Spatial Numeric Classification Model Suitability with Landuse Change in Sustainable Food Agriculture Zone in Kediri Sub-district, Tabanan Regency, Indonesia

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Abstract. The development of rapid population will make the availability and utilization of land resources is increasingly shrinking in number, especially occurs in rice field. Since the last 5 years the numbers of farmland is decreasing by industry, infrastructure development, tourism development and other services. The agricultural problems facing at the moment is the occurrence of a change of use of agricultural land into farming now is not more popular is called over the function of agricultural land into non-farming. According to the Central Bureau of statistics (BPS) of the province of Bali (2013) within a period of 14 years (1999-2013), there has been a change of use of agricultural land be not agriculture/wetland functions over the 4,906 hectares. When averaged over the function flatten paddy fields per year occurred in Bali approximately 350 ha (0.41%). The highest paddy fields over the function during a period of fourteen years there is in Tabanan area of 1,230 ha. To maintain the existence of the rice fields or subak in Bali in particular, need to be done protection against agricultural lands sustainable. Ninth District/Town in Bali today, haven't had a Perda on protection of agricultural land sustainable food that is mandated by law 41 Year 2009. This will have an impact on food security of the region, and the world's cultural heritage as the water will lose its existence as a system of irrigation organization in Bali. The purpose of this research was done to (1) determine the numerical classification of spatial parameters of sustainable food farm in Tabanan Regency Kediri Subdistrict, (2) determine the model of the zoning of agricultural land area of sustainable food that fits on Years 2020, 2030, 2040, and in district of Kediri, Tabanan Regency. The method used is the kuantitatif method includes the focus group discussion, the development of spatial data, analysis geoprocessing (spatial analysis and analysis of proximity), and statistical analysis, interpolation of digital elevation model raster data, and visualization (cartography) and qualitative methods include the study of the literature (introduction). The research results obtained by as much as 23 rice fields mapped in spatial control system based on its geographical location. The parameters in the classification of sustainable food farming in district of Kediri consists of (1) the suitability of the location of a rice field with spatial Plan area of Tabanan Regency years 2012-2032, (2) land use, (3) Watershed morphology, (4) the type of irrigation, (5) rainfall, (6) the form region, (7) the high place, (8) the suitability of the
agroecosystem paddy fields, (9) productivity, (10) the distance from the center of town, (11) minimum area. Spatial numerical classification produces a wide variety of modeling (5 models) and is associated with the projected changes in rice fields by the year 2020, 2030, and 2040. In the year 2020 using model 4 due to sustainable subak in model 4 of 2682.71 ha, approached the farm field area by the year in 2020 of 2684 ha. In the year 2030 using model 3 due to sustainable subak on the model is 1651.37 ha 3 plus ¾ buffer subak of 773.51 ha be 2424.88 ha approached the farm field by the year in 2030 of 2364 ha. In the year 2040 using model 2 due to sustainable subak on the model of 307,99 ha 3 plus ¾ buffer subak of 1781.04 ha be 2089,33 ha approached the farm field by the year in 2040 of 2033 ha.

**Keywords:** Modelling, GIS, Subak, Agriculture, Sustainable

1. **Introduction**

The development of rapid population will affect the availability and utilization of land resources is increasingly shrinking in number especially occur in farmland. Since the last 5 years the number declining farmland due to infiltration by industry trade, infrastructure development, tourism development and other services. A problem that often occurs is the conversion or/over the function of farmland to non-agriculture. This much going on caused the increasing activity of the economy, trade, industry of city centres, as well as the tourism sector which is the underpinning of the economy of Bali. The existence of the attractions as well as the construction of facilities and infrastructure resulted in a very dynamic land conversion while the availability of land for agriculture is very limited, in line with the problems encountered in national food like the degradation of soil fertility, water utilization, competition of food deficits.

According to the BPS province of Bali (2013) within a period of 14 years (1999-2013), there has been a change of use of agricultural land into agricultural/ over the function instead of the paddy fields in Bali province covering an area of 4,906 ha. When averaged over the function flatten paddy fields per year occurred in Bali approximately 350 ha (0.41%). The highest paddy fields over the function during a period of fourteen years there is in Tabanan area of 1,230 ha, later followed by Jembrana Regency of Buleleng Regency 1,078 ha, ha 677 acres, Badung Regency area of 672 ha, town Denpasar area of 659 ha, Gianyar Regency area of 497 ha and ha 173 acres of Klungkung Regency. But the addition of extensive paddy fields occurs in the Karangasem Regency area of 58 hectares and Bangli (village of the subdistrict Mengani Kintamani area of 22 ha). Ninth District/Town in Bali today, haven't had a Perda on protection of agricultural land sustainable food mandated by law 41 Year 2009. This will have an impact on food security of the region, and the world's cultural heritage as the water will lose its existence as a system of irrigation organization in Bali. One of the technologies used is the spatial geographic information systems (GIS) and remote sensing (RS). RS with GIS can provide an excellent framework for obtaining precise and accurate data, measurements and synthesis, all of which are crucial for environmental analysis of eco-environmental comprehensive socio-associated with the changes to the data area of the rice fields [3][5]. Therefore conducted research of spatial model of numerical classifications with the projection of land use change on sustainable food agricultural areas in district of Kediri Regency of Tabanan, Indonesia.

The purpose of this research was done to (1) Determine the Boundaries of The Rice Field subak In Kediri Subdistrict (2) determine the numerical classification of spatial parameters of sustainable food farm in Tabanan Regency Kediri Subdistrict, (3) determine the model of the zoning of agricultural land area of sustainable food that fits on Years 2020, 2030, 2040, and in district of Kediri, Tabanan Regency.
2. Literature Review
Protection of agricultural land of sustainable food (PLP2B) is a system and process in planning for establishing, developing, utilizing and fostering, controlling and supervising food and farmland region on an ongoing basis. Under Law Number 41 Year 2009 about the PLP2B, is one of the Government's policy in controlling the pace over the function of agricultural land, in particular rice fields in Indonesia (7). PLP2B has the aim to (1) protect food and farmland area on an ongoing basis, (2) ensure the availability of agricultural land for sustainable food, (3) realize self-reliance, resilience and food sovereignty, (4) protect the ownership of agricultural land that belong to farmers, food (5) enhancing the prosperity and welfare of farmers and society, (6) improving the protection and empowerment of farmers, (7) improving the provision of employment for a decent life, (8) maintain the ecological balance and (9) realize the revitalization of agriculture.

In terms of soil and water conservation, water control system been established since the 7th century with the irrigation system of half technical and simple. Farm water control system also serves as a flood control, capture precipitation, mainly located in the upper reaches of the river. Rice plant as a contributor to oxygen (O2) at the micro as well as macro-scale [4]. Wide range of requirements set out in Act No. 41 of the year 2009, then should the whole Subak in Bali land need special attention about its existence. The existence of the need for the development of agriculture, such as housing, tourism, retail, industry and means of developing the infrastructure, then the necessary of land conversion to a limited extent, especially in the area around the urban centers of Government and tourism.

Law No. 41 of the year 2009 on the protection of agricultural land of sustainable food in article 9 contains a land suitability, availability of infrastructure, land use, land and technical potential of the extents of the unity of the expanse of land. The physical condition of the territory: position of the location of the form against watersheds, a means of irrigation, rainfall, the shape of the area/relief/slope slopes, altitude, rainfall, place land suitability of agroecosystem, compliance against Spatial Plan area and land use, associated with the region that needs to be protected in agriculture sustainable food [4][6].

3. Methodology
This research was carried out in district of Kediri, Tabanan Regency. Kediri Subdistrict covering 53.50 km², with altitude 0-123 m above sea level, and there are 23 Subak irrigation rice field. Extensive Subak in Kecamatan Kediri is 2844 hectares [1].

3.1. Materials and Tools
The tools used in this research is a set of computers and computer software (Qgis 2.10.1).
The materials used in this research are:
- Quickbird satellite imagery of Tabanan Regency Year 2013 from Geospatial Information Agency.
- Raster DEM, sourced from Aster satellite image,
- Map the Spatial Plan of Tabanan Regency Years 2012-2032,
- Map the watershed morphology Agency of Watershed Management of Northern Bali,
- Indonesia Topographical Map scale 1:25,000,
- Secondary data of rice production sourced from Kediri subdistrict office of Food and Horticulture Farming of Tabanan Regency
- Data of potential ricefield suitability of Kediri Sub-district.

3.2. Research Procedures
Research procedures include preliminary phase, Interpretation of satellite images and the arrangement of the references coordinate system, Focus Group Discussion, updating of rice field data and Spatial Analysis, Classification and Mapping Criteria.
3.2.1. Preliminary Phase. Research activities originated from a literature study to obtain preliminary information about the condition of the area from the results of previous research studies, both in the form of data reports, scientific journals, and maps. Preparation of materials research, and and planning of research that will be done.

3.2.2. Interpretation of satellite images and the arrangement of the references coordinate system. Interpretation of satellite imagery for identification, description and classification of land use and landform analysis was conducted using three methods of analysis namely: (1) the elements of the analysis, (2) pattern analysis, and (3) fisiografi analysis. Element analysis is carried out with 9 elements: shapes, and sizes, colors and contrasts, textures and patterns, shadows, location, and associations. Nine elements are used for the classification of land use. Preparation of the coordinate system references using the UTM projection system (universal transverse Mercator), World Geodetic System 1984 Datum (WGS84), and 50 southern zones. Then digitation is conducted on screen to make spatial data of rice fields in Kediri Subdistrict.

3.2.3. Focus Group Discussion (FGD). Focus groups conducted to determine Subak boundary in district of Kediri which will be followed by 23 Pekaseh (leader) of Subak. Spatial data of rice fields then arranged based on the subak boundary that has been specified in the Focus Group Discussion.

3.2.4. Updating ricefield data. Update data is focused on mapping the zonation of Subak, digitation of Regional planning (RTRW) map of Tabanan Regency, morphological data obtained from on screen digitation of watershed map, an altitude map obtained from raster DEM data analysis, distance from the town center obtained from buffer analysis, the rainfall data obtained from the analysis of isohyet map and landuse data obtained from landuse map.

3.2.5. Spatial Analysis, Classification and Mapping Criteria. Criteria and mapping the area of sustainable food farming by modifying the weights and score corresponds to the physical condition of the area. As the parameters are presented in Table 1 [4] [6].

| No. | Parameter                                                                 | Weight | Valuation | Score | Value |
|-----|---------------------------------------------------------------------------|--------|-----------|-------|-------|
| 1   | Suitability of the location paddy fields with spatial plan area:           |        |           |       |       |
|     | a. Protected areas and Protected strategic                               | 11     | 3         | 33    | 66    |
|     | b. Agricultural Cultivation Area                                         | 2      | 2         | 22    |       |
|     | c. Nonagricultural area                                                  | 1      | 1         | 11    |       |
|     | **Value**                                                                |         |           |       | **66**|
| 2   | Landuse:                                                                 | 10     |           |       |       |
|     | a. Irrigation Paddy Field                                                | 3      | 3         | 30    |       |
|     | b. Moor                                                                  | 2      | 2         | 20    |       |
|     | c. Mix Garden                                                            | 1      | 1         | 10    |       |
|     | **Value**                                                                |         |           |       | **60**|
|   | Position and or subak location in watershed: |   | Irrigation System: |   | Rainfall: |   | Landform: |   | Altitude: |   | Suitability of Agroecosystem Land for Paddy Field: |   | Productivity: |   | Distance from Center of City: |   | Minimum area: |   |
|---|-------------------------------------------|---|-------------------|---|-----------|---|-----------|---|-----------|---|---------------------------------------------|---|----------------|---|------------------|---|----------------|---|
| 3 | a. upstream                                | 9 | a. Technical Irrigation – semi technical | 8 | a. > 2500 mm/th                  | 7 | a. Hilly up to the mountain, slope > 40 % | 6 | a. >500 MASL | 5 | a. Very Suitable (S1)                           | 4 | a. >5 ton/ha/planting period                    | 3 | a. > 5km                                               | 2 | a. > 10 ha                                           | 1 |
|   | b. middle                                  |   | b. Simple irrigation                        |   | b. 2000 – 2500 mm/th              |   | b. Wavy up to choppy, slope 25-40%        |   | b. 100 – 500 MASL                                |   | b. Suitable (S2)                                |   | b. 2.5 - 5 ton/ha/planting period                |   | b. 2.5 – 5 km     |   |
|   | c. downstream                              |   | c. Rainfed                                  |   | c. <2000 mm/th                    |   | c. Flat up to ramps, slope < 25 %         |   | c. <100 MASL                                    |   | c. Marginal Suitable (S3)                        |   | c. <2,5 ton/ha/planting period                   |   | c. <2,5 km                                           |   | c. < 5 ha                                           |   |
|   |                                           |   |                                           |   | Value                            |   |                                           |   | Value                              |   | Value                                           |   | Value                                           |   | Value                                           |   | Value                                           |   |
|   |                                           |   |                                           |   | 3 27                              |   |                                           |   | 3 24                                          |   | 3 18                                           |   | 3 12                                          |   | 3 9                                               |   | 3 6                                               |   | 3 3                                             |
|   |                                           |   |                                           |   | 2 18                              |   |                                           |   | 2 16                                          |   | 2 10                                           |   | 2 8                                           |   | 2 6                                               |   | 2 4                                               |   | 2 2                                             |
|   |                                           |   |                                           |   | 1 9                               |   |                                           |   | 1 8                                            |   | 1 5                                            |   | 1 4                                           |   | 1 3                                               |   | 1 3                                             |
|   |                                           |   |                                           |   | 54                                |   |                                           |   | 48                                            |   | 42                                            |   | 36                                           |   | 24                                               |   | 18                                             |
|   |                                           |   |                                           |   |                                   |   | (Table 3.1.)                              |   | Value                                          |   | Value                                          |   | Value                                          |   | Value                                          |   | Value                                          |   |         |   |
| 6 |                                           |   |                                           |   |                                   |   |                                           |   | 3 18                                          |   | 3 10                                           |   | 5                                           |   | 4                                                 |   | 2                                               |   | 1                                             |
| 7 |                                           |   |                                           |   |                                   |   |                                           |   | 3 15                                          |   | 2 10                                           |   | 1 5                                           |   | 3                                                 |   | 2                                               |   | 1                                             |
| 8 |                                           |   |                                           |   |                                   |   |                                           |   | 3 12                                          |   | 2 8                                           |   | 1 4                                           |   | 3                                                 |   | 3                                               |   | 1                                             |
| 9 |                                           |   |                                           |   |                                   |   |                                           |   | 3 9                                           |   | 2 6                                           |   | 1 3                                           |   | 3                                                 |   | 6                                               |   | 1                                             |
|10 |                                           |   |                                           |   |                                   |   |                                           |   | 3 6                                           |   | 2 4                                           |   | 1 2                                           |   | 2                                                 |   | 1                                               |   | 1                                             |
|11 |                                           |   |                                           |   |                                   |   |                                           |   | 3 3                                           |   | 2 2                                           |   | 1 1                                           |   | 1                                                 |   | 1                                             |   | 6                                             |
All parameters then intersected to combine spatial data and attribute data, then to create total score. The result of the total score then statistically analysed using statistical summary [7] by the formula in equation (1).

\[ s = \sqrt{\frac{n \sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_i)^2}{n(n-1)}} \]  

(1)

where :
- \( s \) = standard deviation
- \( x_i \) = value x num-i
- \( \bar{x} \) = average
- \( n \) = data total

Based on the distribution of data, then maximum value, minimum, average, and standard deviation are generated. Data then can be grouped or classified based on average data and standard deviation with various modeling as follows:

a. Model 1 consisting of sustainable subak, buffer and converted, is obtained from the following formula:
   - Sustainable subak: \( x > \text{average} + 1 \text{standarddeviation} \)
   - Buffer subak: \( (x < \text{average} - 1 \text{standarddeviation}) \) up to \( (x > \text{average} + 1 \text{standarddeviation}) \)
   - Converted subak: \( x < \text{rata-rata} - 1 \text{standarddeviation} \)

b. Model 2 consisting of sustainable Subak, buffer and converted, is obtained from the following formula:
   - Sustainable subak: \( x > \text{average} + \frac{1}{2} \text{standarddeviation} \)
   - Buffer subak: \( (x < \text{average} - \frac{1}{2} \text{standarddeviation}) \) up to \( (x > \text{average} + \frac{1}{2} \text{standarddeviation}) \)
   - Converted subak: \( x < \text{average} - \frac{1}{2} \text{standarddeviation} \)

c. Model 3 consisting of sustainable Subak, buffer and converted, is obtained from the following formula:
   - Sustainable Subak: \( x > \text{average} \)
   - Buffer Subak: \( (x < \text{average} - \frac{1}{2} \text{standarddeviation}) \) up to \( (x > \text{average}) \)
   - Converted subak: \( x < \text{average} - \frac{1}{2} \text{standarddeviation} \)

d. Model 4 consisting of sustainable subak, buffer and converted, is obtained from the following formula:
   - Sustainable Subak: \( x > \text{average} - \frac{1}{2} \text{standarddeviation} \)
   - Buffer Subak: \( (x < \text{average} - 1 \text{standarddeviation}) \) up to \( (x > \text{average} - \frac{1}{2} \text{standarddeviation}) \)
   - Converted Subak: \( x < \text{average} - 1 \text{standarddeviation} \)

e. Model 5 consisting of sustainable Subak, buffer and converted, is obtained from the following formula:
   - Sustainable Subak: \( x > \text{average} - 1 \text{standarddeviation} \)
   - Buffer Subak: \( (x < \text{average} - 1 \frac{1}{2} \text{standarddeviation}) \) up to \( (x > \text{average} - 1 \text{standarddeviation}) \)
   - Converted Subak: \( x < \text{average} - 1 \frac{1}{2} \text{standarddeviation} \)

3.2.6. Analysis of Suitability of Numerical Classification Model with Change Projection of Subak Area.
Changes in rice fields over the last 5 years (2010 to 2015) in Kecamatan Kediri are calculated using the formula on Equation (2)
Change of paddy fields per year = \( \frac{\text{paddy field area of 2015} - \text{paddy field area of 2010}}{5 \text{ years}} \)  

From the data of rice fields changes per year can be determined from the projection of changes in Subak area by the year 2020, 2030 and 2040. The suitability of the modeling is determined from the area of the sustainable Subak and the buffer of Subak approached by the Subak area in each specified year. Parameter data was performed by visualization (cartography) for map making of 11 parameters and also making Subak zonation map in various modeling in Kediri sub-district of Tabanan regency.

4. Result and Discussion

The result of Subak mapping in Kediri Sub-district which obtained from Focus Group Discussion presented in Figure 1. Subak Map of Kediri Sub-district which consists of 23 Subak is presented in Appendix 1.

The map of parameters in the classification of sustainable food farming in Kediri Sub-district consists of (1) the suitability of the location of a rice field with Regional Spatial Plan of Tabanan Regency of 2012-2032, (2) existing land use, (3) Watershed morphology, (4) the type of irrigation, (5) rainfall, (6) the landform, (7) altitude, (8) the suitability of the agroecosystem of rice fields, (9) productivity, (10) the distance from the city center, (11) minimum area, are presented in Figure 2 to Figure 12.

![Figure 1. Map of Subak in Kediri Subdistrict](image.png)
Figure 2. Suitability of the Location of Rice Field with Regional Spatial Plan of Tabanan Regency of 2012-2032

Figure 3. Existing Landuse of Kediri Sub-district

Figure 4. Watershed morphology

Figure 5. Irrigation Type

Figure 6. Rainfall Intensity

Figure 7. Landform
The results of the intersection of eleven-parameter in Kecamatan Kediri resulted a modeling based on the standard deviation of the population data which divided into three regions: Subak sustainable, subak buffer, and subak converted, shown in Table 2.
Table 2. Value of Subak Sustainable, Subak Buffer, and Subak Converted in The Modeling

| Modeling      | Formula                                      | Value  |
|---------------|----------------------------------------------|--------|
| **I. Sustainable Subak** | | |
| model 1       | x>average +1standarddeviation                | x>136.4 |
| model 2       | x> average + ½ standarddeviation              | x>132.7 |
| model 3       | x> average                                   | x>129  |
| model 4       | x> average – ½ standarddeviation              | x>125.3 |
| model 5       | x> average – 1 standarddeviation              | x>121.6 |
| **II. Buffer Subak** | | |
| model 1       | (x< average -1standarddeviasi) up to (x> average +1 standarddeviation) | 121.5<x<136.4 |
| model 2       | (x< average - ½ standarddeviasi) up to (x> average + ½ standarddeviation) | 125.3<x<132.7 |
| model 3       | (x< average – ½ standarddeviation) up to (x> average) | 125.3<x<129 |
| model 4       | (x< average – 1 standarddeviation) up to (x> average – ½ standarddeviasi) | 121.6<x<125.3 |
| model 5       | (x< average – 1 ½ standarddeviation) up to (x> average - 1 standarddeviation) | x<117,9<x<121,6 |
| **III. Converted Subak** | | |
| model 1       | x< average -1 standarddeviation               | x<121,6 |
| model 2       | x< average - ½ standarddeviation              | x<125.3 |
| model 3       | x< average – ½ standarddeviation              | x<125.3 |
| model 4       | x< average - 1 standarddeviation              | x<121,6 |
| model 5       | x< average – 1 ½ standarddeviation            | x<117,9 |

The results of the area of each model are presented in Figure 13 and maps of each region in each model in Kediri Subdistrict are presented in Figure 14.

![Figure 13. Graph of Subak Zoning Area in Various Models](image-url)
Figure 14. Map of Subak Zonation in Various Models

In 2016 irrigated rice fields approximately reached 2844 ha [1] and in Year 2010 irrigated rice fields approximately reached 3036 ha [2]. Area of rice fields which converted into non-farming each year can be calculated as Equation (3).

\[
\text{Extensive rice converted per year} = \frac{\text{year 2010 extensive rice} - \text{extensive rice year 2016}}{\text{6 years}}
\]  

(3)
The extensive of rice fields which converted per year is 32 hectares. To calculate the projected changes in rice fields for the years 2020, 2030 and 2040 calculated by subtracting the total change of the year and multiplied by the change of rice fields annually as shown in Table 3.

**Table 3. Projection Data of Rice Field Change Year 2020, 2030 and 2040 in Kediri Sub-district**

| Year | Area (hectare) |
|------|----------------|
| 2015 | 2844           |
| 2020 | 2684           |
| 2030 | 2364           |
| 2040 | 2044           |

Based on the data of subak zonation modeling and projection of rice field change in 2020, 2030, and 2040 in Kecamatan Kediri, adjustment of the model to see the area of Subak Sustainable and Subak Buffer, shown in Tabel 4.

**Table 4. Conformity of Subak Zoning Modeling with Projection of Paddy Field Change Year 2020, 2030 and 2040**

| Year | Modeling in the year |
|------|----------------------|
| 2020 | Model 4              |
| 2030 | Model 3              |
| 2040 | Model 2              |

Modeling in year 2020 using model 4 because of the area of Subak sustainable in model 4 of 2682.71 ha approaching rice field area in the year 2020 which amounted to 2684 ha. In 2030 using model 3 due to the subak sustainable area in model 3 of 1651.37 ha plus ⅔ width of subak buffer of 773.51 ha to 2424.88 ha nears rice field area in year 2030 which equal to 2364 ha. In 2030, the area of land modeling and projection is still under the zoning area of crop agriculture in the spatial plan of Tabanan Regency of the year 2012-2033 at 2382.71 ha. In 2040 using model 2 because of the Subak Sustainable area in model 2 of 307.99 ha plus ⅔ width of the buffer subak of 1781.04 ha to 2089.33 ha is close to 2040 ha of rice field area in 2040 ha.

From the suitability modeling with the projection of Subak area can be determined sub-zonation of Subak that must be preserved, Subak Buffer zonation that can be preserved and converted, also Subak zonation to be converted. The width of the area and location based on the geographical location of the Subak in Kediri Subdistrict can be explained and presented in Appendix 1.

5. **Conclusions and Recommendations**
5.1. **Conclusions**
Based on the results and discussion can be concluded:
1. Kediri sub-district consists of 23 Subak of rice fields and mapped s based on geographical location.
2. Parameters in the classification of sustainable food farming in Kediri sub-district consists of (1) the suitability of the location of a rice field with Regional Spatial Plan of Tabanan Regency years 2012-2032, (2) land use, (3) Watershed morphology, (4) the type of irrigation, (5) rainfall, (6) the regional landform, (7) altitude, (8) the suitability of the agroecosystem paddy fields, (9) productivity, (10) the distance from the city center, (11) minimum area.
3. Spatial numerical classification produces a wide variety of modeling (5 models) and is associated with the projected changes in rice fields by the year 2020, 2030, and 2040. In the year 2020 using model 4
due to sustainable subak in model 4 of 2682.71 ha approached the farm field area by the year in 2020 of 2684 ha. In the year 2030 using model 3 due sustainable subak on the model of 1651.37 ha 3 plus ¾ buffer subak of 773.51 ha be 2424.88 ha approached the farm field by the year in 2030 of 2364 ha. In the year 2040 using model 2 due sustainable subak on the model of 307.99 ha 3 plus ¾ buffer subak of 1781.04 ha be 2089.33 ha approached the farm field by the year in 2040 of 2033 ha.

5.2. Recommendations
1. This modeling can be used for other areas according to the characteristics of the given areas.
2. To meet the needs of food, food supply can be increased through agricultural intensification, so that productivity obtained at least 8 tons / ha.

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### Appendix 1 Data of Subak Zonation in some Modeling in Kediri Subdistrict

| Subak Name          | Wide_Hectare | Village       | Model 2_hectare | Model 3_hectare | Model 4_hectare |
|---------------------|--------------|---------------|-----------------|-----------------|-----------------|
|                     |              |               | Sustainable Subak | Buffer Subak | Converted Subak | Sustainable Subak | Buffer Subak | Converted Subak | Sustainable Subak | Buffer Subak | Converted Subak |
| Subak ayung         | 113.51       | Cipaka        | 13.11           | 69.27           | 25.70           | 16.07           | 66.31           | 25.70           | 82.38           | 25.70           | 0               |
| Subak banjar anyar  | 10.02        | Banjar Anyar  | 0               | 50.11           | 0               | 0               | 50.11           | 0               | 50.11           | 0               | 0               |
| Subak batan gole    | 7.06         | Kediri        | 0               | 53.04           | 0               | 0               | 53.04           | 0               | 53.04           | 0               | 0               |
| Subak bentukel      | 329.66       | Bengkel       | 0               | 294.95          | 26.31           | 245.57          | 49.38           | 26.31           | 294.95          | 0               | 26.31           |
| Subak demung        | 112.14       | Kediri        | 2.27            | 108.82          | 1.03            | 21.68           | 89.41           | 1.03            | 111.09          | 0               | 1.03            |
| Subak gadon i       | 141.54       | Pandak Gede   | 0               | 33.45           | 9.20            | 33.45           | 0               | 9.20            | 33.45           | 0               | 9.20            |
| Subak gadon ii      | 169.36       | Beraban       | 0               | 145.87          | 23.39           | 0               | 145.87          | 23.39           | 145.87          | 0               | 23.39           |
| Subak gadon iii     | 255.80       | Beraban       | 0               | 315.75          | 72.4            | 152.92          | 162.83          | 72.40           | 378.75          | 0               | 72.40           |
| Subak jadi          | 78.97        | Banjar Anyar  | 70.53           | 8.40            | 0               | 78.93           | 0               | 0               | 78.93           | 0               | 0               |
| Subak jangga        | 60.22        | Belalang      | 0               | 43.55           | 24.8            | 0               | 43.53           | 24.80           | 43.53           | 0               | 24.80           |
| Subak kediri        | 113.60       | Kediri        | 10.81           | 99.16           | 3.89            | 30.26           | 79.55           | 3.89            | 109.71          | 0               | 3.89            |
| Subak melata        | 115.18       | Bawul         | 0               | 157.75          | 18.57           | 157.75          | 0               | 18.57           | 157.75          | 0               | 18.57           |
| Subak mundeh        | 161.30       | Nyimbu        | 34.11           | 229.24          | 1.91            | 157.69          | 105.66          | 1.91            | 263.35          | 0               | 1.91            |
| Subak nyitdah i     | 113.27       | Pandang Mantung | 34.93         | 18.73           | 0               | 34.93           | 18.73           | 0               | 53.66           | 0               | 0               |
| Subak nyitdah ii    | 80.86        | Pandak Gede   | 0               | 53.6            | 6.73            | 53.60           | 0               | 6.73            | 53.6            | 0               | 6.73            |
| Subak nyitdah iii   | 275.84       | Nyitdah       | 270.52          | 0               | 5.33            | 270.52          | 0               | 5.33            | 0               | 0               | 5.33            |
| Subak nyitdah iv    | 68.88        | Belalang      | 289.92          | 0               | 3.89            | 289.92          | 0               | 3.84            | 289.92          | 0               | 3.84            |
| Subak sunggulan      | 76.32        | Banjar Anyar  | 0               | 76.31           | 0               | 67.32           | 8.99            | 0               | 76.31           | 0               | 0               |
| Subak sampangan     | 117.14       | Banjar Anyar  | 58.71           | 4.40            | 0               | 63.11           | 0               | 0               | 63.11           | 0               | 0               |
| Subak sung i        | 158.31       | Abun Tawung   | 40.46           | 115.83          | 0               | 125.72          | 31.57           | 0               | 156.29          | 0               | 0               |
| Subak tungkub i     | 129.66       | Nyimbu        | 11.63           | 14.06           | 0               | 11.63           | 14.06           | 0               | 25.69           | 0               | 0               |
| Subak tungkub ii    | 197.89       | Kabu Kabu     | 31.43           | 125.32          | 40.88           | 111.92          | 44.83           | 40.88           | 156.75          | 16.89           | 23.99           |
| Subak tungkub iii   | 100.13       | Kabu Kabu     | 61.3            | 21.86           | 17.14           | 0               | 21.86           | 17.14           | 21.86           | 0               | 17.14           |