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Utilization of UAV (Unmanned Aerial Vehicle) technology for mapping and identification of agroforestry land cover patterns in Namolandur Village, North Sumatra

H Arinah[1], A S Thoha[1]*, Z Mardiyadi[2] and O A Lubis[1]

[1]Faculty of Forestry, Universitas Sumatera Utara, Medan, North Sumatra 20155, Indonesia
[2]Faculty of Forestry, Universitas Papua, Manokwari, Indonesia

*Email: a.siddik@usu.ac.id

Abstract. Agroforestry-based land use is widely used in society, particularly in rural areas. With a combination of tree crops (annual) and crops (seasonal), agroforestry patterns can maximize land utilization. Unmanned aircraft, often known as drones, can map and detect land cover to optimise land usage based on agroforestry. Drones have various advantages, including low cost, ease of acquisition, and the ability to utilize them in high-risk situations without endangering human life or in difficult or inaccessible places. They can also fly at low altitudes, resulting in cloud-free shots and sharper images. This research focuses on using an unmanned aerial vehicle (UAV) to map agroforestry patterns in Namolandur Village and detect and determine the area of each agroforestry pattern land cover using aerial camera photos. Using the Mavic 2 pro drone and Pix4D Mapper software for aerial photo processing, Namolandur village became the research subject. The data analysis revealed that agrisilviculture, agrosilvofishery, and agrosilvopastoral were the forms of land use with agroforestry patterns in the village of Namolandur. In addition, water guava, duku fruit (*Lansium domestika*), oil palm, coconut, and a combination of fish ponds, cattle, and goats are among the geographical analysis of the area and each form of land use.

1. Introduction

Remote sensing and Geographic Information System Technology (GIS) are research methods to obtain spatial data for mapping and environmental observations [1]. The data sources used are satellite imagery and aerial photography [2]. Aerial photography is a photo image obtained from aerial surveys using both manned and uncrewed aircraft flying above the earth's surface at low altitudes [3]. On the other hand, mapping with Unmanned Aerial Vehicle (UAV) is a strategy or method for faster and more efficiently mapping on a large scale. In addition, of course, we can save time compared to using conventional survey methods. In addition, the drone can fly at low altitudes, the resolution of the photos obtained can be very detailed, which is less than 25 cm per pixel [4]. Thus, drones or Unmanned Aerial Vehicles (UAVs), which are commercially available and increasingly economical in price, create great potential as a tool for environmental and ecological analysis, for example, in agriculture, biodiversity [5-7].

Data obtained from satellite imagery and aerial photography is primary data that needs to be processed and integrated into a system that can manage, analyze and display spatial information [8]. One of the standard analyses in remote sensing and vegetation mapping is automatic land cover classification, distinguishing various objects [9]. The land use and cover data help identify land

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suitability, alternatives, better land-use choices, and planning for land change. The uniqueness of land use in an area must also be considered because different regions will undoubtedly have other characteristics. So the development planning process will be different. Accurate spatial data can be obtained by integrating remote sensing data with geographic information systems [10]. Agroforestry is defined as planting trees on agricultural land. The Canadian International Development Centre first pioneered agroforestry and identified development priorities in the forestry sector in developing countries in the 1970s. The identification results show that forests in developing countries have not been used optimally. In addition, activities that lead to environmental destruction were found [11].

Agroforestry consists of three main components, namely forestry, agriculture, and animal husbandry [12]. However, other researchers [13-15] suggest that agroforestry consists of Agrisilviculture, namely land management that combines forestry components with agriculture, Silvopastura, which island management that combines forestry components with livestock, and Agrosilvopastoral, namely land management that combines agricultural elements with forestry and animal husbandry. In addition to the three forms above, Nair [15] added another system categorized as agroforestry: Silvofishery, which island management combines forestry and fisheries components. This study aims to identify land cover based on agroforestry and commodities using UAV in Namolandur Village, Namorambe District, North Sumatra.

2. Data and Methodology

The data collection area of this research is Namolandur Village, Namorambe sub-district, North Sumatra. The data collection area has various covers such as settlements, agricultural land, fish ponds, roads, and rivers, with a total study area of 105.26 ha. UAV data images were acquired in October 2020 with a flight height of 400 m and a ground resolution of 9,95 cm/pix. It had only one mission with a coverage area of 401 ha and captured 192 images used to produce an orthophoto for the study area. In creating the orthophoto of the UAV, each image was mosaicked after building geometry in the Pix4D Mapper software [16]. The results of the orthophoto will then be processed into a map. The flight plan is illustrated in Figure 1.

Figure 1. Flight plan for aerial imagery acquisition

Processing of photos into orthophoto is done using Pix4D Mapper software. the results of 192 aerial photo shoots in the Namolandur village, Pix4D Mapper software was used to form orthophotos with medium accuracy and produce good orthophotos. The results of the orthophoto area study are presented in Figure 2.
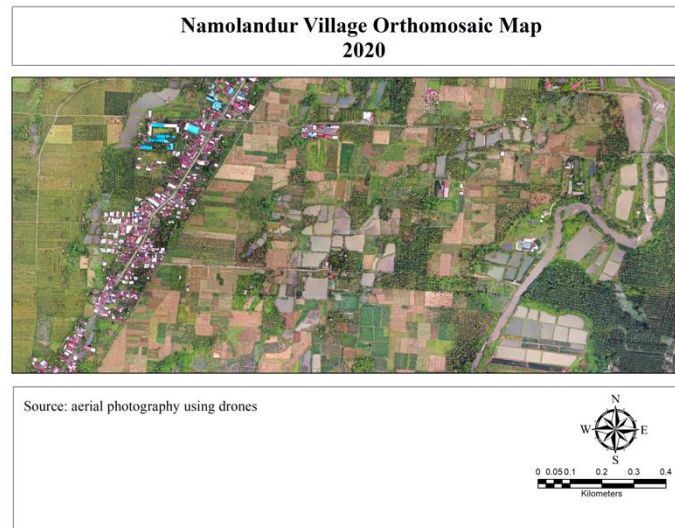
Figure 2. Results of Orthophoto Namolandur Village

Aerial photo images are interpreted by looking at the characteristics/characteristics of objects in general by considering the elements of interpretation and then described based on interpretation elements such as shape, size, pattern, shadow, hue or colour, texture, geographical location, and associations (Utilization of drones).

The next stage, delineation of the results, is carried out to facilitate grouping objects to be presented into the map according to the interpretation theme, which is limited by object classification or category. Then, using ArcGIS 10.4, construct polygons with land-use characteristics. Finally, the location is retrieved using a Smartphone with the Avenza maps program, based on the ArcMap application's points. Finally, a ground check is also used to evaluate the correctness of the interpretation that has been made.

3. Results and Discussion

3.1. Land cover Identification

The analysis of the aerial photographs of Namolandur Village obtained 3 types of land use: Agroforestry, Agrosilvopastoral, Agrosilvofishery, and 7 types of land cover. The area of each land cover type is presented in table 1, and the results of the land cover classification map are illustrated in Figure 3.

Tabel 1. Type and Area of Land Cover Based on Aerial Photography

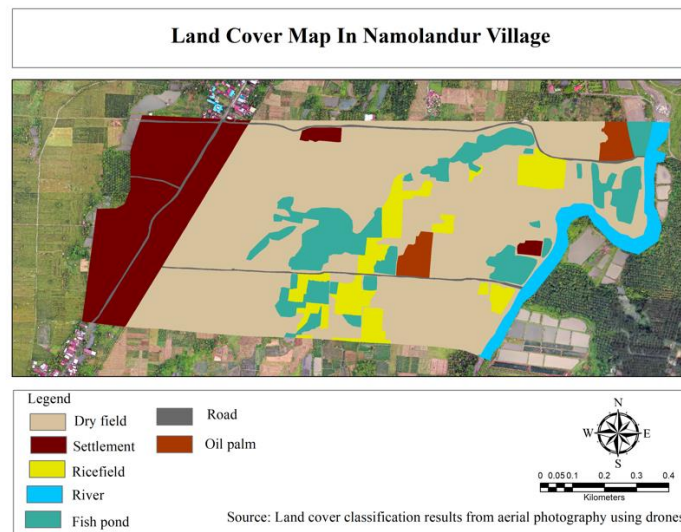| No.	Types of Land Cover	Area (Ha)	Per cent (%)
1.	River	4,69	4,46
2.	Dry field	60,61	57,59
3.	Ricefield	7,31	6,95
4.	Settlement	16,45	15,63
5.	Oil Palm	2,19	2,08
6.	Fish pond	11,91	11,32
7.	Road	2,08	1,98

Figure 3. Land Cover Map of Namolandur Village

According to table 1, it can be seen that land use and land cover in Namolandur Village is dominated by dry fields with an area of 60.61 ha out of a total of 105.26 ha, followed by settlements of 16.45 ha and fish ponds covering an area of 11.91 ha. The delineated land cover can be seen on the land cover map of Namolandur Village. The results of the delineation are presented in figure 2. In table 1, land use of dry fields and fish ponds dominates in Namolandur Village. According to Wibowo et al. [17], freshwater fish farming (fish ponds) is the local wisdom of the people who live in watersheds. Namolandur Village is close to the river deli.

3.2. Agroforestry Land Use Identification

Dry fields in the village of Namolandur are a type of land cover based on agroforestry. Several types of agroforestry in this village are agrosilviculture, agrosilvopastoral, and agrosilvofishery. People in this village combine types of agricultural commodities, livestock, and trees. Commodities that make up various types of seasonal and annual plants by applying a simple agroforestry system. A simple agroforestry system is a simple agroforestry model of a conventional blend consisting of a small number of elements, which describes what is now known as a classical agroforestry scheme [18] .

The people of Namolandur Village use a simple agroforestry system. In this system, the community cultivates a mixed garden cropping pattern that combines seasonal crops such as rice, corn, bananas, and forestry plants (tree species) such as teak, guava, and duku. In addition, there are non-timber crops such as coconut, dates, and areca nuts. The trees planted can have high economic value, such as teak, rambutan, duku fruits, and guava. Non-timber crops with high economic value include rice, corn, bananas, coconuts, and areca nuts. The types of livestock kept mainly by the community are cows and goats, while the kind of fish is carp. In addition, the people in Namolandur Village also cultivate oil on their land.

The positive interactions that occur between the various components that make up agroforestry include physical, biological factors, socio-economic and cultural factors, and policies that also play an essential role in influencing human actions in managing an agroforestry landscape [19]. Both forms of land use apply agroforestry patterns. The pattern applied consists of a seasonal crop pattern in which corn, guava, rice, coconut, duku, bananas, and rambutan are the main crops, while forestry crops, such as teak, are planted on the margins and grow wild. Mixed gardens are land owned by the people of Namolandur Village, which is located not far from the settlement. On average, it is a distance of 0,1-1 km from settlements. The more detailed information is presented in Table 2.

Tabel 2. Agroforestry Land Use

Type of Use Area	Commodity Type composer	Aerial Photography	Field Condition		
Agrosilviculture	Rice, corn, bananas, teak, duku fruit, dates, coconut, oil palm, rambutan, areca nut				
Agrosilvopastoral	Cow, oil palm, dates, corn, guava				
Agrosilvofishery	Goldfish, coconut, oil palm, rambutan, duku fruit, rice				

4. Conclusion

The land cover identification through aerial photography in Namolandur village, 7 types of land cover were found. The type of cover in the village of Namolandur (> 50%) consisted of dry fields with an area of 60.61 ha, followed by settlements of 16.45 ha and fish ponds of 11.91 ha. Therefore, there are 3 types of agroforestry land use in this village: Agrosilviculture, Agrosilvopastoral, and Agrosilvofishery.

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