Mapping the village forest of Pattaneteang through drone participatory mapping

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Abstract. The Government of Bantaeng Regency, South Sulawesi Province is one of the first districts established policies to support community-based forest management and to adopt the Ministry of Forestry (Kemenhut) policy on Community Forests (CF – Hutan Kemasyarakatan HKM) and Village Forests (VF – Hutan Desa HD). There is one VF located in Pattaneteang, which has characteristics and great resource potential. In the VF management process, several problems arise in conflicts between villages over boundaries that increase with reducing the landscape as a resource. The utilization of a geographic information system (GIS) in landscape management is expected to provide complete information for managing the form of VF areas integrated with each other. This study aims to produce a precise map of the VF area based on the image map of the drone results. The latest methods are used to produce accurate delineation of the region through drone participatory mapping (DPM) technology involving several related parties. DPM is a group-based research method that gives participants the freedom to make discussions on topics with minimal intervention from researchers. Simply put, it is an activity in which villagers choose to location referencing and other features related to the topic given on the map. The participatory monitoring method was carried out through a Focus Group Discussion (FGD). The results showed that Pattaneteang Village which, has an area previously about 1303.81 ha after the village was carried out, participatory mapping reducing became 1107.79 ha, then participatory mapping was carried out based on the result of the drone, Pattanetang area was obtained to be 1109.92. While the extensive VF based on Decree of the Minister of Forestry No.55 / Menhut-II / 2010 dated January 21, 2010, Pattaneteang VF forest area was 339 ha after drone based-participatory mapping (DPM) to 429.71 ha related to three types of forest, namely Core Forests, Utilization Forests, and Dispute Forests are covering 48.15 ha, 198.12 ha and 181.43 ha, respectively. The results of this study can be used as a reference in planning sustainable village forest management areas.

Keywords: geographic information system, precision maps, village forests

1. Introduction

Decentralization has revived a new bottom-up approach to forest governance in Southeast Asia. In Indonesia, social forestry and customary rights (customary forests) are among the leading forms of forest management [1]. Forests are a source of landscape services that are important for the sustainability of ecosystems. Well, preserved forests are very important to biodiversity conservation and provisioning landscape services [2]. Tropical forests provide ecosystem services directly or indirectly derived from ecosystem functions [3] [4].

The Ministry of Forestry has provided access to village communities to manage forest areas legally, one of which is the village forest (VF-Hutan Desa, HD) scheme with management access rights for 35 years [5]. Village forest development can contribute to the development of livelihood security for people dependent on forest resources. VF
management, in principle, is how to involve the community around the forest to benefit from the existence of the forest without changing the function and status of the forest area.

In recent years, the community forestry model has become a popular approach to forest management globally [6]. Community Forest Management (CF-"Hutan Kemasyarakatan, HKM) is increasingly recognized as a potentially effective means of protecting forests [7]. Community forestry (CF) development such as village forest (VF), has been considered as a successful national strategy to improve rural livelihoods and environmental protection, where local people protect and manage forest resources to increase forest cover and improve forest conditions to provide forest products such as fuelwood, wood, animal feed, leaf litter and other ecosystem services (ES) [8].

Participatory mapping is a type of public participation that includes creating and using spatial information for various purposes. Participatory mapping differs significantly in design and implementation, for example, public participatory GIS (PPGIS), participatory GIS (PGIS), and Volunteered Geographic Information (VGI) [9]. Community assessments of land use are important for planning and allocation, especially in areas where conflicts over limited resources have occurred historically or are likely to arise [10].

The application of participatory mapping in land use planning can be regarded as a planning support system (PSS), emphasizing the participatory components of the system. As a form of public participation, participatory surveying and mapping have many ideal goals for public participation, such as increasing trust, reducing conflict, providing information and education to the public, incorporating public values into decision-making, and improving the quality and legitimacy of decision-making [11]. Specifically, this study aims to map the village forest area (VF) of Pattaneteang Village based on drone images to produce a precise map of the VF area and check the VF spatial distribution based on the participatory mapping.

2. Data and Methods
The research was carried out in Pattaneteang Village, Tompobulu District, Bulukumba Regency, South Sulawesi, Indonesia. Geographically, Pattaneteang Village is located between 119° 57’ 53” and 120° 2’ 9” East Longitude (EL) and 5° 22’ 31” and 5° 24’ 40” South Latitude (SL). This village is 155 Km from the capital city of South Sulawesi Province. Pattaneteang Village is located in the ecosystem at the foot of the Bawakaraeng-Lompobattang Mountains, with the topography at an altitude between 650-1760 masl. The research data consisted of primary data and secondary data. This research uses primary data in the form of drone image maps, existing data on village land use, and types of commodities developed by the village community. Secondary data is in the form of village administrative boundary data set by the government and village administrative boundary data resulting from the participation of villagers.

Four main methodological steps were taken to carry out participatory mapping of the Pattaneteang Village Forest. It begins with taking drone images of Pattaneteang Village based on the village administrative map. Unmanned Aerial Vehicle (UAV) technology or drones are currently gaining popularity. In addition to increased sensor capabilities, drones also produce aerial images that can be used to map accurately, easily understand to managing environmental landscapes [12]. Second, making an orthophoto map by combining drone photos to form a mosaic image of the entire study area. Third, the implementation of participatory mapping based on drone image maps. Fourth, delineating the boundaries of the Pattaneteang VF area as well as comparing village administrative boundaries based on the results of drone based-participatory mapping, administrative boundaries of participatory village maps, and administrative boundaries by the government.
2.1 Taking Aerial Photographs using Drones
To take aerial photos using drone DJI Mavic Pro to get the village aerial photo data Pattaneteang. Preparation begins with a flight path planning, which includes the polygon design of the research area based on a village map with a buffer as far as 50 meters from the village administrative boundary, determining the size of the photos that are overlapping (sidelap and overlap), planning starting location take-off, landing, and fly high. The applications used are Pix4D Capture and Ctrl + Dji. The flight path created includes all research areas, which are divided into 35 polygons. Sidelap and overlap are used by 70%, the take-off and landing locations are in open areas with a flying height of 200 meters above ground level at the take-off locations.

Determination of the Ground Control Point (GCP) for geometry correction by installing markers at 30 points at the research location, measured by GPS Garmin, this correction is made if the coordinates of the drone do not match the truth, but if it is appropriate, then no correction is made. Camera calibration and drone GPS calibration are carried out with the DJI Go 4 application so that the resulting aerial photos can match the correct coordinates. Calibration is done before drone take-off.

2.2 Combining Drone Photo results
The raw images of each flight were compiled using the photogrammetric software Agisoft Metashape. The principle is that each photo has coordinated and overlaps with another photo next to it. The ortho mosaic results are then combined to form an image mosaic of the entire study area (orthophoto map) using the Arc Gis 10.5 software.

2.3 Drone Participatory Mapping (DPM)
After generating an orthophoto map of Pattaneteang Village based on the drone results, the map was then printed for the purpose of participatory mapping (PM) based on drone images. In implementing participatory mapping (PM) is combined with Focus Group Discussion (FGD). Use a combination of PM and FGD as these methods are well established in the field of development studies and planning. Using this method is an efficient way to know a group perspective. Participatory discussions make an important contribution to social knowledge and learning about forest management models [13]. The FGDs, in turn, helps to generate more descriptions of the topics at issue as well as a deeper understanding of local history, perceptions, and meanings of the region itself [14].

The Participatory Mapping (PM) based on orthophoto maps, is printed at a scale of 1:10,000 (size A0). Mapping was carried out together with 15 community members representing community specialists as informants (Forestry extension, village government and NGO members, farmers, and community leaders). In community-based forest management, organizations outside the community play an important role in achieving various social and ecological goals [15]. The PM’s main objective is to accurately delineate the Bantaeng District Village Forest Area’s boundaries and extent.

The PM first introduces the topic and collects background information about the informant (such as age, family details, main livelihood, education, personal knowledge of the landscape), and then locates it on the aerial photo map. First, informants mark their houses on the map, and then indicators for each different landscape service are mapped one by one using colored paper for each marked indicator. Allow the information provider to draw as many locations as possible for each indicator. Each indicator is fully mapped with descriptive statements to add relevant information, such as which plants are grown, how to use medicinal plants, and why certain places are considered beautiful or important. PM to determine boundaries area and area sizes were carried out together with selected community groups who then delineated village boundaries and village forest boundaries, determining boundaries marked with attributes that could be confirmed in the field. The
colored paper markers are manually copied onto the A3 paper copy of the aerial photo map. At the end of each interview, the original image map and marked data were also taken for verification.

2.4 Overlay of Drones Participatory Mapping (DPM) Results
DPM results are then delineated using ArcGIS 10.5 and then overlaid with the base map used are village administration map by the government and the participatory map that has been carried out by the village government. The aim is to compare the mapping results using drones with the available maps.

3. Result and Discussion

3.1 Orthophoto Map of Pattaneteang Village
An orthophoto is a reproduction of a photo that has been corrected for errors by plane tilt, relief, and lens distortion [16]. An orthophoto is a result of the process of aerial photogrammetry. An orthophoto is a type of aerial photograph that has been corrected for geometric errors using DEM data and GCP data to be used for mapping purposes without any scale inconsistencies throughout the scope of the photo [17]. Orthophoto can be created after the Dense Point Clouds, Mesh, and DEM stages are complete. Orthophoto maps (drone images) are used to obtain high accuracy and make it easier to determine different land cover boundaries. Sjaf (2015) research results reveal that used drones can make it easier for rural communities to prepare careful planning with a substantial drone innovations database. The Orthophoto map used is the result of photographs from drones combined to form a mosaic image of the entire study area. The principle is each photo has coordinated and overlaps with another photo next to it, processed using Agisoft Metashape (figure 1).

3.2 Drone Participative Map Pattaneteang Village
Pattaneteang Village was a division of Labbo Village in 1980 [18]. Participatory mapping (PM) is a type of public participation that includes creating and using spatial information for various purposes [19]. Based on government administration, Pattaneteang Village has an area of 1309.9 ha (Figure 2). After participatory mapping (PM) was carried out by the village government in 2018 through tracking the Pattaneteang Village Mapping Team, it was found that the area of Pattanetang Village was 1107.79 ha. Participatory mapping by the Pattaneteang Village government was carried out for six months. On the Bantaeng Regency map, the administrative area of Pattaneteang Village boundaries is in the Labbo Village area of 196.9 ha. Develop local participation as a strategy to protect and maintain the biological and environmental resources and historical value of cultural landscapes [20]. Then, after participatory mapping based on the drone results, the final area of Pattanetang Village was 1109.92 ha. This area is not much different from the participatory results that have been implemented by the village government. The Pattaneteang Village Government made the river flow as the ecological boundary between villages, and these rivers are the Bialo River and the Kulepang River. PM may include objective assessments (for example, the distribution of species based on community science or mapping paths for entertainment) and/or subjective data (for example, the perceived quality of the landscape or the location of intangible environmental services) [21]. Community assessment of land use is very important for planning and distribution, especially in areas where conflicts of limited resources have occurred or may occur in history can arise [10].
Figure 1 Orthophoto map of Pattaneteang Village, Tompobulu District, Bantaeng Regency

Figure 2 Administrative boundaries map of Pattaneteang Village
3.3 Pattaneteang Village Forest Area by Drone Participatory Map

Drone based-participatory mapping was also carried out to determine the boundaries and area of the Village Forest area managed by the Pattaneteang community. Village Forest mechanism is a form of forest management. Collective forest management has a positive impact on the provision of environmental services that are beneficial to local, regional, national, and international users [8].

Based on the results of DPM, the area of Pattaneteang Village Forest (VF) is 427.70 ha, which is categorized into three types and forest status according to the results of the PM that has been carried out by the village government (Figure 3). In the final stage, the VF area is then compared with the area from each of the three different data sources (Table 1). Village Forest area previously determined by the government in the Decree of the Minister of Forestry No.55 / Menhut-II / 2010 dated January 21, 2010, Pattaneteang Village covering an area of 339 ha. After carrying out PM by the village government, the area of VF is 429.71 ha, which is divided into Core Village Forest covering 48.38 ha, Utilization Village Forest covering an area of 199.05 ha, and Administrative Dispute Village Forest covering an area of 182.28 ha. However, after carrying out DPM, the total area of VF Pattaneteang was 427.70 ha, consisting of Core Village Forest covering an area of 48.15 ha, Utilization Village Forest covering an area of 198.12 ha, and Administrative Disputing Village Forest covering an area of 181.43 ha.

Utilization VF is the forest that is intensively managed by the community to cultivate coffee and cloves. Core Village Forest is part of the Lompobattang Protected Forest area, which the community only uses for their daily needs in non-timber forest products (NTFP). Not only as a producer of wood and forest NTFPs, it also functions as a provider of environmental services, reducing natural disasters while protecting nature [22]. Meanwhile, administrative dispute VF is an area that also has the status of Lompobattang Protected Forest. The area is administratively part of the administration of Pattaneteang Village, Tompobulu District, Bantaeng Regency, but the population in this area are residents of Borong Rappoa Village, Kindang District, Bulukumba Regency. Participatory methods allow decision-makers to understand the views and issues of local communities and determine strategies to support agriculture, and public participation can also be used as a landscape planning tool [20].

| No | Data Sources                        | Core Village Forest (Ha) | Utilization Village Forest (Ha) | Village Forest Administrative Dispute (Ha) | Total area (Ha) | Difference Area: DPM (%) |
|----|-------------------------------------|--------------------------|---------------------------------|------------------------------------------|----------------|-------------------------|
| 1  | Government Participatory mapping    | -                        | -                               | -                                        | 339            | 20.74                   |
|    | by Village                          |                          |                                 |                                          |                |                         |
|    | Drone Participatory Mapping         | 48.38                    | 199.05                          | 182.28                                   | 430            | 0.47                    |
| 3  | Participatory Mapping               | 48.15                    | 198.12                          | 181.43                                   | 428            |                         |

Table 1 Comparison of the area and type of Pattaneteang Village Forest based on data sources
Figure 3 Map of the Pattaneteang Village forest area

4. Conclusion
The results showed that through drone based-participatory mapping, accurate data would be obtained regarding the extent and boundaries of an area. The area obtained in DPM is not much different from the PM that has been carried out by the village government. However, the important difference between the use of participatory and tracking methods is that this will take a very long time. The study also shows that a participatory approach, integrated with precise satellite imagery (drone imagery), is an appropriate approach to involve local communities in discussions about forest landscape management. A participatory approach can increase efforts to integrate perceived public values into land and resource management decision-making processes, especially in data-poor rural areas.

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