several criteria such as having a moderate to high level of vulnerability to land subsidence phenomena and being in a location that supports the construction of a benchmark, which is not on private land and easy to reach and there is a little multipath).

D. CONCLUSIONS

This study focuses on determining the location of the benchmark for the phenomenon of land subsidence in Lampung. The phenomenon of land subsidence in this location is rarely studied by other researchers. Based on this research, Areas that are prone to land subsidence phenomena can be estimated using spatial engineering based on several relevant parameters such as land cover in the area, the activity of groundwater use and the type of rock that makes up sediment in the area. The results obtained from this spatial engineering process are an area of 12292.60 km² or 37.12% of the Lampung province has a relatively low level of land subsidence vulnerability, 20230.64 km² or 61.19% with a moderate level of vulnerability, and 540, 32 km² or 1.63% with a high level of vulnerability.

The coverage of areas with medium to high class areas reaches 61.19% of the total area of Lampung province because the majority of land in Lampung province is agricultural and plantation land which are included in high-level water extraction along with industrial areas.

The location of land subsidence observation points that are planned based on the results of previous spatial analysis is placed in areas with a level of vulnerability to land subsidence phenomena with medium to high classes. In addition, the location of the point is checked through the Google Earth Pro application to see the situation around the point that will be placed to prevent the location of the point on people's private land and locations where there are fewer multipaths. There are 87 observation points located and scattered in regencies / cities in Lampung province with the following details.

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