Mapping of tenure status of paddy field and their relation to rice farming

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Abstract. Some important government programs, such as Sustainable Agriculture Food Protection, in its implementation need to be supported by tenure status of paddy field map. High resolution satellite imagery is data source that can be used for mapping of that data. The rice is a staple food for Indonesian people, however the conversion of paddy field into built-up area increase due to population growth and economic activity. This study aims to map the tenure status of paddy field and rice farming. Mapping of the tenure status is based on paddy fields parcel resulting from visual interpretation of high-resolution satellite imagery and field verification. The tenure status of paddy fields were obtained from fieldwork with the census method on each parcel. Analysis of rice farming was assessed based on the area and tenure status of paddy fields. The results showed that the mapping accuracy of the parcel number was 96.72%. The spatial pattern of parcel based on owner and sharecropping categories show all have cluster patterns (NNI <1). Rice farming of paddy managed by owner or sharecropping are both still feasible (R/C ratio> 1) and the highest profit is >2 hectare, but those managed by owner is more profitable ($R^2 = 0.71$).

Keywords: land tenure, ownership, paddy field parcel, spatial pattern, sharecropping

1. Introduction
In the Geospatial Law No. 04 of 2011, Article 18, Paragraph (1) mention that the Indonesian Topographic Map (RBI) is made on a scale of 1: 1,000,000, 1: 500,000, 1: 250,000, 1: 100,000, 1: 50,000, 1 : 25,000, 1: 10,000, 1: 5,000, 1: 2,500, and 1: 1,000 [1], but large-scale maps (≥ 1: 10,000) are not yet available for all of Indonesia. The RBI map functions as a base map for the creation of thematic maps, where the scale of the RBI map should be greater or equal to the scale of the thematic map (Article 20 paragraph 1). So far, most government programs produced the thematic map on a scale of 1: 50,000 (medium-scale) such as Regional Spatial Planning (RTRW) maps, land use maps, topographic maps etc. However, several government programs that in its implementation require the tenure status map of the paddy field in large-scale such as the Sustainable Agriculture Food Protection (LP2B) program. High-resolution remote sensing data such as IKONOS, QuickBird and GeoEye can be a source of data for large-scale mapping.

Paddy fields in Indonesia are normally vulnerable to conversion of built-up areas because this land use generally has a flat topography, good accessibility, but has a low land rent, although the rice is a staple food for Indonesian people. In general, the cost of paddy field conversion into the built-up area...
is relatively cheaper in flat areas and good accessibility. Comparison of paddy fields land rent with oil palm in Seluma Selatan District, Bengkulu Province is 1: 1.25 [2], and compared by settlements in South Lampung Regency (Linduk Village, and Tajimalela Village) are 1: 1.47 and 1: 5.59, respectively [3]. Factors influencing farmers’ decision to maintain paddy fields are low taxes, low land prices, low income (their livelihood), small cultivated land (their livelihood) and land purchased from their own business (not inheritance) [3]. Therefore, the government issued Law No. 41 of 2009 concerning the protection of sustainable food agricultural land.

In 2017, Pandeglang Regency has 49,796 hectares of paddy fields [4] and can contribute 30% to the total production of Banten Province [5]. Pandeglang Regency with a population of 1.2 million peoples need 10,500 tons of rice per month, if it is estimated that in December the harvest area is 7,000 hectare with a productivity of 6 tons/hectare then rice production is 21,000 tons (50% depreciation) [5]. Although Pandeglang Regency still has a surplus of rice, it is necessary to protect paddy fields in accordance with the mandate of Law No. 41 of 2009 about sustainable food agriculture protection.

Rice produced from the Cimanuk District has a brand name that is "cimanuk rice". Irrigated paddy fields are predominantly found in Cimanuk District because of the availability of water as an irrigation water source. The livelihoods of the people in Cimanuk District are paddy field farmers. Therefore, good potential in the Cimanuk District needs to be protected to support the LP2B program. The aim of the study was to map the tenure status of paddy fields and their relation to rice farming.

2. Research method

2.1. Study area
The study area located in Cimanuk District, Pandeglang Regency, West Java consists of 11 villages (figure 1). Cimanuk District is located between two mountains, namely Pulosari Mountain and Karang Mountain with slopes (3-15)%. The distance of the Pandeglang Regency to Jakarta is 104 km with a travel time of 2-3 hours and 158 km to Bogor with a travel time of 3-4 hours.

![Figure 1. Study area on Cimanuk District, Pandeglang Regency.](image-url)
2.2. Mapping of tenure status of paddy field

Mapping of tenure status of paddy field in Cimanuk Regency begins with visual interpretation of paddy fields from SPOT imagery mosaics in 2017, IKONOS imagery mosaics in 2010 and supported by book of Land Tax Payer List (DHKP) containing the name and sketches of paddy fields ownership. The delineation of paddy fields boundary is done in the middle of the "galengan" of the paddy field using the on-screen digitizing technique. The attribute of each paddy field parcels in Cimanuk District, such as the name of owners and sharecropper was collected by census technique through interviews with the head of farmers group, farmers and community leaders. Accuracy assessment of the interpretation results of paddy field parcels from the imagery was only done in Dusun 1, Cimanuk Village as a sample area.

2.3. The spatial pattern of status tenure of paddy fields

The spatial pattern of the tenure status of the paddy field was determined by the Average Nearest Neighbor (ANN). The average nearest neighbor distance is the distance between each feature centroid and its nearest neighbor’s centroid location. Feature in this research is polygon of tenure status of paddy field. The spatial pattern can be expressed by Nearest Neighbor Index (NNI) that can be calculated by formula [6] below:

\[
NNI = \frac{D_{nn}}{D_{e}}
\]

Where:
- \( NNi \) : Nearest Neighbor Index
- \( D_{nn} \) : Mean nearest neighbor distance (observed distance) (m)
- \( D_{e} \) : Mean random distance (expected distance) (m)
- \( D_{ij} \) : Nearest neighbor from object i to j (m)
- \( N \) : Number of the observed objects
- \( A \) : Area of Cimanuk Districts (m²)

Category of spacial pattern:
- If \( NNi < 1 \), dispersed
- If \( NNi =1 \), random
- If \( NNi >1 \), clustered

2.4. Rice farming analysis

Rice farming is calculated based on the ratio of revenue and cost (R/C ratio) to different areas and tenure status. If R/C ratio is more than 1, it means that the rice farming is still feasible [7], and unit of R/C ratio used in this research is Rp/hectare/one planting period. Variables used to determine the production costs are seeds, fertilizers, pests, tractor rental, and labor. The revenue is obtained from the sale of rice produced.

Data for rice farming analysis was obtained from interviews guided by questionnaires to farmers. The sampling technique used in this study was stratified random sampling where the farmer population was stratified based on the cultivation area (hectare/farmer) and the tenure status of the paddy field. The sample size is 10% of the farmer population in Dusun 1, Cimanuk Village. The minimum sample size is 10% of the population [8]. The farmer population in Dusun 1 in 181 people, therefore the sample size (10%) is 18 people and added 12 people as a backup sample for data security. The number and distribution of samples are shown in table 1 and figure 2, respectively.
Table 1. Sample distribution based on the cultivated paddy field.

| Area (hectare) | Farmer population (person) | Sample size 10% (person) | Sample backup (person) | Number of sample (person) |
|----------------|----------------------------|--------------------------|------------------------|---------------------------|
| ≤ 0.5          | 93                        | 9                        | 8                      |                           |
| > 0.5 - ≤ 1.0  | 50                        | 5                        | 5                      | 10                        |
| > 0.1 - ≤ 1.5  | 20                        | 2                        | 4                      | 6                         |
| > 1.5 - ≤ 2.0  | 8                         | 1                        | 1                      | 1                         |
| > 2.0          | 10                        | 1                        | 2                      | 3                         |
| Total          | 181                       | 18                       | 12                     | 28                        |

2.5. Relationship between status tenure and rice farming profit

Analysis of the relationship between rice farming with the cultivation area and also the tenure status was calculated by correlation formula (4). A correlation is a statistical technique that shows whether and how strongly pairs of variables are related to each other [9]. The strength of the relationship between the two variables will be expressed by a correlation coefficient.

\[
r_{xy} = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2} * \sqrt{n(\sum y^2) - (\sum y)^2}}
\]  

(4)

Where:
- \(r_{xy}\) : Relationship between x and y
- \(x\) : Rice farming (IDR/hectare/one planting period)
- \(y\) : Cultivation area of paddy field (hectare) and tenure status (owner farmer, sharecropper)

3. Result and discussion

3.1. Thematic verification of parcel map of paddy field

Thematic verification of parcel mapping of the paddy field was conducted in a small area (Dusun 1, Cimanuk Village, Cimanuk Regency) because it used census technique. The number of parcels in Dusun 1 is 3,759 parcels (10.11%) of the total number of parcels in the Cimanuk Regency (37,163 parcels). The verification result showed that the interpretation accuracy of the paddy field using remote sensing imagery (mosaic of SPOT 2017, mosaic of Ikonos 2010) is 96.72%. It gets from the ratio between the number of parcels before (3,759 parcels) and after (3,636 parcels) verification (figure 3)

Accuracy of objects interpretation from remote sensing imagery is effected by interpreter experience, interpreted object characteristic, imagery quality [10], and the time gap between imagery acquisition and field check [11]. In this case, the quality of interpretation results due to the paddy field conversion, the small parcel of paddy field making delineation and haze on imagery.
3.2. Mapping of tenure status of paddy field

In this study, the tenure status maps of paddy fields are maps that contain parcels of paddy fields that are equipped with attributes such as owner's name, sharecropper's name, their address, etc. This detailed mapping was carried out on irrigated paddy fields in Cimanuk District which covers 1,499.38 hectares. The tenure status of the paddy field is divided into 2 categories, namely owner and sharecropper [12], but [13] divided into 3 categories: owner, sharecropper and tenant. In the Law No.02 of 1960, Article 1 mention that the owner is the person who does the cultivation of his own rice field, the sharecropper is the person who does the cultivation of other people's paddy fields [14], tenant is the people who rent other people's rice fields.

Table 2. Number of parcels and area of paddy field in Cimanuk District.

| Statistical value          | Owner   | Sharecropper | Tenant | Outside Cimanuk District | None-paddy field | Total  |
|----------------------------|---------|--------------|--------|---------------------------|------------------|--------|
| Number of parcels          | parcel  | 22,435       | 13,822 | 1                         | 639              | 266    | 37,163 |
| Total area                 | hectare | 930.49       | 523.08 | 0.04                      | 27.13            | 18.64  | 1,499  |
| Total area as %            | %       | 62.06        | 34.89  | 0.003                     | 1.81             | 1.24   | 100    |
| Number of farmers          | person  | 1,710        | 695    | 1                         | -                | -      | -      |
| Minimum area/farmer        | hectare | 0.00001      | 0.01   | -                         | -                | -      | -      |
| Maximum area/farmer        | hectare | 8.49         | 9.90   | -                         | -                | -      | -      |
| Average area/farmer        | hectare | 0.54         | 0.75   | -                         | -                | -      | -      |

Table 2 shows that the paddy field area in Cimanuk District is 1,499.38 hectares or 37,163 parcels (figure 4a) divided into 930.49 hectares or 22,435 parcels cultivated by the owner and 523.08 hectare or 13,822 parcels cultivated by sharecropper and only 0.04 hectare or 1 parcel leased to other farmers. The paddy fields that were converted into built land were 27.23 hectares (639 parcels) and the paddy
fields cultivated by farmers from Mangalawangi, Keduhejo and Mekarjaya Districts (outside of Cimanuk District). The location of the three districts borders the District of Cimanuk. However, paddy fields are still dominant (96.95%) cultivated by farmers in Cimanuk District, both as owner, sharecropper and tenant.

The cultivation area of paddy fields for each farmer is still under 1 hectare, where for the owner and sharecropper is 0.54 hectares/farmer; 0.75 hectares/farmer, respectively. If paddy fields are managed extensively then the benefits obtained are also large [15]. The Agricultural Census (2013) shows that the number of farmers with paddy field area between $> 0.1 \leq 0.5$ hectare is 14.6 million households (55.9%) of the total farmer households, while those with an area of $< 0.1$ hectare is 4.3 million (16%) and the rest (28.1%) with paddy fields $> 0.5$ hectare. In the study area, the owners or sharecroppers whose cultivation of paddy fields around 8.49 hectare and 9.90 hectares (table 3) were very few, each with only one person.

Figure 4b shows that the spatial pattern of paddy fields is a cluster (NNI <1) both for paddy fields managed by the owner (NNI = 0.63) or sharecropper (NNI = 0.52). Rice fields with owner farmer status clustered in the south (Cimanuk, Batubantur, Rocek, Kadudodol, Gunung Datar, Sekang and Mount Cupa Villages), while paddy fields are managed by sharecroppers clustered in the north (Kadubungbang, Kapahandap, Dalambalar and Kadumongdang Villages).

![Figure 4. Parcels of paddy field (a) and status of paddy field (b) in Cimanuk District.](image)

3.3. Rice farming in different area and tenure status
Rice farming in Dusun 1, Cimanuk District is still feasible (R/C ratio > 1), both for farmer-owners (R/C ratio = 3.89) and sharecroppers (R/C ratio = 2.45). Table 3 shows that the paddy fields managed by the owner are more profitable (IDR 15,363,853/ hectare /one planting period) rather than the sharecropping system (IDR 6,730,997 / hectare /one planting period). The relationship between the R/C ratio and the tenure status of paddy fields is quite strong with $R^2 = 0.71$[16].
Table 3. Profit of rice farming in different area and tenure status.

| Tenure status   | Area (hectare) | Sample size | Cost IDR/hectare/ one planting period | Revenue IDR/hectare/ one planting period | Profit IDR/hectare/ one planting period | R/C ratio |
|-----------------|----------------|-------------|--------------------------------------|------------------------------------------|----------------------------------------|-----------|
| Owner           | ≤ 0.5          | 2           | 4,725,268                            | 13,940,218                               | 9,214,950                              | 2.95      |
|                 | >0.5 - ≤ 1.0   | 4           | 5,504,939                            | 20,361,111                               | 14,856,173                             | 3.70      |
|                 | >1.0 - ≤ 1.5   | 3           | 5,374,888                            | 22,085,544                               | 16,710,656                             | 4.17      |
|                 | >1.5 - ≤ 2.0   | 1           | 5,429,412                            | 21,176,471                               | 15,747,059                             | 3.90      |
|                 | >2.0           | 1           | 5,423,.810                           | 25,714,286                               | 20,290,476                             | 4.74      |
| Average         |                |             | 15,363,863                           |                                          | 6,739,907                              | 2.45      |
| Sharecropping   | ≤ 0.5          | 8           | 5,462,066                            | 10,726,563                               | 5,451,567                              | 2.03      |
|                 | >0.5 - ≤ 1.0   | 5           | 4,224,369                            | 10,783,209                               | 6,558,839                              | 2.55      |
|                 | >1.0 - ≤ 1.5   | 3           | 4,254,646                            | 12,161,969                               | 7,907,323                              | 2.86      |
|                 | >1.5 - ≤ 2.0   | 1           | 3,635,838                            | 9,104,046                                | 5,468,208                              | 2.50      |
|                 | >2.0           | 2           | 6,430,953                            | 14,700,000                               | 8,269,048                              | 2.29      |
| Average         |                |             | 6,730,997                            |                                          |                                        | 2.45      |

The profit-sharing system of rice production between the owners and the sharecropper has been regulated in Law No. 02 of 1960. Article 4 paragraph 1 letter states that profit-sharing from rice production is 1/2: 1/2 for the owners and the sharecropper if (article 2) production costs become joint responsibility [14]. Production costs are costs used to purchase seeds, fertilizers, livestock power, planting costs, harvest costs and zakat (article 2) [14]. However, this revenue sharing system has been modified depending on the agreement between the owner and the sharecropper, for example, profit sharing can be in the form of rice or money, but generally in the form of money because it is easier and more practical. In the community, a profit-sharing system is found with a ratio between the owner: the sharecropper is 3/4: 1/4 if the production costs are the responsibility of the owner.

The relationship between R/C ratio and managed paddy field area is weak with R² = 0.41 [16], this means that the more paddy field area does not always indicate the greater the profit (table 4), due to variations in the components of production costs, productivity and the selling price of rice. Paddy fields managed by the owners and the sharecropper can provide the highest profit if the land area is > 2 hectare, which are IDR 20,290,476/hectare/one planting period and IDR 8,269,048/hectare/one planting period, respectively. The minimum area of paddy fields managed by farmers to obtain income equal to or higher than the poverty limit of the Central Bureau Statistics (BPS) is 0.65 hectare [17]. In Cimanuk District, paddy fields that are managed by owners and sharecroppers are 0.97 hectare and 0.87 hectare, respectively. The national poverty limit based on household income, which is IDR 1,990,170/household/month [18].

4. Conclusions

Thematic verification of parcel mapping of paddy field is 96.72% obtained from the ratio between the number of paddy field parcels based on remote sensing (mosaic SPOT 2017 and mosaic IKONOS 2010) and field survey (census). Dusun 1, Cimanuk Village, Cimanuk Regency has 37,163 parcels of paddy field that managed by 185 farmers. The spatial pattern of paddy field parcel based on owner and share-cropping categories show all have cluster patterns (NNI >1).

Rice farming of paddy managed by owner or sharecropping is both still feasible (R/C ratio> 1), but those managed by the owner are more profitable (R² = 0.71). The highest profit is obtained on cultivated paddy field >2 hectare, either those managed by owner or sharecropping system, although the relationship between the R/C ratio and the area of paddy field cultivation is weak (R² = 0.41).
5. References

[1] President of The Republic of Indonesia 2011 *Goverment Regulation No. 04 Year 2011 Geospatial Information* (Jakarta, ID: Secretary of State of the Republic of Indonesia)

[2] Hamdan 2012 *Thesis: The economy of conversion of paddy fields into oil palm plantations in Seluma Selatan District, Seluma Regency, Bengkulu Province* (Bogor, ID: IPB University)

[3] Kulsum U, Arifin B and Abidin Z 2015 Determinant of farmers decision for rice field conversion to housing *Journal of Agribusiness Sciences* 3(2) 192-199

[4] Division of Agriculture, Pandeglang Regency 2017 *The study of the data delineation of per capita land mapping to support the sustainable agriculture food protection* (Pandeglang, ID: LP2B)

[5] Ministry of Agriculture 2018 *Harvesting in Pandeglang Regency, planting policy of 1 million hectares is appropriate*, available at web: http://www.pertanian.go.id/home/?show=news&act=view&id=2471 (download at 28 July 2019)

[6] Clark P J and Evans F C 1954 *Distance to nearest neighbour as a measure of spatial relationship in population* *Ecology* 35 445-453 doi.org/10.2307/1931034

[7] Normansyah D, Rochaeni S, Hamaerah DA 2014 Analysis of horticulture farming income in Tani Jaya Group, Ciaruteum Ilir Village, Cibungbulang District, Bogor Regency. *Agribusiness Journal* 8(1) 29-44

[8] Gay L R, Geoffrey E M and Peter A 2009 Educational research, competencies for analysis and application (New Jersey, US: Pearson Education, Inc.)

[9] Sugiyono 2013 *Statistica for Research* (Bandung, ID: CV Alfabeta Publishing)

[10] Lillesand T M, Kiefer R W and Chipman J W 2014 *Remote Sensing and Image Interpretation* 7th ed. (Canada, US: John Wiley and Sons, Inc.)

[11] Bennett M M and Smith L C 2017 Advances in using multitemporal night-time lights satellite imagery to detect, estimate, and monitor socioeconomic dynamics *Remote Sensing of Environment* 192 176-197

[12] Panichvejsunti T, Kuwornu John K M, Shivakoti G P, Grunbuhel C and Soni P 2018 Smallholder farmers’ crop combinations under different land tenure systems in Thailand: The role of flood and government policy *Land Use Policy* 72 129-13

[13] Mudakir B 2011 Land productivity and income distribution based on land tenure status on rice farming (a case study of Kendal Regency, Province of Central Java)

[14] President of The Republic of Indonesia 1960 *Goverment Regulation No. 02 Year 1960 Profit Sharing Agreement* (Jakarta, ID: Secretary of State of the Republic of Indonesia)

[15] Gupito R W, Irham and Waluyati L R 2014 Analysis of factors affecting the income of sorghum farming in Gunungkidul Regency *Journal of Agro Ekonomi* 22(1) 66-75

[16] Sarwono 2006 *Methodology of Quantitative and Qualitative Research* (Yogyakarta, ID: Graha Ilmu Publishing)

[17] Susilowati S H and Maulana M 2016 Area of Farming and Welfare of Farmers: Existence of Gurem Farmers and Urgency of Agrarian Reform Policy *Agricultural Policy Analysis* 10(1) 17-30.

[18] Central Bureau of Statistics 2018 *Social and Population in Indonesia* (Jakarta, Indonesia: BPS)