Land Use Changes of Ternate Island 2017-2022
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Abstract. The phenomenon of land use change always increases with population growth so that sooner or later these conditions will cause changes in land use. This study aims to determine changes in land use on Ternate Island in 2017-2022. The method used maximum likelihood classification and used Ternate island land use data from sentinel 2 image extraction in 2017, 2020 and 2022 to analyze changes in land use. There are 7 forms of land use in the study area, namely water bodies, dense vegetation, bushes, farm land, settlements, bare land, scrub and cloud cover that cannot be extracted from multispectral images. Land use that dominates the island of Ternate is dense vegetation and settlements. Land use, dense vegetation is evenly distributed on the slopes of Gamalama volcano and settlements are scattered at the foot of the volcano. Land use change on Ternate island in 2017-2020 and 2017-2022 is dominated by dense vegetation to settlements. Changes in dense vegetation to gardens and grasses are land clearing activities in preparation for the use of settlements.

1 Introduction
Ternate Island is one of a series of volcanic islands in North Maluku province. Morphologically, the mainland of Ternate Island has a volcanic peak or caldera in the middle of the island. The formation of volcanic landforms is influenced by the type of magma [3]. Meanwhile [5] the surface morphology of volcanic islands is largely dominated by the control of exogenous processes. The topography of this island has varying slopes and is dominated by steep to steep slopes, making it difficult to develop residential and industrial activities. Meanwhile, the coastal areas are occupied as residential areas whose pattern is parallel to the coastline that surrounds the island. For population density, it generally occupies the central, southern and northern parts which are the city center. Gamalama Volcano itself has a height of around 1715 m above sea level. The area of Ternate Island is 5681.30 Km² with a sea area of 5,457.55 km² while the land area is 133.74 Km² [1].

Population growth encourages the expansion of land use changes from non-built areas to built-up areas [8]. The increasing population certainly has an impact on the need and availability of land. Land is bare land, cultivated land, or uncultivated land which is associated with socio-economic meaning or function for society (Spatial Planning Dictionary, 1997). Meanwhile, the definition of land is the surface of the earth, including parts of the body of the earth and water as well as the space above it so that it is directly related to land use. Whittow in Sutikno and Sunarto [6], views land as a plot of the earth's surface which includes geological parameters, surface deposits, topography, hydrology, soil, flora and fauna together with the results of human activities both past and future. will come. Land use is all kinds of human intervention, either permanently or cyclically, on a collection of land resources with the aim of obtaining benefits from the land to meet their living needs, whether material or spiritual or both [7]. For this reason, land use always involves human intervention in utilizing resources, both natural resources and artificial resources, to meet human needs. Land use change is a change in the form of land use from the previous one, whether or not it refers to the regional spatial layout plan. This change phenomenon can be seen over a certain period of time [2]. Land use changes can be identified through maps [4]. The aim of this research is to analyze changes in land use on Ternate Island 2017-2022.

2 Research Methods
The research was conducted on the island of Ternate, which consists of 5 districts, namely the districts of Central Ternate, North Ternate, South Ternate, West Ternate and Ternate Island, North Maluku Province. The data used is the Topographical Map of Ternate and Sentinel 2 image data for 2017, 2020 and 2022. The method used to obtain land use data uses the guided classification of the maximum likelihood type, while the analysis of land change data uses overlay analysis and descriptive analysis.

3 Results and discussion
The area of Ternate Island is 5681.30 km² with a sea area of 5,457.55 km² and on the land part there is the Gamalama volcano with an area of around 40 km² with a radius of 5.8 km². Ternate Island is administratively
included in the North Maluku region with 5 sub-districts, namely North Ternate District, Central Ternate District, South District, West Ternate District and Ternate Island District. The city of Ternate became the capital of North Maluku province in 1999-2010 (UU RI No 46 of 1999 and UU RI No 6 of 2003).

Table 1. Area and type of land use on Ternate Island

<table>
<thead>
<tr>
<th>No</th>
<th>Land use</th>
<th>Area (Km²)</th>
<th>2017</th>
<th>2020</th>
<th>2022</th>
<th>2017</th>
<th>2020</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water bodies</td>
<td>1,14</td>
<td>1,09</td>
<td>1,05</td>
<td>1,12</td>
<td>1,07</td>
<td>1,03</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Dense vegetation</td>
<td>69,51</td>
<td>69,8</td>
<td>70,7</td>
<td>68,28</td>
<td>68,56</td>
<td>69,52</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Bushes</td>
<td>0,02</td>
<td>0,01</td>
<td>0,00</td>
<td>0,02</td>
<td>0,01</td>
<td>0,00</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Farm land</td>
<td>0,11</td>
<td>0,85</td>
<td>0,64</td>
<td>0,11</td>
<td>0,83</td>
<td>0,63</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Settlements</td>
<td>23,40</td>
<td>25,1</td>
<td>25,4</td>
<td>22,98</td>
<td>24,74</td>
<td>24,97</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Bare land</td>
<td>0,33</td>
<td>0,26</td>
<td>0,53</td>
<td>0,32</td>
<td>0,26</td>
<td>0,52</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Clouds</td>
<td>3,60</td>
<td>0,41</td>
<td>0,32</td>
<td>3,54</td>
<td>0,40</td>
<td>0,31</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Scrub</td>
<td>3,69</td>
<td>4,21</td>
<td>3,07</td>
<td>3,63</td>
<td>4,13</td>
<td>3,02</td>
<td></td>
</tr>
</tbody>
</table>

Source: Sentinel 2 image classification results for 2017, 2020, 2022

There are 7 types of land use on Ternate Island, namely Water bodies (lakes and boundaries of Ternate Island), Dense vegetation, Settlement, farm land, Scrub, bare land, scrub and clouds. Clouds present in land use types are a permanent disturbance in multispectral image classification. Most of the land use covered by clouds is open land use covered by scrub and dense vegetation around the peak of Gamalama volcano. Apart from atmospheric activity, the clouds that are at the top of Gamalama volcano also come from small eruptions of Gamalama volcano. Land use types from 2017 to 2022 are still dominated by dense vegetation and settlements (table.1 and figure.1). The use of land with dense vegetation with an area of more than 69 Km² (table.1) is spread across the middle volcanic slopes and upper volcanic slopes (figure.1). Residential land use area of over 23 Km² from 2017-2022. The use of rice fields is not found on Ternate Island because the landform is a volcanic island and has limiting factors such as slope and soil type that do not support the use of rice fields. The use of farm land, scrub, bushes and water bodies is shown in a low area.

Figure 1. Ternate Island Land Use Diagram 2017-2022

Figure 2. Ternate Island Land Use Map 2017

Figure 3. Ternate Island Land Use 2020

Land use in 2017, dense vegetation dominates, spread evenly across the 5 sub-districts of Ternate Island (figure 2). The next land use that dominates is settlements spread evenly at the foot of the Gamalama volcano in the Districts of Central Ternate, South Ternate and North Ternate, while for the sub-districts of Ternate Island and West Ternate District there are still few due to accessibility constraints that are still low.
Land use in 2020 is 3.4 km$^2$ of scrub, 0.2 km$^2$ of bare land, 20.6 km$^2$ of settlements, 0.7 km$^2$ of farm land, 57.2 km$^2$ of dense vegetation, and 0.9 km$^2$ of water bodies. Cloud cover in 2020 land uses is mostly in densely vegetated land uses. A large distribution of land use is found in dense vegetation and settlements.

The largest forms of land use in 2022 are dense vegetation 58 km$^2$, settlements 20.8 km$^2$, Scrub 2.5 km$^2$, water bodies 0.9 km$^2$, farm land 0.4 km$^2$, bare land 0.4 km$^2$, and cloud of 0.3 km$^2$ which is mostly covered with dense vegetation.

Changes in land use 2017-2020 from one form to another so that there is a change in the area of land use. Farm land in this land use are land planted with horticultural plants, while dense vegetation land use is land that contains annual plants with tall trees and the land below is covered with scrub and bushes. The land use of the body of water is the lake and the perimeter of the island of Ternate. The dominant land use changes from 2017-2020 were from dense vegetation to settlements areas of 1.80 Km$^2$, dense vegetation to scrub land use of 0.71 Km$^2$ and change to garden land use of 0.53 Km$^2$. The decrease in changes in the area of dense vegetation is due to land conversion from annual forests on the lower slopes to horticultural plantations, bare land and scrub in preparation for building settlements and clearing forests for settlement locations (new housing), although the use of dense vegetation land is still relatively high at 66.42 Km$^2$ while the area of settlements land use increased from 19.2 Km$^2$ to 20.6 Km$^2$ (table 2 and table 3). The increase in changes in residential area does not only come from dense vegetation but also from the use of scrub land amounting to 0.19 km$^2$, farm land 0.02 km$^2$ and from water bodies 0.05 km$^2$. The change in land use from bodies of water to settlements is the use of land for settlements spread across the coast due to the creation of local piers for local sea transportation.

Changes in the land use of Ternate Island in 2017-2022 are still dominated by changes in the addition of the area of settlements land use by 2.25 km$^2$ and tend to experience an increase in the increase in area from the 2017-2020 land change. Changes in land use from dense vegetation to farm land use of 0.21 km$^2$ tend to decrease from the 2017-2022 land use change, so from 2020 there will be a conversion of land use from farm land to settlements and scrub. The area of dense vegetation in 2017-2020 and 2017-2022 tends to remain the same.

4 Conclusion
There are 7 forms of land use on Ternate Island, namely water bodies, dense vegetation, bushes, farm land, settlements, bare land, scrub and cloud cover. Cloud cover is a permanent disturbance that cannot be extracted in images for land use classification. Settlements land use is spread dominantly in 3 sub-districts, namely Central Ternate, South Ternate and North Ternate which tend to have flat slopes and easy accessibility. The use of dense vegetation land is spread across 5 subdistricts and is dominant on the slopes of the Gamalama volcano. Forms of open bare land and scrub tend to cover deposits of pyroclastic rock or ‘batu angus’ and some are associated with residential areas such as...
fields, green parks and cemeteries. Changes in land use on Ternate Island in 2017-2020 and 2027-2022 that dominate are dense vegetation and settlements.

References