Optimization of farmer pattern as an effort to improve farmers' income and environmental friendliness in Bogor, Indonesia

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Abstract. Setting the cropping pattern in the use of paddy fields is one of the important steps that determine the income, use, and distribution of farm labor. The study was conducted by utilizing secondary data production, cost analysis, etc. in the series 2009-2018 in Bogor Regency. The analysis uses linear programming by setting the raw area of paddy fields and paddy farmer labor as constraints and maximizing income as a goal. The use of agricultural land in the Bogor Regency continues to shrink every year. The optimal solution to the cropping pattern that is produced turns out to still leave land and labor resources, so an alternative cropping pattern is needed to utilize these resources. The recommended cropping pattern needs to be implemented through empowering farmer groups proportionally according to the area of land and labor they have.

1. Introduction
One of the phenomena in land conversion is land conversion. This phenomenon arises with increasing demand and demand for land, both from the agricultural sector and from the non-agricultural sector, due to population growth and development activities [1]. The phenomenon of land use change occurs due to structural and demographic structural transformation, specifically in developing countries [2]. Land use is a form of farmer’s efforts to utilize land, namely managing land by regulating and regulating the types of plants according to broad balance and certain regulating optimal results can be obtained for certain purposes [3]. The use of land is a manifestation of the efforts of farmers to use their land, namely managing the land by determining and regulating the types of plants according to the broad balance and a certain turn so that optimal results can be obtained for certain purposes.

The level of income of peasant households is determined by the area of agricultural land that is actually controlled. Limited access to land is one of the factors causing poverty in terms of limited productive assets and resources that can be accessed by farming communities. Limited access of farming communities to land is illustrated by the uneven distribution of tenure and land ownership by farm households, where the majority of farm households each own less than half a hectare of land and there is a tendency for a smaller average land tenure per agricultural household [4]. In an effort to increase income, farmers diversify their farming with various patterns and types of integrated commodities [5]. But in its development, they face various challenges and risks such as: (1) crop failure, (2) pest and plant disease attacks, (3) water scarcity and (4) low production prices. As a
result, production per hectare is not the same as yields per hectare received, so farmers receive a fair nominal value from their farming [6].

Farming systems that focus on diversity and rationality of agricultural practices that are not systematic and irregular [7]. The smaller the farm the higher the business [8]. Apart from rice, paddy fields can be planted with a variety of other potential crops. One of the commodities suitable to be planted in paddy fields other than rice is horticulture. Setting the cropping pattern in the use of paddy fields is one of the important steps that determine farmers' income. Efforts made by farmers in farming are expected to obtain optimal income. Also, setting the cropping pattern will determine the use and spread of farm labor.

This study aims to (1) find out the change in land cover in Bogor Regency, (2) find out the optimal allocation of planting area from selected commodities cultivated from a cropping pattern that provides the highest net income, and (3) Provide alternative formulations of the pattern selected commodities, taking into account the constraints of land area and labor.

2. Research methodology

This study was designed to utilize series cropping and harvest report data for a period of 10 years (2009 - 2018) through observing data/reports. The research focused on optimizing the use of paddy fields with consideration of being in a strategic location and an infiltration area and oriented to agribusiness.

The method of collecting data is secondary data collection obtained from various sources, namely the Department of Agriculture, and the Bogor Regency Central Bureau of Statistics, among others in the form of data on rice fields, crop rotation patterns, mainstay commodities, production, farm labor, farm cost analysis, etc. Some supporting data about cropping patterns, a general description of agricultural conditions is obtained through communication or interviews with sub-district staff, and farmer group leaders.

The population in this study were all villages from selected sub-districts, namely Sukaraja, Leuwiliang and Jasinga sub-districts. The sample villages are determined purposively. The sample villages are villages that have paddy fields according to the scope of the study which is limited to paddy fields, which are as many as 9 villages. The paddy fields that will be optimized are aggregate paddy fields from the wetland area of all sample villages. The cropping pattern that will be used as an optimized model is the cropping pattern that the majority is done by farmers from the sample villages. In this study, there were no respondents or samples of farmers [9]. Data relating to farmers are farming analysis of labor requirements, production facilities, commodity prices, etc. obtained from farm recapitulation. The recapitulation data is obtained through the enumeration of farms from all farmers for each type of commodity being cultivated. The analytical method used is quantitative analysis with Linear Programming:

**Purpose Function**

- **Maximum net income**

  \[ Z = \sum_{i=1}^{n} C_j X_j \quad (j=1, 2, ..., n) \]

- **Constraint Function**

  **Land area**

  \[ \sum_{j=1}^{n} a_{ij} X_j \leq A_i \]

  **Labor**

  \[ \sum_{i=1}^{m} \sum_{j=1}^{n} b_{ij} X_j \leq B_i \]

Where:

- \( Z \) = Maximum farm income (IDR / Ha)
- \( C_j \) = Profits obtained from plants to j (Rp. Ha)
- \( X_j \) = optimal area of plant type to j (Ha)
- \( A_i \) = The total area of paddy fields available in the planting season to i (Ha)
aij = The input coefficient of the output of the cultivated wetland area
bij = Labor requirements for the month to the type of planting to j
n = Number of commodities cultivated
Bi = HOK available for a month i (number of farmers)

3. Results and discussion

3.1. Changes in land use
Bogor Regency is part of the Jabodetabek mega-city unit (Jakarta, Bogor, Depok, Tangerang, and Bekasi) which is directly affected by the development of the city. This impact is marked by land changes, one of which is agriculture. There is a new trend in agricultural development in the world, by analyzing the potential of food production in big cities by integrating land-use policies and programs and managing natural resources and changing rural landscapes in metropolitan areas. Conventional agriculture causes agriculture not to function optimally so that it can be easily defeated by other sectors and converted. Multifunctional agriculture is becoming a new paradigm that emerges today as a suitable way to maintain the remaining agricultural land and develop agriculture [10].

![Figure 1. Bogor Regency land use in 1972 – 2018.](image)

**Table 1.** Bogor Regency land cover in 1972 - 2018 (percent).

| No | Land Cover          | 1972 | 1983 | 1992 | 2005 | 2016 |
|----|---------------------|------|------|------|------|------|
| 1  | Water Body          | 1.37 | 1.59 | 2.02 | 2.19 | 1.98 |
| 2  | Building            | 2.25 | 8.88 | 11.23| 28.58| 35.6 |
| 3  | Forest              | 11.87| 11.19| 10.65| 5.99 | 8.62 |
| 4  | Mixed Garden        | 31.07| 26.8 | 32.08| 27.84| 16.86|
| 5  | Farm / Dry Land     | 37.71| 33.67| 21.92| 19.07| 25.76|
| 6  | Grass               | 6.51 | 5.95 | 5.55 | 4.29 | -    |
| 7  | Rice Fields         | 9.22 | 11.92| 16.55| 12.04| 11.18|
|    | Total               | 100  | 100  | 100  | 100  | 100  |
The Office of Food Crops, Horticulture and Plantations in Bogor Regency, West Java, noted that around 1,000 hectares of agricultural land in the area had contracted, especially in the past three years. The reduction in agricultural land in the Bogor Regency region was caused also by growth factors in the population and migrants opening businesses in this region. The area of agricultural land, agro-tourism, and mining in Bogor Regency is 15,517 hectares or 45.28 percent of the 34,270 hectares of the Bogor Regency land area. Changes in land use in Bogor Regency can be seen in figure 1 and table 1.

Table 2. Harvested area of agricultural land in Bogor Regency (Hectares).

| No | Komodities       | 2012    | 2013    | 2014    | 2015    | 2016    | 2017    | 2018    |
|----|------------------|---------|---------|---------|---------|---------|---------|---------|
| 1  | Paddy filed      | 85.652  | 93.429  | 90.745  | 90.625  | 85.768  | 85.652  | 93.429  |
| 2  | Corn             | 46.583  | 85.768  | 90.345  | 89.345  | 90.961  | 86.488  | 97.687  |
| 3  | Soja             | 90.961  | 86.488  | 77.898  | 91.800  | 85.768  | 94.405  | 97.687  |
| 4  | Peanut           | 94.405  | 97.687  | 89.345  | 91.800  | 95.566  | 89.749  | 95.566  |
| 5  | Green pea        | 89.749  | 95.566  | 90.961  | 47.154  | 89.749  | 93.786  | 95.566  |
| 6  | Corn             | 93.786  | 95.566  | 77.898  | 94.405  | 93.786  | 95.566  | 91.800  |
| 7  | Caspe            | 95.566  | 91.800  | 86.488  | 91.800  | 95.566  | 89.749  | 95.566  |
| 8  | Sweet potato     | 47.154  | 88.513  | 91.800  | 94.405  | 97.687  | 93.786  | 95.566  |
| 9  | Tales            | 48.185  | 91.800  | 94.405  | 97.687  | 93.786  | 95.566  | 91.800  |
| 10 | Vegetables/fungus| 94.405  | 86.488  | 86.488  | 88.513  | 91.800  | 95.566  | 86.488  |
| 11 | Aglaonema/aurora | 90.961  | 47.154  | 90.961  | 86.488  | 97.687  | 94.405  | 97.687  |
| 12 | Bio farmaka      | 85.768  | 94.405  | 97.687  | 86.488  | 85.768  | 94.405  | 97.687  |

In table 2 it can be seen that the harvested area of agricultural land in Bogor Regency from 2012 to 2019 for a year of planting. In general, the harvested area is 2 times the land area, meaning that every year the farming pattern in Bogor Regency is 2 times planting rice and then 2 other commodities such as paddy - paddy - corn or paddy - vegetables - vegetables.

The harvested area for rice varieties of agricultural land in Bogor Regency in 2012 - 2018. In general, the planting area is 2 times the existing land area. Inpari, IR 64 and Mekongga rice varieties are planted in Bogor Regency in the east while in the west they plant more Ciherang and Cisadane rice varieties.

3.2. Farming cropping pattern
The majority of farming patterns are rice - rice - rice - horticulture. The intended cropping pattern can be illustrated in the following figure 2.

By calculating the distribution of labor per type of activity and the variation of production facilities for each selected commodity, the average production in 2009-2018, and the selling price obtained a net income of farming per Ha for each commodity, namely rice Rp. 3,699,500; Corn Rp. 4,286,000, and cassava Rp. 2,441,400,-.

3.3. Farmer income optimization
- Purpose Function
  Maximum \( Z = 3,699,500 X_1 + 4,286,000 X_2 + 2,141,400 X_3 \)
- Constraint Function
  Paddy field constraints = 263.65 Ha; and labor constraints = 6050 HOK, determined by calculating the conversion of female HOK to male HOK (0.7) through the wage approach.
The results of the optimization of the rice-paddy-maize cropping pattern provide a net income ($Z$) of Rp. 4,305,843.65. The above net income is obtained if only planting 2 commodities as a base, namely $X_1$ (rice) covering an area of 81,099 Ha and $X_2$ (corn) covering an area of 62,115 Ha. The allocation of planting will have implications for the existence of resources that have not been utilized sufficiently large. In the rainy season, land that is not utilized 120.44 ha and in the dry season 201.54 ha. This can occur, among others, influenced by the period of cultivation of commodities and the distribution of HOK needs per month that is different for each commodity.

Manpower (HOK) can only be fully utilized in October, February, and June. Workers in November, December, January, March, April, May, July, August, September there are many lefts. Allocation of monthly labor utilization can be known from the difference in HOK available with the remaining HOK. From the Reduced Cost value, it can be seen that planting corn and cassava commodities will cause a net income reduction. If you continue to grow corn, the net income will decrease by Rp. 70,329,051.75 and if planting cassava net income is reduced by Rp. 58,162,967.15. This can occur because the optimal solution does not take into account the possibility of adding external workers so that the addition of labor is done by shifting the workforce in the months where the workforce is used up. Because of this scarcity, 1 workforce in October was worth Rp. 46,843.16 and 1 workforce in February worth Rp. 664,866.53, indicated by the value of Shadow Price.

3.4. Implementation of farming planting patterns
In farming, many factors need to be considered and considered, including market, ecological, and social. Therefore a mathematical solution is needed to utilize land and labor resources that have not been utilized in optimal cropping patterns through the addition of commodity planting, taking into account the months at the time of rare HOK / used up, harvesting age, and distribution of farming activities per month. From the calculation results, it turns out that the alternative pattern gives $Z$ or net income greater than the optimal pattern of Rp. 7,460,749.88. In an alternative cropping pattern, it is recommended to plant corn one time in the rainy season accompanying rice and planting cassava twice in the dry season.

Planting patterns are implemented through the application of the concept of the proportion of plant area to the area of paddy fields owned by each village then divided by the number of group members. The area of the commodity that must be planted in each village is the multiplication of the percent of rice fields with the total area of the commodity that must be planted. After the area is obtained, it is divided by the number of members of the farmer group, so that the area of the commodity that must be planted by each farmer will be obtained.

4. Conclusion
Based on the results of the research above then

- The use of agricultural land especially rice every year has decreased
- Allocation of planting area from selected commodity cropping patterns cultivated Rice-rice-maize is rice 81 Ha; and corn 62.1 ha. The optimal cropping pattern is the rice pattern - rice - corn which gives net farmer income of Rp. 4,305,843.65,-
- The recommended alternative cropping pattern is a paddy-rice-maize pattern, with a broad allocation of 81 Ha respectively; 114.7 ha; 91.6 ha. This cropping pattern provides a net income of Rp. 7,460,709,24,-

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References
[1] Arifien Y and Rustiadi E 2019 Change Pattern of Land Use of Jabodetabek Area Through Irio and Dimamic System Approach Agricultural Science 3(1) 12-21
[2] Darwis V 2008 Keragaan Penguasaan Lahan Sebagai Faktor Utama Penentu Pendapatan Petani
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 pus. anal. sos. ekon. dan kebijak. pertan. pp 158–175
[3] Budiasa I W 2012 Pemodelan sistem usahatani terintegrasi untuk mendukung pertanian berkelanjutan Bumi Lestari Journal of Environment 13(1)
[4] Eliyarti 2017 UNES Journal of Scientech Research UNES J. Sci. Res. 2(2) pp 148–158
[5] Budiasa I, Ambarawati I and Mega I 2012 Optimasi Sistem Usahatani Terintegrasi untuk Memaksimalkan Pendapatan Petani E-Journal Agribisnis dan Agrowisata (Journal Agribus. Agritourism) 1(2) pp 96–105
[6] Sumampouw C M, Molenaar I R and Tooy I D 2017 Analisis Optimasi Usahatani Kelompok Tani Pajale (Padi, Jagung Dan Kedele) Di Kabupaten Minahasa Selatan In COCOS 1(1)
[7] Lukman Nurhuda D R A and Setiawan B Jurnal Ekonomi Pertanian dan Agribisnis (JEPA) 1(2)
[8] Suphendi S, Rustiadi E and Juanda B 2014 Optimasi Pendapatan Petani Melalui System of Rice Intensification di Kabupaten Indramayu Jurnal Pengkajian dan Pengembangan Teknologi Pertanian 17(2)
[9] Sugiyono 2016 Metode penelitian pendidikan (kuantitatif kualitatif dan R & D) Bandung: Alf
[10] Budihari 2007 Perubahan fungsi lahan pertanian menjadi perumahan berdampak terhadap sosial ekonomi di Desa Bongan Kecamatan Kediri Kabupaten Tabanan J. Univ. Pendidik. Ganesha Singaraja 1