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Spatial Mapping of Coconut Plantation in Airmadidi District, North Sulawesi Using Geographical Information System

Wiske Rotinsulu[1], Geby Margaretha[2], Sandra Pakasi[3]
[1,2,3]*Faculty of Agriculture Sam Ratulangi University, Manado, Indonesia*

Email: wiske_rotinsulu@unsrat.ac.id

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Abstract
Coconut (*Cocos nucifera* L.) known by many as the "tree of life is a leading agricultural commodity in North Sulawesi. Coconut is one of the most significant palm crops for both commercial and subsistence use worldwide. Airmadidi District has the potential for plantation land, especially coconut, which is indicated by the area of coconut plantation land in Airmadidi in 2021 of 3,373.13 Ha. This research aims to produce spatial mapping of coconut plantation in Airmadidi District using visual interpretation techniques; and to determine the area of coconut plantations in Airmadidi District. Visual interpretation method using on screen classification of satelite imagery SPOT 2022 obtained from SAS Planet. Images were digitized with a geographic information system using ArcGIS 10.8.2 software. The results of the visual interpretation show a map of the distribution of coconut plantations spread across all villages in Airmadidi District, North Minahasa Regency. The total area of coconut plantations in Airmadidi District is 3 023 Ha. Tanggari village has the largest spread of coconut plantations, namely 870,460 Ha, while Sarongsong Satu village has the smallest area, only 2.24 Ha. There was a decrease in the area of coconut plantation during the period of three year which was 305,51 Ha. The decline in the area of coconut plantations in North Sulawesi, especially in Airmadidi District, is thought to be caused by the conversion of coconut plantation land into residential or industrial areas.

Keywords— Coconut Plantation, Visual Interpretation, Satellite Imagery,

Introduction

Coconut (*Cocos nucifera* L.) is a plant that has an important meaning in the North Sulawesi region, coconut is a popular commodity and has high potential so that North Sulawesi is known as the "Nyiur Melambai Region". Because every part of the coconut plant is useful, it is referred to as the "tree of life. These various benefits are obtained from wood, leaves, fruit flesh, coconut water, fiber and shell. Coconut is a source of vegetable oil, coconut plants also provide income for farming families, as a source of foreign exchange for the country, providing employment opportunities, triggering and stimulating the growth of new economic centers, as well as driving the growth and development of downstream industries based on coconut oil and its by-products in Indonesia.

In the midst of the Covid pandemic back in 2020-2022, coconut has become one of the agricultural favorites with its VCO (Virgin Coconut Oil) product which is claimed to be able to kill the Corona virus. VCO contains Lauric fatty acid has been demonstrated to possess antiviral and antibacterial qualities (Henrietta, 2022). Study done by found Dayrit (2020) that the coconut product industry is growing at the fastest rate because of its antiviral properties, which have been

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shown to be effective in treating COVID-19

North Sulawesi is an area that has agricultural potential, its dry land is dominated by plantation crops, namely coconut. In North Sulawesi, the area of coconut plantations in 2021 is 265,547.76 Ha. In 2020 the area of coconut plantations will be 266,967.93 Ha. There was a decrease in the area of coconut plantations by 1420.17 Ha (BPS Sulawesi Utara, 2022). Coconut plantations in North Sulawesi are mostly people's plantation businesses, to be able to obtain economic value from plantations, farming communities still rely on primary products, namely copra or granulated coconut. Along with technological developments, there are more and more forms of processed coconut products, one of the products that is growing rapidly among the public is virgin coconut oil (VCO). Apart from that, coconut oil can apparently be used for energy substitution, namely for biodiesel (Hamka, 2012).

North Minahasa Regency is a district in North Sulawesi Province which is the main center for coconut plantations with an area of 48,235 Ha of coconut land producing copra in North Sulawesi. Based on region, the highest coconut production is in North Minahasa Regency, namely 41,255.50 tonnes in 2021 and 39,665.81 tonnes in 2020 (BPS Sulawesi Utara, 2022). Airmadidi District is the capital of North Minahasa Regency. It has the potential for plantation land, especially coconut plants, which is indicated by the area of coconut plantation land in Airmadidi in 2020 the area of coconut plantations was 3,328.51 Ha, (BPS Minahasa Utara, 2022). As the capital of North Minahasa Regency, Airmadidi allows land use to change into residential and industrial areas. Monitoring plantation areas is also not fast enough, it will still take a long time to get information about the condition of the coconut area itself. In order to see the distribution and extent of coconut plantations in Airmadidi District, spatial mapping is needed using a remote sensing data and Geographic Information System.

Up-to-date land cover information is needed for policy makers or relevant stakeholders for sustainable land resource management. The general method used to obtain land cover information is by field survey and using remote sensing data and Geographic Information System (GIS) technology. The problems faced with monitoring changes based on field surveys are the size of the study area, the length of time and the large cost of the survey. As a result, the monitoring carried out is ineffective because it cannot follow the rate of land cover change, especially in tropical regions. Remote sensing technology provides land cover data that is up-to-date, high quality, efficient and relatively cheap and with wide area coverage for effective inventory and monitoring of land cover changes (Jensen, 2015). Up-to-date land cover information is needed for policy makers or relevant stakeholders for sustainable land resource management (Rotinsulu et al, 2022). This study aims to produce a spatial map of coconut plantation in Airmadidi District using visual interpretation techniques; and to determine the area of coconut plantations in Airmadidi District.

Literature Review

Coconut (Cocos nucifera L.) is the sole member of the Cocos genus of the palm- family of Arecaceae. Coconut is a native plant from coastal areas of Southeast Asia (Malaysia, Indonesia, Philippines) and Melanesia (Chan & Elevitch, 2006). It spreads to Latin America, the Caribbean and Tropical Africa. In Indonesia, coconut plants can be found in almost all provinces, from flat coastal areas to relatively high mountain areas. Coconut (Cocos nucifera L.) is a strategic commodity that has a social, cultural and economic role in the lives of Indonesian people.

Coconut is called the tree of life, because every part of the plant can be used as follows: (1) coir: coir fiber, doormat, broom, mattress, material for making spring beds; (2) shell: charcoal, activated carbon and handicrafts; (3) fruit flesh: copra, coconut oil, coconut cream, coconut milk, desiccated coconut); (4) coconut water: vinegar, nata de Coco; (5) coconut trunk: building

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materials for frames or roofs; (6) coconut leaves: sticks for brooms, woven items (party or Mayang decorations); (7) coconut sap: brown sugar (Alouw, 2020, Henrietta et al, 2022).

Geographic Information Systems can be used to determine the distribution of natural resources. Geographic Information Systems are used to see the condition of plantations, GIS can be used to see changes in land use. Remote sensing technology provides up-to-date, high-quality, efficient and relatively inexpensive land cover data with wide area coverage for effective inventory and monitoring of land cover changes (Jensen, 2015).

Remote sensing and GIS data have been used to monitor land cover changes in the Tondano watershed, North Sulawesi (Rotinsulu, et al 2018). According to Jensen (2015), image interpretation is an activity to examine remote sensing images (photographic images and non-photographic images) with the aim of identifying objects and providing descriptions of these objects. Remote sensing technology provides the latest information on land cover that is high quality, efficient and affordable with wide area coverage to carry out inventory and monitor land cover changes effectively (Rotinsulu, 2022).

Visual analysis is a method of obtaining information that has been applied for a long time in remote sensing data. Most research in landscape ecology uses visual analysis to obtain information regarding various landscape sizes. Visual analysis is often carried out on aerial photos or other high-resolution imagery. Visual analysis can also be carried out on medium resolution image data in combination with several digital processing techniques (Kosasih, 2019, Wahyuni, 2021, Seidlova, 2021, Grishkin, and Karimov, 2021, Ramadhan and Hidayati, 2022). In general, analysis is carried out on remote sensing data in printed form, although this analysis can also be carried out on digital media. Visual interpretation of coconut land cover in North Bolaang Mongondow Regency was successfully carried out by Rotinsulu *et al*, 2022. The results obtained showed differences in the extent of coconut land cover with BPS published data and visual interpretation data. Visual image interpretation shows that coconut plantations are found in smallholder plantation areas, generally on beaches, roadsides and around residential areas. There are also coconut plantations that border forest areas (Rotinsulu, et al. 2022).

Visual interpretation in general is the recognition of objects on the earth's surface based on the spatial visual characteristics of the object. The characteristics of these objects can be recognized by using elements of image interpretation. Visual image interpretation is an approach based on recognizing spatial characteristics/characteristics of objects, namely hue/colour, size, shape, texture, pattern, height, shadow, site and association (Jensen, 2015). Visual interpretation is carried out by relying on visual abilities. The Geographic Information System is able to provide the information needed regarding mapping a coconut plantation more easily (Rombe, et al. 2021).

The accuracy of interpretation results is largely determined by the interpreter's ability to recognize objects. Object interpretation is carried out by delineating the objects in the image. Knowledge of the landscape of the area being interpreted, understanding the characteristics of the object being studied, and the ability to think spatially are needed by the interpreter to produce accurate interpretation results.The interpreter's experience and knowledge of the location or object of observation plays a very important role in the interpretation process. Visual analysis also requires relatively longer time compared to digital techniques in the analysis process. The form and quality of image data can influence the accuracy of interpretation results.

Research Method

This research was conducted in North Minahasa Regency during the period of February-April 2023. The map of the study site can be seen in Figure 1. SPOT satellite imagery 2022 of the study site was obtained through SAS Planet platform. Field research was conducted to obtain existing condition of coconut plantation in Airmadidi Regency.

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The classification technique used is visual classification which depicts each layer of land cover on a computer screen using ArcGIS 10.8 software. Land cover class detection is carried out by delineating the outer boundaries of groups that have the same color and shape and separating them from the others. Then identification and analysis are carried out using spatial information. Visual interpretation of coconut plantation land is based on several elements, namely pattern, shape, texture, and association (Jensen, 2015).

The resulting map is then overlaid with other spatial data, namely administrative digital data, rivers, settlements and roads. Then dissolve and clip to produce a spatial map of the coconut plantation land which is ready for layout. Map layout is the final stage in map creation. Map layout means arranging the placement of the map title, legend, scale, data source, publisher and so on. The final result is "Spatial Map of Coconut Plantations in Airmadidi District". The area of coconut plantation land and the distribution of coconut plants. The data obtained was analyzed descriptively. Flowchart of research análisis procedure can be seen in the Figure 2.

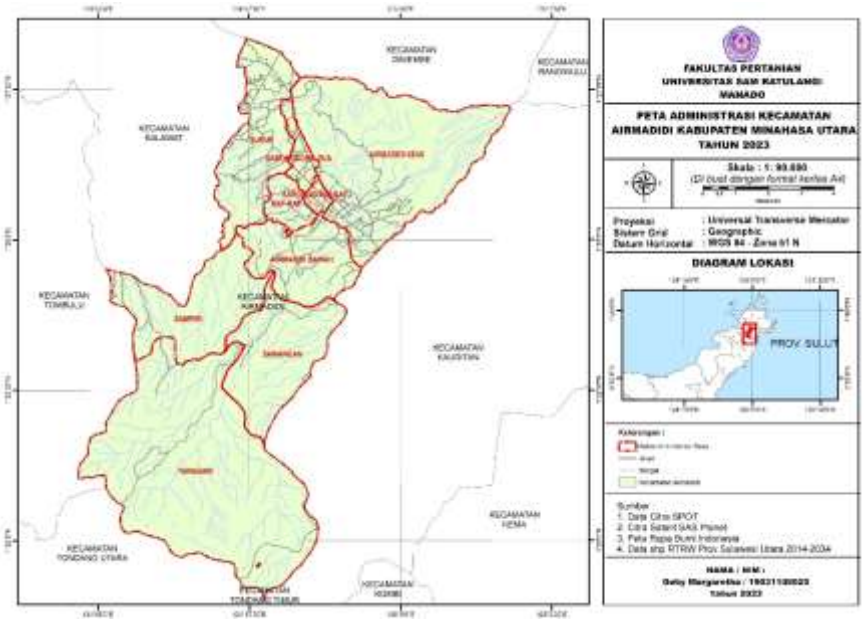
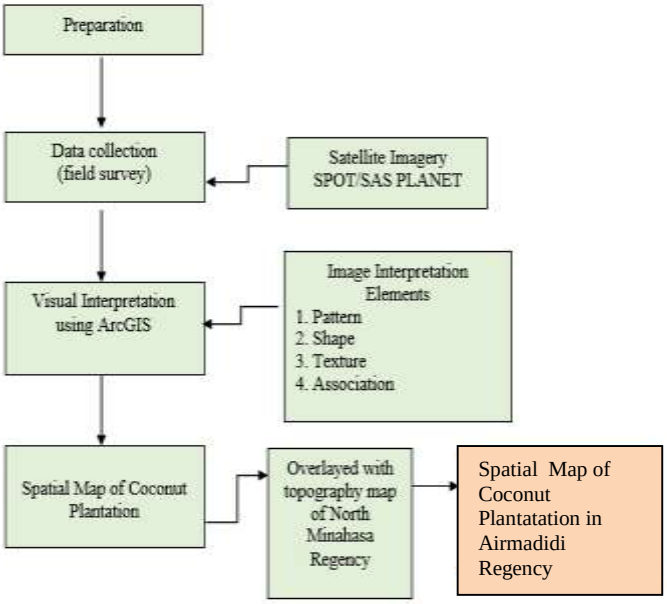


Figure 1. Map of the Study Site



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Results and Discussion

Spatial map of coconut plantantation can be produced using visual interpretation method (Figure 7). Severel elements of image interpretation were used namely pattern, shape, texture, and association.

a. Pattern. A pattern is a series of vegetation forms. Coconut plantations in the Airmadidi sub-district have a specific pattern, namely a marching pattern, so they are easy to recognize. This pattern is due to the method of planting coconuts in parallel with certain optimal planting distances, namely 9 x 9 x 9, so that coconuts have a wide canopy and help coconut plants get enough sunlight and help reduce pest attacks.

Figure 3. Patterns of Coconut Plantation

b. Shape. Shape is a qualitative measure of the length, width and height of an object. In the visual interpretation analysis carried out based on the shape of the plant canopy. The coconut plant has a star canopy shape, so when viewed from above it will be easier to recognize, making it easier to interpret the image.

Figure 4. Shape of Coconut Canopy

c. Texture. Texture is the roughness or smoothness of the visualization of the surface of an object in an image. The rough texture of coconut plants shows variations in type, size and vegetation. Figure 5 shows this Coconut plantation mixed with other plants because the location is near natural forest.

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Figure 5. Texture of Coconut Plantation

d. Association. The relationship of a phenomenon with other phenomena around it is called association. Figure 6 shows coconut plantations in Airmadidi District associated with settlements, roads and rivers

Figure 6. Association of coconut plantation

Based on visual interpretation analysis, a spatial map of coconut plantation can be produced (Figure 7). The distribution of coconut plantation land in Airmadidi District is spread throughout the existing villages, namely the villages of Tanggari, Sampiri, Sawangan, Airmadidi Bawah, Airmadidi Atas, Sarongsong I, Sarongsong II, Rap-rap, Sukur.

The total area of coconut plantations in Airmadidi District in 2022 resulting from visual interpretation is 3,023 Ha. Meanwhile, based on data from Statistical Agency North Minahasa Regency in 2020, area of coconut plantation was 3,328.51 Ha. There was a decrease in the are of coconut plantation during the period of three year which was 305,51 Ha. The decline in the area of coconut plantations in North Sulawesi, especially in Airmadidi District, is thought to be caused by the conversion of coconut plantation land into residential or industrial areas. Findings obtained from a study conducted by Rotinsulu, et al. (2018) in the Tondano watershed area which includes Minahasa Regency, North Minahasa Regency and Manado City indicates changes in land use over the last 13 years (2002-2015), namely from forest land to agricultural areas, and from agricultural areas to urban and residential areas.

According to research conducted in Kalawat District from 2009 to 2019, there was an increase in residential area of approximately 203 Ha (Luntungan et al., 2019). Several previous

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researchers have reported changes in land cover that show an increasing trend of built-up area. Purwekerto City research using predictions and simulations revealed that fluctuations in LULC change on a regular basis, particularly for built-up land, indicating significant growth (Ramadhan and Hidayati, 2022). Land conversion occurs in Indonesia and elsewhere due to rising demand for residential land (Rahmi et al., 2020, Juniyanti et al., 2020, Kaswanto et al., 2021).

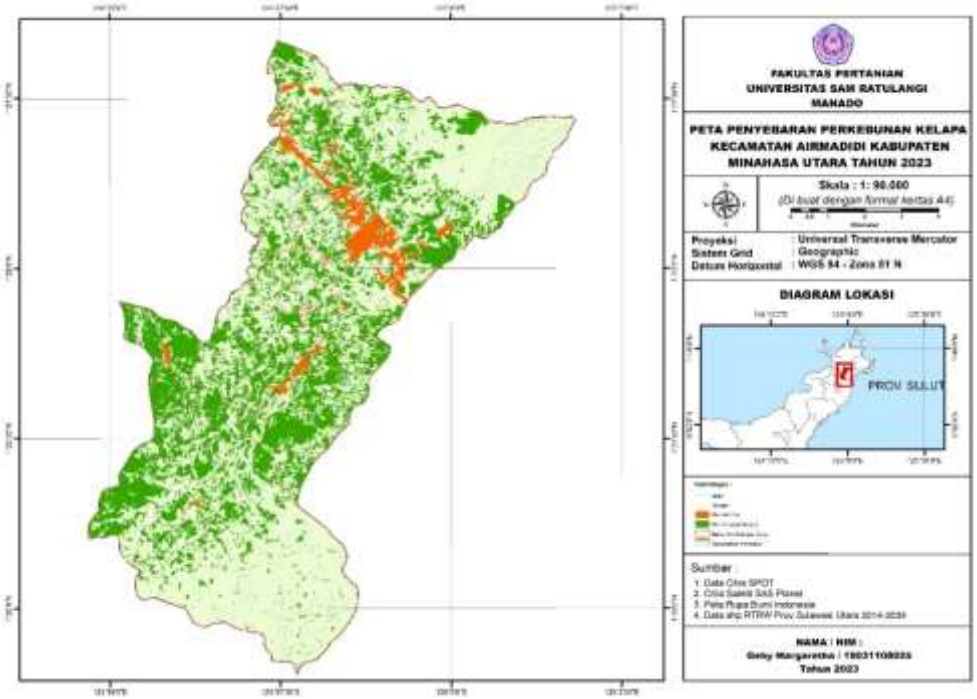

Figure 7. Map of Coconut Plantation in Airmadidi District

The distribution of coconut plantations in Airmadidi District was determined using visual interpretation analysis. Area calculations were carried out based on each village in the Airmadidi District area. The distribution of coconut plantations in Airmadidi District is found in all the villages. The total area of coconut plantations in Airmadidi District is 3,023 Ha. The plantation area in Tanggari village is 870,460 Ha, Sampiri is 502,129 Ha, Sawangan is 508.13 Ha, Airmadidi Bawah is 233.97 Ha, Airmadidi Atas is 533,580 Ha, Sarongsong one is 2.24, Sarongsong two is 58,360 Ha, Rap- rap of 51.76 Ha, Sukur of 262,350 Ha. Tanggari Village is the village that has the largest plantation area, namely 870,460 Ha, while the smallest plantation area is in Sarongsong Satu village with an area of 2.24 Ha because this area is dominated by residential communities.

Tabel 1. Distribution of Coconut Plantations in Airmadidi District

Villages	Area (Ha)
Tanggari	870,460
Sampiri	502,129
Sawangan	508,13
Airmadidi Bawah	233,97
Airmadidi Atas	533,580
Sarongsong Satu	2,24
Sarongsong Dua	58,360
Rap-Rap	51,76
Sukur	262,350

Airmadidi District	3.023

Conclusion

1. Visual interpretation shows a map of the distribution of coconut plantations spread across all villages in Airmadidi District, North Minahasa Regency, namely the villages of Tanggari, Sampiri, Sawangan, Airmadidi Atas, Airmadidi Bawah, Sarongsong I, Sarongsong II, Rap Rap, Sukur which are known through interpretation analysis Visual imagery uses a geographic information system by paying attention to elements of pattern, shape, location, texture and association.

2. The total area of coconut plantations in Airmadidi District is 3 023 Ha. Tanggari village has the largest spread of coconut plantations, namely 870,460 Ha, while Sarongsong Satu village has the smallest area, only 2.24 Ha. There was a decrease in the area of coconut plantation during the period of three year which was 305,51 Ha. The decline in the area of coconut plantations in North Sulawesi, especially in Airmadidi District, is thought to be caused by the conversion of coconut plantation land into residential or industrial areas.

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