International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Unmanned Aerial Vehicle (UAV) Data as a Land Cover Data Renewal in Pandanrejo Village, Kaligesing Sub-District, Purworejo

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Abstract

The high activity of the community caused changes of the land cover in a region. The changes is needed to be renewed to support the actualisation of data in the field with the data on the map. Remote-sensing technology development is able to make the data renewal of a certain area to get easier. One of the strategies that can be done to make this data renewal is by using UAV technology. UAV or Unmanned Aerial Vehicle has various advantages, such as: it has real time and actual data. Moreover, it is cheaper and more effective technology which can be used to get high-resolution data. Pandanrejo village has a variety of land cover types according to its relief. Based on the visual interpretation and classification elements, there are 23 classification classes that refer to classification for detail scale mapping. Based on the aeral photograph, UAV can provide a detail data extraction on a 1:5000 scale. On that scale, field's appearences, in the form of its vegetations, buildings, and other kind of appearances in Pandanrejo Vilage, Kaligesing Sub-district, Purworejo, can be seen and identified in detail way. This research is aimed to: (1) analyze and make a visual interpretation to what extent UAV can be used to make a land cover data renewal and land cover mapping and (2) provide the detail information about to what extent UAV can be used to make a land cover data renewal and land cover mapping. The method employed in this research was to do a visual interpretation by employing on screen digitization to get the land cover classification in order to make the land cover data renewal of Pandanrejo Village.

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The results of this research are the Pandanrejo Village's land cover mapping based on the analysis and visual interpretation of UAV data and also the update of Pandanrejo Village monograph data based on the interpretation process and calculation of the Pandanrejo Village's land cover area.

Keywords: UAV; Land Cover; Visual Interpretation; Onscreen Digitation.

1. Introduction

Land is a part of the Earth surface which is very useful for human life. It consists of physical and non-physical factors [1]. Land cover is a physical material appearance of the Earth surface. It describes the relation of natural process and social process. Land cover may provide the important information in modelling and understanding the phenomena happens in Earth surface [2]. Land cover data may also be used as device in studying the climate change and in understanding the relationship between human activity and global changes [3,4,5]. When people's activity level in a certain area is getting higher, the occurace of environment changes is getting higher as well. Therefore, it is important to make the data renewal of the land use. Land cover is a basic information in geoscience and global changes [5]. The information related to land cover is an important factor which can be used as a determinant in improving hydrological systems, ecosystems, and the atmosphere [6,7,8].

Based on several policies and rules of Indonesian Laws and Regulations related with geospatial information, which are the Implementation of Law No. 4 Year 2011 Regarding Geospatial Information, Indonesian Presidential Regulation No. 9 Year 2016 Concerning the Acceleration of One Map Policy Implementation at the Accuracy Level of Map Scale 1:50.000, land cover data is considered as one of the important informations related with the next Indonesian Government's policies.

Remote-sensing is an important and effective media which can be used to observe the land cover. It is because remote-sensing may provide information on the diversity of spatial appearance on Earth surface quickly, broadly, precisely, and easily [4,9,10,11]. Remote-sensing data are needed in monitoring the changes that have been occurred. Therefore, it is important to decide the most suitable method in collecting the data. However, sometimes there are several obstacles that disturb the monitoring process itself such as vehicle's limited flight time and also when there are clouds which cover the object appearances. High quality of remote-sensing data are needed to make an update towards the data of the land cover itself especially on a large scale. Small Format Aerial Photography (SFAP) using UAV (Unmanned Aerial Vehicle) method is one of the strategies which may be able to be applied in monitoring the changes happens in a certain area. Limited availability of high-resolution image data of an area makes UAV is suitable to be employed because of its relatively fast operating system and its capability of flying at low altitudes to produce a very high-resolution image [12]. Aerial photograph from UAV is almost not affected/disturbed by the atmospheric condition. This research was conducted in Pandanrejo village, Kaligesing, Purworejo. It was done in order to update the data and find out to what extent UAV can be used in updating the land cover data of this village area which has diverse topography.

As in previous studies conducted using various similar methods, it provides some insights related to the research being carried out. The use of UAV photography as a data source for land cover mapping is considered as more detail in presenting objects [13]. In [14] also used UAV to determine objects in cadastral mapping that considered appropriate to provide detailed features related to settlement landscape at a scale of 1: 1000, agricultural landscape at a scale of 1: 2500 and planimetric at a scale of 1: 10,000 according to technical guideline of government regulation number 24 of 1997 and is a solution to map areas with various topographies. Research by [15] classified land cover vegetation from UAV imagery using OBIA to determine land cover in Cilacap Regency, while this study used visual interpretation. The other research in [16] used visual interpretation method for mapping changes in land use through Landsat, so that the source of the data used in this study is a Landsat image that has a lower spatial resolution but with a wider area coverage

Based on [17], basically image interpretation is divided into two main activities. They are the activity of recording the data from satellite imagery and the activity of using the data for a particular purpose. Data from UAV are used to observe the changes of land cover by doing a visual interpretation. Based on [18], image interpretation is an act of studying/observing the aerial photograph or satellite imagery to identify an object and to value the important meaning of the object itself. Meanwhile, visual interpretation is one of the paradigms which is used to identify the object in remote-sensing data by using the interpretation keys through the eyes. There are 9 (nine) interpretation elements that can be used, which are:

- Tone and color. Tone refers to darkness and brightness level of the satellite imagery. Color refers to an appearance of something which can be seen by the eyes using narrow portion of the spectrum which is narrower from the visible spectrum.
- Shape is qualitative variable which gives the configuration or the framework of an object. Therefore, this object can be recognized based on its shape only.
- Size is the object attributes in the form of distance, area, height, slope, and volume. Since size element is a scale function, therefore in taking the advantage of using size as a satellite imagery interpretation element, it is very important to remember the scale.
- Patterns, height, and shadow are classified into tertiary complexity level. Its level of complexity is higher than the complexity of shape, size, and texture as the element of the satellite imagery interpretation. Patterns or spatial arrangement is a characteristic which gives marks towards the human-made object and several natural object as well.
- Shadow tends to hide the detail or an object which is located in a dark area. Generally, an object or a sign is invisible or it may seem faintly.
- Texture is a frequency of tone changes in an image [19]. It also can be said as a repetition of a group of several objects which are too small to get differentiated individually [18].
- Site. Along with association, site is classified into higher complexity level. Site is not a direct object characteristic. It is the position of an object towards another object around it [18].
- Association can be considered as a relation of one object to another. This relationship can make the other objects become recognized on the satellite imagery. This object can be used as a hint of another object.

2. Materials and methods

2.1. Materials

This research was conducted in Pandanrejo village, Kaligesing sub-district, Purworejo, Central Java. It is aimed to observe to what extent UAV image can analyze land cover in large scale so that it may provide the information for the data renewal of land cover itself especially in Pandanrejo village, Kaligesing, Purworejo. There are several materials needed, such as:

- Aerial photograph by using UAV (taken on May 2019) which has been orthorectified.
- Classification of Land Use in the Validation Module of Spatial Planning Map from Spatial Information Agency
- Monograph data of Pandanrejo Village, Kaligesing sub-district, Purworejo from 2016 to 2019

2.2. Methods

The data collection was done by preparing the materials used in doing the research – both in the form of primary data: aerial photographs that have been acquired and the basic classification of the land use for large scale mapping, as what is described in figure 1. This process is followed by preparing the monograph data of Pandanrejo Village taken from Pandanrejo Village's data.

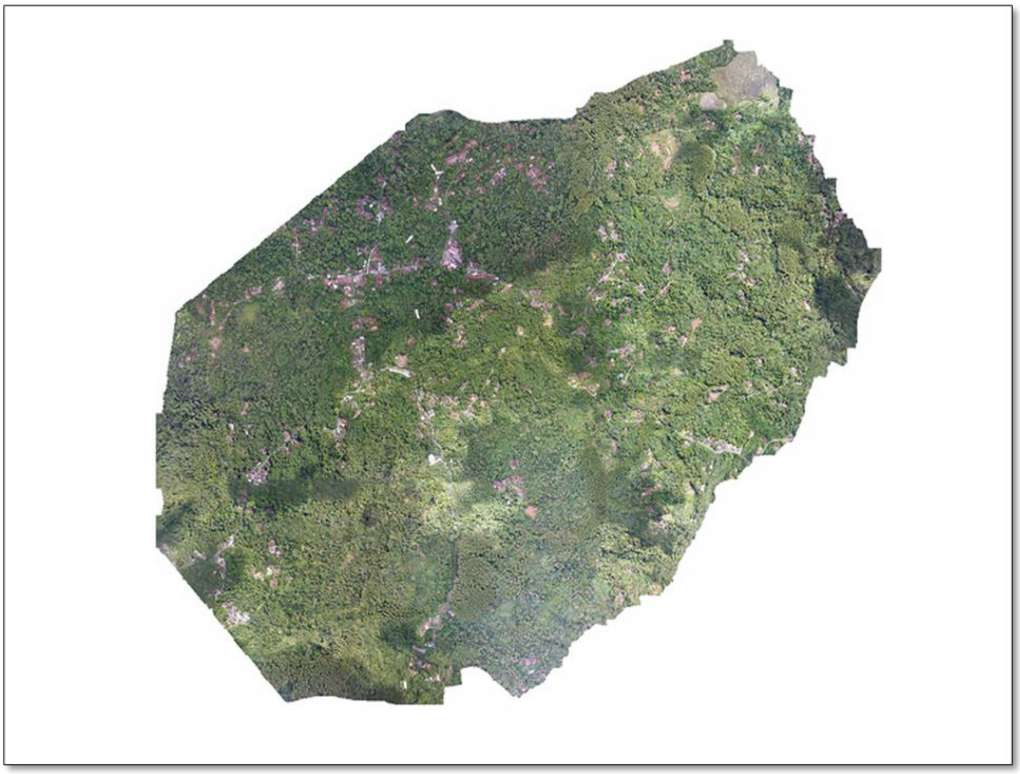

Figure 1: Aerial Photograph of Pandanrejo Village

Results processing is divided into two main activities. They are the land use classification process by doing visual interpretation and also digitization process. The next step is analyzing the data renewal which is done based on the monograph data of Pandanrejo Village. Visual interpretation was done by employing 9 (nine) elements of interpretation which are color and tone, texture, shape, size, site, patterns, association, shadow, and convergence of evidence. It was aimed to classify the land cover. The classification was done based on the Classification of Land Use in the Validation Module of Spatial Planning Map for middle to detail scale. This classification was aimed to get informations in detail way based on detail classification and it was adjusted with technical specification of the presentation of the village map. Onscreen digitization can be generally defined as a conversion process from analog data to digital format. Digitization is done towards the aerial photograph based on the guidelines. Digitization process is done by implementing the previous interpretation results with down-scalling methods (from general to detail).

The analysis of the data renewal and land use was done by comparing the classification and visual digitization which was taken from the village agency in the form of the monograph data. It was analyzed in order to observe to what extent UAV can be used to make the monograph data renewal of Pandanrejo Village.

3. Results

Aerial Photograph were used in this study were captured using UAV on May 2019. Aerial photography coverage covers the entire village of Pandanrejo (figure 1). Pandanrejo Village administrative boundaries are shown in the figure 2. This research, however, is subject to several limitations. First, the classification used refers to the Validation Module of Spatial Planning Map from Spatial Information Agency. The map scale used is a large scale, specifically 1: 5000, so a detailed classification class should be needed. Even though the object being mapped is land cover, a specific point object is named using land use naming and improved by detailing the types of plants using Latin. Second, no field survey was conducted to validate land cover. Due to the current pandemic conditions, it is not possible to conduct direct field surveys. The classification is carried out by visual interpretation assisted by digital validation using Google Street View. The classification results obtained are sufficient in accordance with the real field conditions.

Figure 2: Pandanrejo Village administrative boundaries

Visual interpretation is conducted by optimizing the original color of the aerial photograph in order to conclude the identified object. Then, the objects are analyzed based on 9 (nine) elements of interpretation. It is aimed to strengthen the recognition of the object. 9 (nine) interpretation elements used in this research are tone and color, patterns, shape, size, shadow, texture, site, association, and convergence of evidence. The interpretation is conducted based on the expert knowledge. Each elements or interpretation key has their own roles in recognizing the objects specifically.

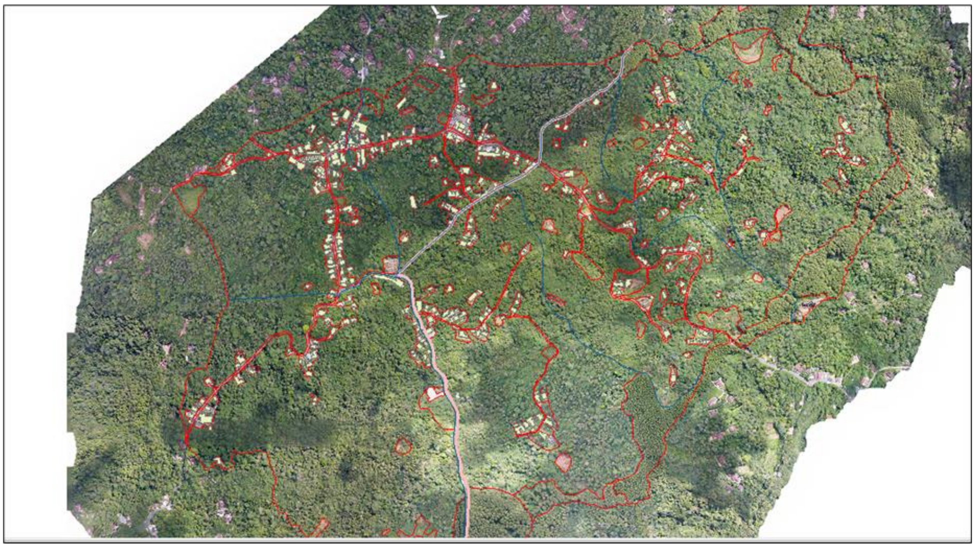

Figure 3: Digitized aerial photograph based on classification guidelines

UAV aerial photograph can be used in data extraction process to get the detail scale. It can even present the object appearances up to a scale of 1:1000. Based on the interpretation, the object appearance can be seen very clearly in the form of its shape, size, and its specific characteristic. Therefore, the UAV satellite is very suitable to be used in making the land cover mapping on large or detail scale. In fact, it can be used to identify the vegetation species based on its certain characteristic. Object classification from aerial photograph is conducted by identifying each visual appearance through the eyes. This process requires references. Moreover, it is also done based on interpreter's knowledge.

Figure 4: Mixgarden Object (*S. mahagony*, *C. nucifera*, and *A. chinensis*)

Figure 4 shows an object appearance in the form of mixgarden which includes *Albizia chinensis* (Osbeck.) Merr., 1916, *Swietenia mahagoni* (L.) Jacq., 1760, and *Cocos nucifera* L., 1753 trees. The first interpretation key element which is able to be seen is its green color. It shows that this object is a greenery vegetation. Those three kinds of vegetation are identified based on its canopy shape. Each of them has different canopy shape and characteristics. *Albizia chinensis* (Osbeck.) Merr., 1916 canopy tends to have wide and irregular characteristic. Its leaves are not too dense. Therefore, it can be seen that there are several gaps on its canopy. *S. Mahagony* canopy, however, has a circular and round shape. It has lush foliage so that there is no gap found on its canopy. The *C. nucifera* tree's canopy is the easiest canopy to recognize. Its shape looks like a star. Moreover, it also has sparse leaves so that there are gaps on the canopy.

Figure 5: Dryfield with vegetables object

Object in Figure 5 can be defined as a dryfield with vegetables because of its interpretation keys in the form of tone and color, shape, size, pattern, site and association. Based on its shape, this object has an irregular shape which is related to non-natural appearances or it can be said that it is a human-made object. Its size is not too large and it is located near from the residential area and the road network. Its tone and color give an information that this object is a dryfield or a cultivated land. It is elongated, well-organized, not too dense, and not too high plant patterns.

Figure 6: Dryfield with cashcropsobject

Object in Figure 6 is categorized based on the interpretation keys in the form of shape, size, site and association which are the same with the fields object. Based on its tone and color, it can be seen that there are dark and light green color. There are also elongated, well-organized, and quiet high plant patterns which may give an information that this object is a dryfield area (not for paddy/rice) and it may be categorized in a dryfield with cashcrops classification.

Figure 7: Bare land object

Bare land object in figure 7 is identified based on its tone and color which is similar like dry soil color. Its tone is bright which has no buildings or other objects on it.

Figure 8: *P. mekusii* Forest

Land cover classification in the form of *Pinus merkusii* Jungh. & de Vriese forest (figure 8) can be identified based on its shape visual interpretation key. It has small-rounded canopy shape which the distance is close to one another. Its pattern is identical and well-organized. It has green color with medium tone and it is associated with the terracing system as well. This conditon may give an information that this area is located in a highland. It is because highland is one of the *P. merkusii* trees habitat.

Figure 9: Gunung Ki Sebutong tourism

The object appearance in figure 9 which can be seen from this aerial photograph has its own uniqueness. It is because it has irregular shape of rocks. Moreover, its texture is bumpy and it is also associated with the surrounding forest. Its uniqueness should be interpretated with convergence of evidence in the form of information related with the existence of this tourism area which is located in the area in which this research is being conducted. This information is taken from the secondary data.

UAV aerial photograph is able to differentiate an object to another with relatively high level of detail. In this case, buildings appearance can be identified in more detail way; whether it is identified as residential buildings or non-residential buildings.

Figure 10: Residential buildings

Residential buildings in figure 10 are identified based on its tone and color. It seems like a real appearances of the roof tile. Moreover, it also has regular geometric shape with identical pattern arrangement. Since it is associated with another building, it is more certain that this area is a villagers' residential buildings which tends to be not very well-organized. However, it can be identified that they tend to be clustered.

Figure 11: School (left), traditional market (middle), and cemetery (right)

Meanwhile, for non-residential buildings, they are identified by several detail classification such as: cemetery, animal farm, traditional market, mosque, school, and shopping complex buildings. The classification is obtained from the element of the multilevel roof shape and also another specific characteristic such as for the mosque, there is a loudhailer/megaphone. Another specific characteristic that can be found is the appearance of flagpole at a school and also the appearance of regular roof shape of a market. Road network can be considered as an association element of shopping complex buildings.

Figure 12: Aspalt road network (left) and Concrete road network (right)

Based on figure 12, it can be seen that there are asphalt and concrete road network. They are identified based on shape and its elongated patterns. There is different tone and color of each type of roads. Concrete road network has white color with bright tone meanwhile asphalt road network has black color and darker tone. Asphalt road size is bigger than concrete road. It is related to asphalt road's functionality as the main road network. Moreover, the texture of each type road is different. Asphalt road has smoother texture than the concrete road.

Table 1: Land cover classification

Land Cover	Area (ha)
Mixgarden (*S. mahagony*, *C. nucifera*, and *A. chinensis*)	168.017
Dryfield with Vegetables	0.169
Dryfield with Cashcrops	2.836
Dryfield with Seasonal Plant	0.771
Bare Land	0.196
A. Chinensis forest	2.451
Bushes	0.207
P. Merkusii Forest	20.089
Homestead garden	1.699
Domestic industry buildings	0.142
Mosque	0.103
Gunung Ki Sebutrong Tourism	0.403
Gunung Gajah Tourism	0.137
Villager's Residential Buildings	14.046
Traditional market	0.492
Cemetery	0.374
School	0.424
Public Health Center (Puskesmas)	0.043
Government Offices	0.037
Animal Farm	0.306
Concrete Road Network	
Asphalt Road Network	
River	

Relatively detailed map of Pandanrejo Village can be created from the UAV's aerial photograph. The classification process is conducted by dividing the area based on its general to detail appearances. There are 23 classifications of land cover using visual interpretation showed in Table 1. From the classification result, it is visualized in a large scale of a map as Land Cover Classification Map showed in figure 13.

LAND COVER MAP PANDANREJO VILLAGE, KALIGESING, PURWOREJO

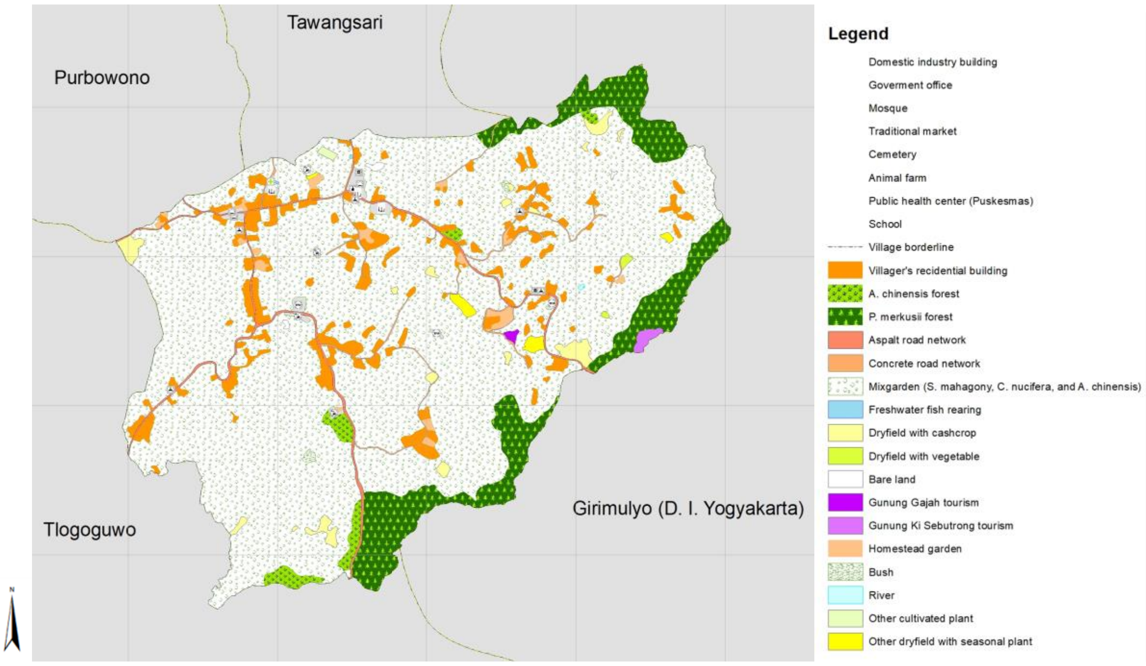

Figure 13: Land Cover Map Pandanrejo Village

Monograph data obtained from Pandanrejo Village's agency is able to be seen in table 2. This monograph data is taken from 2016 and does not change until 2019. Based on the classification from the UAV photograph, the detail appearances used as the Pandanrejo village data source renewal can be obtained. It is important since the village monograph data remains the same because there is no measurement done on the field as the result of its accessibility which is relatively difficult and lack of field worker.

Generally, the monograph data written in table 2 are the residential buildings, garden, ricefields, homestead garden, cemetery, offices, and other general infrastructure. The residential buildings in monograph data is 69,148 ha meanwhile based on the classification it is written only 14,46 ha. This different number happens because the interpreter only measures it based on the residential building's roofs only. It also applies to the classification which has the physical building such as Public Health Center (Puskesmas), schools, market, shop complex buildings, and government's offices. Interpreter uses building as one of physical characteristics of the building itself and then it is connected to the other interpretation keys so that the identified appearance detail information about it can be obtained. Besides, the offices data taken from the village monograph data are the combination of several public facility. The interpreter, then, divides it to be several classification objects. Therefore, interpretations using aerial photographs can provide more detailed results than the monograph data that the village already has.

Meanwhile, there is a slight difference measurement number of the land cover in the form of vegetation, such as garden, between the data from the interpretation and from the monograph data. It happens because it is possible that the vegetation object is still be re-cultivated by the society resulting in the development of vegetation covers. Therefore, the mixgarden area taken as the result of the interpretation by using UAV is higher than individual plantation land by village's monograph data. Moreover, there are also many streep terrains which makes it is quite hard to do the direct measurement process. The difficult access caused some vegetation areas can not be measured in detail and separately so that the area specified on the village monograph data is quite in general. It is because of two things. Firstly, there is no measurement process done and secondly the data of Pandanrejo Village land cover are not able to be found.

Table 2: Pandanrejo Village's monograph data

Village data	Area(ha)
Residential Buildings	69,148
Ricefield	-
Cemetery	-
Homestead garden	-
Garden	-
Offices	0,345
Public Infrastructure	-
Ricefield	-
Dryland	69,714
Marshland	-
Tidal	-
Peat Fields	-
Reservoir	-
Public Plantation Land	-
State Plantation Land	-
Private Plantation Land	-
Individual Plantation Land	160,890
Village's Treasury Land	3,120
Sports Field	-
Government Offices	0,345
Public Space	-
General Cemetery	-
Landfill	-
School	0,255
Shop buildings	0,32
Market	0,375
Terminal	-
Road	6,1515
Total public facility land	12,4666
Protected Forest	24,0

In using the UAV, it can be considered that this method is effective to make the data renewal which is included in the monograph data. Data from the UAV may provide detail information related to the land cover which can be interpreted with the interpretation keys/elements. The result of the data as the result of interpretation process can be used as the supporting data source of monograph data since it is difficult to do the physical measurement on the field.

4. Conclusion

The aerial photograph of the UAV is able to be used to make a land cover map on a large scale by employing the visual interpretation elements. It can also be used to update detailed spatial data periodically. However, it has its advantage and disadvantage. The advantage by using aerial photograph with visual interpretation is that it is efficient especially related to the time, cost, and effort with its appearances which is relatively detail. Meanwhile, its disadvantage is that the result is based on the physical interpretation keys and the knowledge of the interpreter only so it is not a definite measure.

5. Recommendation

It will be better to do the interpretation process of land cover followed by field survey as the accuracy test and validation of the data.

Acknowledgements

We would like to thank the Faculty of Geography, Universitas Gadjah Mada has given the facility to carry out this research. We also thank the Pandanrejo Village apparatus who have been willing to share village data and have welcomed us well.

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