LiDAR application of intertidal coastal zoning for aquaculture in Wolo Village, Kolaka, Southeast Sulawesi

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Abstract: Coastal Zones or Regions have abundant natural resources, support polluted areas' welfare and are a source of regional income. Wolo Village coastal resources support a regional economy covering 3.44 square kilometers, as it is presented in the RTRW master plan and included in the regional-based maritime and fisheries and economic development concept (Minapolitan). The characteristics of the Wolo village coast support various types of aquaculture which are beneficial to its population. However, for sustainable growth, there is a need for aquaculture zoning of the intertidal areas. This zoning will provide the means to maintain the balance of coastal resources, ensures sustainability and it will support government developing programs. Intertidal coastal area zoning can be carried out by a zoning system that obtains space utilization in accordance with a criterion that supports the sustainable development of existing coastal resources and follows the RTRW master plan. To determine the physical condition of region spatially, DTM and DSM data obtained from Light Detection and Ranging (LiDAR) data can be used. The sustainable zoning boundaries for each cultivation would be found by using Geographic Information System. The results obtained using this method are that most of the coast in Wolo village included in Zoning III, which has potential for the development of coral reefs cultivation and Zoning I, which has the potential for the development of seaweed cultivate. From the obtained results, it can be concluded that the potential on the coastal of Wolo Village, as a producer of seaweed that can be further developed in accordance with sustainable zoning program and support the national Minapolitan Area.

1. Introduction
Indonesia is an archipelago with a sea area that is wider than the mainland. The ocean has abundant natural resources. The potential of abundant marine natural resources can be utilized to support the life of living things. At present most of the ocean areas that have the potential to be exploited, but some of these uses do not pay attention to environmental balance, causing damage. There are also ocean areas that store potential untapped resources, one of which is the Wolo village sea area.

Wolo village has natural resources that have the potential to be managed and developed. It can be seen from the aquaculture production data that has experienced an increase, as in 2013 - 2014 amounted to 4930 tons and in 2014 - 2017 increased by 3336.72 tons. Based on the 2012-2032 RTRW, the Wolo region is included in the national minapolitan area, supported by the allocation of fisheries and seaweed cultivation. In accordance with Ministerial Regulation No. 12 of 2010 concerning Minapolitan, Minapolitan is defined as a conception of regional and fisheries-based economic development based on integrated principles, efficiency, quality and acceleration. The existence of potential coastal resources that are qualified, intertidal areas in the village of Wolo can be developed into an aquaculture cultivation area so that it can support Wolo as a minapolitan area and the diversity of ecosystems in it is maintained.
The intertidal zone is located close to human activities with high environmental dynamics so that this region is vulnerable to disturbance. The intertidal zone is an area that is affected by both the highest tides and lowest ebb tides in the sea area, the intertidal zone is also known as the littoral zone. Using LiDAR data, processing in the intertidal region can be done using a zoning system. Zoning is one of the supporting techniques of spatial use in accordance with the area's sustainability method. Various biota that can live in intertidal areas, but the zoning carried out in this paper is limited to only 4 types of cultivation, namely seaweed, coral reefs, seagrass beds, and fisheries in the Wolo Village sea area of 62,978 hectares. Bathymetry maps are needed to find out basic information for studying aquatic bottom ecosystems, such as mapping the condition of coral habitats and basic information on marine tourism potential zones and aquaculture [1]. However, current information on bathymetry and coral reefs is difficult to obtain and usually, the information is no longer accurate [2]. Through proper zoning, it is expected that the interrelation of potential diversity in intertidal areas can be structured and regional utilization can be clearly integrated with existing RTRW. The zoning system modeling in the intertidal region of Wolo village uses LiDAR data which aims to display zonation of aquaculture in the intertidal area of Wolo Village as supporting the diversity of ecosystems in the intertidal region and supporting Wolo as a minapolitan area.

2. Methodology
The data used in this study were sourced from LiDAR data processed in the DTM method and Geography Information System. Light detection and ranging (lidar) mapping is an accepted method of generating precise and directly georeferenced spatial information about the shape and surface characteristics of the Earth [3]. The method used is a literature study conducted to obtain relevant supporting information. True three-dimensional imaging more accessible with the continued development of instrumentation. Just as the pixel is the unit of brightness measurement for a two-dimensional image, the voxel (volume element, the three-dimensional analog of the pixel or picture element) is the unit for three-dimensional imaging. And just as processing and analysis is much simpler if the pixels are square, so the use of cubic voxels is preferred for three-dimensions, although it is not as often achieved [4].

2.1. Digital Terrain Model (DTM)
The Digital Terrain Model (DTM) is simply a statistical representation of the continuous surface of the ground by a large number of selected points with known X, Y, Z coordinates in an arbitrary coordinate field [5]. A DTM has the following specific features:

- A Variety of representation forms: In digital form, various form of representations can be easily produced, such as topographic maps, vertical and cross section, and 3-D animation
- No accuracy loose of data over time: As time goes by, paper maps may be deformed, but the DTM can keep its precision owing to the use of digital medium.
- Greater feasibility of automation and real time processing: in digital form, data integration and updating are more flexible than in analog form
- Easier multi-scale representation: DTM can be arranged in different resolutions, corresponding to representations at different scales.

DTM is used to determine the morphology of the ground in coastal areas in the village of Wolo, making it easier to apply to zone in the intertidal area to support the minapolitan area. In addition, DTM can produce landforms and ground depths and heights in the Wolo Village area where the data can support zoning systems in the appropriate use of space.

b. GIS (Geographic Information System)
This study presents the final results of DTM and DSM data which then produce a picture of zoning made in accordance with established rules and criteria that are relevant to the Wolo district RTRW.
The results are obtained from processing using a geographic information system in which there is spatial information from the zoning system, so that it can be understood and easily used by the relevant agencies. The methods used in GIS are digitization and zoning.

2.2. Coral Reef Zoning
At present, there are about 6000 species of species which have been successfully defended, about 1000 species of which occupy shallow waters of less than 20 meters in the Indo Indo Pacific region [6]. Coral reef ecosystem is an ecosystem that is quite important in shallow waters of the tropics, around 600 species of fauna echinoderms are reported to occupy the coral reef ecosystems of Indonesian waters [7]. Coral reef ecosystems are divided into various zones, namely the reef flat zone consisting of sand flat zone, seagrass zone, algae growth zone (Thalamita-flat), and moats zone [8]. At the lowest ebb tide is usually still standing water as high as 20 cm -50 cm. If the seagrass is dominated by the genus Enhalus, usually there are species of sea cucumbers [8].

2.3. Seaweed Zoning
Apart from being a source of food and medicine, some seaweed macros are used as new energy sources, for example as ingredients for biodiesel, biobutanol, and biogasoline [9]. Turbid water (usually containing mud) can block the translucence of sunlight in the water so that the process of photosynthesis is disrupted, while a good depth for seaweed growth is 0.3-0.6 m [10]. Several types of crustaceans that live on coral reef life, such as shrimp and crabs. Shrimp and crabs are one of the demersal fisheries products, which is meant by demersal fisheries related to the two types are fishery products ranging from the coast to a depth of approximately 40 meters [11].

2.4. Seagrass Zoning
Seagrasses can grow in coastal areas and the marine environment of tropical and ugahari regions, except for polar waters because many are covered with ice. Seagrass grows from intertidal to a depth of approximately 90 m [12]. seagrasses generally grow in tidal areas and around coral islands [13]. Grows on substrates with a mud bottom, muddy sand, sand and coral fragments.

The combination of DTM methodology and Geographic Information System which is supported by the existence of orthophoto is processed to produce a zoning system. The final result is zoning in the intertidal area of Wolo Village in accordance with the above literature study to support sustainability in the region. To produce the zoning, the primary data used to integrate several techniques in the methodology are processed with the work steps as in Figure 1.
3. Result and Discussion

3.1. Intertidal Zone

In general, intertidal areas are strongly influenced by tidal and ebb tide patterns, so they can be divided into three zones. Whereas horizontally it can be divided into four zones. The first zone is the area above the highest tide of the sea line that only gets a splash of seawater from the blows of waves and waves that hit the area backshore (supratidal), the second zone is the boundary between the lowest ebb and the highest tides of the sea surface line (intertidal) and the third zone is the lower boundary of the lowest ebb sea level (subtidal). The intertidal zone is an area where tides occur, causing the types of animals and plants that can grow and develop in that region are animals or plants that have high adaptive power. When the tide of marine biota is able to adapt to temperatures and environmental conditions that are different from when there is low tide in seawater. Seaweed Cultivation is carried out in order to process more for consumption and health, thus supporting regional income and making business opportunities or economic resources for the people in the Wolo Village area.
Figure 2. Intertidal Zoning

In general, intertidal community zoning is divided into three zones, namely zone I is the upper tide area (highest) consisting of seagrass and seaweed communities, zone 2 is the middle tide area consisting of seagrass, seaweed, and coral communities, and zone 3 is lower tide area consisting of coral and seaweed communities. Seaweed is able to survive during low tide which is balanced with the conditions at high tide [14].

Figure 3. Intertidal horizontal zoning (Spring dalam Nugroho, 2012)

Coral Reef is one of the marine biotas which is currently experiencing a lot of damage in several marine waters in Indonesia. The coastal area in the intertidal zone of Wolo Village is a location that has the potential for the development of coral reefs because it is at an optimal depth, which is 25 cm at a temperature of 260 - 300C supporting the life of coral reefs (Susilowati, el al, 2012) [15]. The more coral developed in this region will increasingly provide protection to the marine ecosystem. Coral reefs are useful for holding back large waves. Development is carried out in the intertidal region to protect the biota that grows in the intertidal region because coral reefs can protect the marine biota that lives in the intertidal region as well as a place to live and survive to breed to produce more biota and can also be supporters of Wolo as a minapolitan area. Coral Reef is one of the marine biotas which is currently experiencing a lot of damage in several marine waters in Indonesia. The coastal area in the intertidal zone of Wolo Village is a location that has the potential for the development of coral reefs because it is at an optimal depth, which is 25 cm at a temperature of 260 - 300C supporting the life of coral reefs [15]. The more coral reefs developed in this region will increasingly protect the marine ecosystem. Coral reefs are useful for holding back large waves. Development is carried out in the intertidal region to protect the biota that grows in the intertidal region because coral reefs can protect the marine life that lives in the intertidal region as well as a place to live and survive to breed to
produce more biota. Crustaceans, crabs, shrimps, and snails will breed more with favorable conditions, namely the presence of coral reefs.

3.2. Digital Terrain Model Results
Based on the results of the digital terrain model, the depth profile is shown. Wolo village has an intertidal area with a flat profile with a basin. The intertidal zone has an average depth of between 0 - 5m above sea level. The results of the DTM indicate that the intertidal area in Wolo Village supports aquaculture in the form of seaweed, coral reefs, crustaceans, crabs, shrimp, snails, seagrass beds. Digital terrain model results, seaweed cultivation has not been done in the area, but with the intertidal region that has potential, seaweed can be cultivated in the region, namely at an average depth of 25 cm. The picture also shows the presence of coral reefs, so there is potential for more coral reef development. Warm water conditions because sunlight can penetrate in this intertidal region, coral reefs can grow optimally. The more coral reefs that grow, will support the life of marine life in it to be able to continue to breed, such as crustaceans, crabs, shrimp and snails and several types of fish.

Figure 4. DTM and crosssection in flat intertidal

In the picture below, we can see that the intertidal area in Wolo Village has 2 basins. The low basin has a depth of 7.5 m. In this region the basin is wider, which is ± 0.65 ha, while the deeper basin reaches 10 m with a narrower size, which is ± 0.33 ha, so that the basin looks steep. Basins with depths below 10m are not include basin conditions found in the intertidal area of Wolo village, it can be used for aquatic cultivation of another biota, such as pelagic fish species and another marine biota that can live up to 10 m deep. In these basins, coral reefs can still live so they can support the breeding of fish biota that lives at a depth of 5-10 m.
The condition of intertidal areas in Wolo village, it can be seen that the marine biota that can be cultivated are seaweed, coral reefs with biota in it, such as crustaceans, shrimp, crabs, and snails, and for both basins that do not enter the intertidal region, several types of fish can be cultivated, which can be used for consumption and balance of marine life, namely pelagic fish species. The potential shown by DTM can be optimally applied by the local community to get production results that can support the economy in the village of Wolo which is included in the Minapolitan area while maintaining the balance of the marine ecosystem.
3.3. Zoning

Figure 6. Orthophoto and Zoning

Figure 6. (a) shown Zones formed from the results of interpolation of point cloud data produce classes based on height, from 0 to 1 masl area of 2.17 ha, -1 to 0 masl area of 1,512 ha, -2 to -1 masl area of 3,309 ha, -3 to -2 masl areas of 1.2 ha, -4 to -3 masl area of 0.572 ha, and > -5 masl area of 3,118 ha. Based on the findings from orthophoto (b), the beach in Wolo Village has the characteristics of 5.7 ha of white sand with a coral reef area of 17.25 ha, seagrass and two basins with potential for aquaculture covering an area of 1 ha.

Figure 7. Intertidal Coastal Zoning in Wolo Village
Table 1. Area of Cultivation Zones

| Zona | Land cover     | area (ha) |
|------|----------------|-----------|
| I    | Seaweed        | 2.79      |
| II   | Seagrass Beds  | 2.66      |
| III  | Coral Reefs    | 6.35      |
| IV   | Fishery        | 37.08     |

Source: Data processing, 2019

The results of overlays between areas based on height and areas based on aerial photo interpretation (orthophoto) according to the state of the beach in Wolo Village produce four potential zones for intertidal ecosystem cultivation, as shown in Figure 7. Zone I is a zone with a depth of 0 to -1 m above the surface sea with sandy land suitable for seaweed cultivation covering 2.79 ha. Zone II is a zone with a depth of 0 to -1 m above sea level with potential seagrass land that can be a place for various crustaceans and sea cucumbers with an area of 2.66 ha. Zone III is a zone suitable for coral reef aquaculture. This zone has the largest area compared to other zones, which is 6.35 ha. Visually the intertidal area of Wolo Village shows the dominance of coral reefs. Having a depth ranging from -1 to -3 meters above sea level makes corals grow well with good turbidity of water so that the photosynthesis process can take place properly. Whereas in Zone IV, which has depths of more than -5 meters above sea level, two basins surrounded by higher continents are suitable for fish cultivation and a coral reef area of 37.08 ha. Zone IV also has the largest area but is outside the intertidal zone so that its characteristics are different and can be used as a location for aquaculture. While there are intertidal areas that have a height of 0-1 meters above sea level which is usually inhabited by crabs.

4. Conclusion
The conclusion obtained is that most of the intertidal areas in the village of Wolo belong to Zone III, which has the potential for coral reef development and Zone I which has the potential for the development of seaweed cultivation. From the results obtained, it can be concluded that the potential in the Wolo Village, as a producer of coral reefs and seaweed can be further developed in accordance with the zoning system that supports the national Minapolitan Area.

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