The mapping of sustainable food agriculture land in Kediri City

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Abstract. Land is the main capital for agricultural sector’s development. Kediri City has the potential agricultural land area of 1900 ha, which spreads in three districts (Mojoroto, Pesantren, and Kota). 0.27% of Kediri’s Regional income comes from the agriculture sector and provide 30% of the food needs of Kediri City. The sustainability of agriculture lands in Kediri competes with other sectors which become the leading sector of Kediri such as Industry, services, and tourism. The government of Kediri City has the potential agricultural land assets of 548 ha to be developed into sustainable food agriculture land. However, the existing conditions indicate most of the rice agriculture land of Kediri planted with sugar cane, which is not food commodity. Therefore, the aim of this research is to analyze the physical potential of the Kediri agriculture land and analyze the needs of food agriculture land in Kediri City based on population projection. Variables needed to analyze physical potential of agriculture land were topography, soil type, crops commodity, irrigation system and Kediri City’s spatial land use planning. Based on the results of physical potential analysis, it is known that the Kediri City has a potential food agriculture sustainable land that covers an area of 407.26 ha, the potential of alternative sustainable food agriculture land that covers an area of 971.24 ha with the total area of sustainable food agriculture land of 1,378.46 ha. The result shows that until the year 2038, Kediri City requires 892.46 ha of rice agriculture land area. Comparing between the potential and the need for food agriculture land indicates that until 2038, the city of Kediri has sufficient agriculture land to be developed into a sustainable food agriculture area of Kediri City.

1. Introduction

Land is the main capital for the development of the agricultural sector. Kediri city has the potential agricultural land area of 1,900 ha that spreads in three districts. Mojoroto District has 547 ha of agriculture land, Kota District has 267 Ha of agriculture land and Pesantren District has 1,089 ha of agriculture land (Kediri Dalam Angka, 2017). Based on the irrigation system, 99.7% of agriculture land in Kediri has a technical irrigation system (1,903 Ha) and 0.3% of agriculture land has a non-technical irrigation system (6 Ha). The irrigation system is an essential requirement for the development of sustainable food agriculture land. So With 1,900 ha agriculture land, it is expected that...
Kediri City has the potential for developing sustainable food agriculture land’s. The further challenge faced by the agricultural sector is the further eroding of agricultural lands by human economic activity, especially for settlements, infrastructure development (roads, dams, and so forth), or industry. Kediri city’s development causes many agriculture lands converted into non-agriculture functions (Janti, 2016). The loss of productive agricultural land, if it is not controlled, will interfere the continuity and production that eventually can lead to threatened food security, both national and regional food security in 2007 led to the world's food crisis (Sakti, 2013).

One of the efforts of the Kediri city government to protect the existing agriculture land is through Local Regulation number 1/2012 about Spatial Planning of Kediri City which has allocated agriculture land of 500 Ha spread in district of Mojoroto, Kota and Pesantren to be developed into sustainable food agriculture land. That 500 Ha agriculture land is ha not specifically explained the distribution of Sustainable Food Agriculture Land’s classification in 3 Districts of Kediri City, So it is necessary to conduct further research related to Sustainable Food Agriculture Land’s classification and the spatial distribution of the agriculture land that can be developed into Sustainable Food Agriculture Land’s areas.

2. Methodology of Research

For the first research aim, to identify the potential of Sustainable Food Agriculture Land in Kediri Kota using overlay analysis from the arc GIS software and using the land physical criteria for rice agriculture land from Ministerial Regulation No. 17 of 2009 About Guidance on Environmental Capacity Support’s Determination in Spatial Planning and Ministerial of Public Works Regulation No. 41 / PRT / M / 2007 about Guidelines Cultivation Area’s Technical Criteria Guidelines and Subroto (2016: 129 – 133) also Taufik (2017: 63 – 68). The criteria used for rice were the Annual Agricultural Plants classification with the following criteria:

- Rainfall (mm/year) : 1200 – 1600
- Drainage: good – hampered
- Soil texture: soft – medium soft
- Rough Soil Material (cm) : >60
- Slope (%) : <40
- Level of erosion hazard: mild
- Level of Inundation hazard: None, Minim, Medium

The conclusion of the LP2B class was taken based on the following land classes (Table 1) (Sadyohutomo, 2006).

| Class | Level                | Conditions                                                                 |
|-------|----------------------|-----------------------------------------------------------------------------|
| S1    | Very Compatible      | Land does not have any significant restrictions for certain types of use, or has only a small, meaningless restriction in reducing productivity or benefits and will not enhance investment (technology inputs in land use) above a reasonable level. |
| S2    | Moderately Compatible | Land with barriers which in its entirety constitute a moderate limitation for certain types of use on an ongoing basis; such barriers will reduce productivity or benefit and add technological input to land use to a level where the overall profits derived from such use, while still attractive, but of somewhat lower |
The analysis on the needs of food agriculture land in Kediri City used the following steps.

1. Population Projection (y)
The projection of population was obtained from the RTRW document of Kediri City as follows

Table 2. Population Projection

| No | Year | Total Population |
|----|------|------------------|
| 1  | 2018 | 292,335          |
| 2  | 2023 | 319,924          |
| 3  | 2028 | 350,116          |
| 4  | 2033 | 383,157          |
| 5  | 2038 | 419,317          |

2. Food Needs (Kp)
The need for food is the multiplication of rice consumption per capita with a population in a given year. The equation is as follows:

\[ K_p = K_b \times y_t \times 100/83.12 \]  

where:

- \( K_p \) = Food needs in GKG (kg)
- \( K_b \) = rice consumption (kg/per capita/year)
- \( y_t \) = population of year-t (person)

83.12%, is a GKG to rice conversion factor based on the results of a survey of harvest losses and post-harvest rice grain cooperation between BPS and Ministry of Agriculture (2012).

3. Harvest Area Needs (Klp)
The need for harvest area is food demand divided by productivity. The equation is as follows:

\[ K_{lp} = K_p/p \]  

\( p \) = productivity (ton/Ha) Kediri City based on annual production data is 6 tons / Ha.

4. Planting Area Needs (Kt)
Planting area needs are the need for comprehensive harvest area coupled with the crop failure’s risk. The equation is as follows:

\[ K_t = K_{lp} + L_{gp} \]
where:

\[ \text{Klp} = \text{Planting Area Needs (Ha)} \]

\[ \text{Lgp} = \text{area of risk of harvest failure (Ha), where the area of harvest failure (puso) was based on the extent of the national crop failure in 2014, which was 1.99% of the harvested area.} \]

5. **Main Fields Needs (Ks)**

Main fields needs are planting area divided by cropping intensity. The equation is as follows:

\[ \text{Ks} = \frac{\text{Kt}}{\text{IP}} \times 100, \]  \hspace{1cm} (4)

where:

\[ \text{Ks} = \text{fields needs (Ha)} \]
\[ \text{Kt} = \text{the need for planting area (Ha)} \]
\[ \text{IP} = \text{cropping intensity (%). The intensity of planting rice fields in Kediri City is 190 %} \]

3. **Results**

Kediri City has an agriculture land of 2559 ha and it is dominated by food crops and sugar cane. An area of 303.66 ha is planted with rice commodities, and the most extensive is in Mojoroto District area of 123.39 ha. Here is a map of the spatial distribution of rice commodities in Kediri.

![Figure 1. Spatial distribution of rice commodities in Kota District](image)

3.1 **The Condition of Agricultural Support Infrastructure in Kediri City**

The irrigation system is one of the infrastructures supporting the rice-planting process. Overall, Kediri City has an irrigation area of 1,060 ha spread throughout the city. The irrigation system of Kediri City
mostly uses wells and water pumps because the city has a high potential groundwater discharge. Here is a map of the irrigation area of Kediri City.

Figure 2. Irrigation area of Kediri City

Based on Figure 4, it is known that the most extensive irrigation area is in the Pesantren District, covering an area of 691 ha in the form of wells and pumps. It is because the location of the Pesantren District is too far from the point of the spring in Pojok Subdistrict, Mojoroto District. While Mojoroto District itself has the smallest irrigation area, which is 141 ha and Kota Subdistrict has an area of 228 ha. The cropping intensity of food crops (rice) for Kediri City is planting two types of commodities in 1 plot of rice fields with the pattern of planting rice - palowijo - rice. Rice crop productivity in Kediri City is quite varied between 1-6 tons/ha. The productivity of rice can be seen in the following table.

Table 3. Rice Productivity in Kediri City

| No | District | Productivity  | Area (ha) |
|----|----------|---------------|-----------|
| 1  | Mojoroto | High (>6ton)  | 322,758   |
| 2  | Kota     | Low (1-3 ton) | 223,08    |
| 3  | Pesantren| Medium (4-6 ton) | 1,432 |
|    |          | Low (1-3 ton) | 131,647   |

Based on the table, it can be seen that the highest productivity of rice plants from Mojoroto District is 322.76 ha with the productivity is more than 6 tons/ha, while low productivity rice fields are mostly in Kota District covering 223.08 Ha.

3.2 The Compatibility of Rice Agriculture Land in Kediri City
Based on the analysis of the compatibility of rice fields, from the total area of the rice field, there is 1,102 ha of rice fields area classified as class S1 (Very Compatible) and an area of 1,457 ha classified as class S2 (Moderately Compatible / Appropriate). Rice fields with the most extensive class S1 are in Mojoroto District, and rice fields with the most extensive class S2 are in the Pesantren District. The classification of rice fields compatibility can be seen in the following table.

**Table 4. The classification of compatibility of rice fields in Kediri City**

| No | District | Classification | Area (ha) |
|----|----------|----------------|-----------|
| 1  | Mojoroto | S1 Very Compatible (Worth developing) | 625,307 |
|    |          | S2 Moderately Compatible / Appropriate (Worth developing with certain conditions) | 190,384 |
| 2  | Kota     | S1 Very Compatible (Worth developing) | 374,413 |
|    |          | S2 Moderately Compatible / Appropriate (Worth developing with certain conditions) | 76,159 |
| 3  | Pesantren| S1 Very Compatible (Worth developing) | 102,416 |
|    |          | S2 Moderately Compatible / Appropriate (Worth developing with certain conditions) | 1191,321 |

Fields classified as class S1 can be used as P2B fields, while land classified as class S2 can be used as reserve P2B. The most extensive P2B fields in Mojoroto District are located in Gayam Subdistrict, the most extensive P2B fields in Kota District are located in Ngronggo Subdistrict, and the most extensive P2B fields in Pesantren District are located in Tosaren Subdistrict.
Figure 3. Land suitability for rice plant in Kediri City

Based on land compatibility analysis, Mojoroto District has 625,307 ha of land that is very suitable for rice plant and 190,384 Ha of land that is moderate compatible for rice plant. Kota District has 374,413 Ha of land that is very suitable for rice plant and Pesantren District has 102,416 Ha of land that is very suitable for rice plant. Although Pesantren District has the most extensive agriculture land, most of it is not suitable (moderate compatible) for rice plant because Mojoroto District and Kota district have a better water supply for rice plant.

3.3 The Rice Agriculture Land’s Need in Kediri City

From the analysis for the needs of main rice fields in Kediri, it indicates that the population projection in 2038 is 419,317 people, and the food needs for the people in Kediri City will reach 9541.18 tons. Assuming the productivity of rice in Kediri City is 6 tons / Ha, the area of crop failure is 1.99% and the intensity of the Kediri City planting is 190%, in 2018 the Government of Kediri City needs to provide a rice fields area of 622.20 ha and the needs of main rice fields up to 2038 that will cover an area of 892.46 ha.

Based on rice field’s need analysis in 2018, Kediri needs 622.20 ha of rice fields to support 30% of food need. Until the year 2038, Kediri city needs 892.46 ha of rice fields to support food need. Kediri City shas 2,403 ha of agriculture land based on Spatial Planning of Kediri City (RTRW). The government has allocated 1,400 ha of agriculture land for the next 20 years, and the availability of agriculture land in Kediri is still sufficient for rice fields until 2038.

Table 5. The main rice fields needs in Kediri City

| Year | Total Population | Food Needs (ton/year) | Harvest Area Needs (Ha) | Planting Area Needs (Ha) | The Main Fields Needs |
|------|------------------|-----------------------|-------------------------|-------------------------|----------------------|
|      |                  |                       |                         |                         |                      |
| Year | Area (Ha) | Area (Ha) | Area (Ha) | Area (Ha) | Area (Ha) |
|------|-----------|-----------|-----------|-----------|-----------|
| 2018 | 292,335   | 6651,82   | 1108,64   | 1182,18   | 622,20    |
| 2023 | 319,924   | 7279,58   | 1213,26   | 1293,74   | 680,92    |
| 2028 | 350,116   | 7966,57   | 1327,76   | 1415,84   | 745,18    |
| 2033 | 383,157   | 8718,39   | 1453,07   | 1549,45   | 815,50    |
| 2038 | 419,317   | 9541,18   | 1590,20   | 1695,68   | 892,46    |

3.4 Sustainable Food Agriculture Land’s Distribution in Kediri City

Based on the map of the distribution of rice planted commodities and land suitability for rice plant in Kediri City, it can be seen that the total distribution of sustainable food agriculture land in Kediri City is 407,258 ha. Mojoroto District has 201,066 ha of sustainable food agriculture land. Kota District has 148,398 ha of Sustainable food agriculture land and Pesantren District has 57,793 ha of sustainable food agriculture land. In Mojoroto District, the area of sustainable food agriculture land area is in Gayam Sub District (73,851 ha). The distribution of sustainable food agriculture land in Mojoroto District is shown in Figure 4.

![Figure 4. Sustainable food agriculture land in Mojoroto District](image)

Kota district has 148,398 ha area of sustainable food agriculture land, and in Ngronggo Sub District is 56,943 Ha. The distribution of sustainable food agriculture land in Kota District is shown in Figure 5.
Figure 5. Sustainable food agriculture land in Kota District

Pesantren district has the most agricultural land area, but with limited water conditions, so Pesantren District only has 57,793 ha of sustainable food agriculture land. The distribution of sustainable food agriculture land in Pesantren District is shown in the following figure.
Figure 6. Sustainable food agriculture land in Pesantren District

4. Conclusion

Based on the analysis of land suitability for 2,403 ha of rice fields, there is 1,102 ha of the area that can be classified suitable for rice plant and 1,301 ha of the area that can be classified as moderate suitable for rice plant. The needs of the main fields in Kediri City is 892.46 Ha, hence it can be concluded that Kediri City has sufficiently potential rice fields for a sustainable food agriculture land until 2038. District with the most area for sustainable food agriculture land is located in Mojoroto District with an area of 201.07 ha and district with the smallest area for sustainable food agriculture land is located in Pesantren District with an area of 57.79 ha. The results of this study can provide input for the preparation of sustainable food agriculture protection programs following the mandate of Law No. 41 of 2009 concerning Protection of Sustainable Food Agricultural Land (PLP2B).

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