Model of Numerical Spatial Classification for Sustainable Agriculture in Badung Regency and Denpasar City, Indonesia

N M Trigunasih[2], I Lanya[1], N N Subadiyasa[1], and J Hutauruk[2]

[1] Faculty of Agriculture, Universitas Udayana, Bali, Indonesia
[2]Center for Spatial Data Infrastructure Development (PPIDS) Universitas Udayana, Bali, Indonesia

Email: tri5963@yahoo.com

Abstract. Increasing number and activity of the population to meet the needs of their lives greatly affect the utilization of land resources. Land needs for activities of the population continue to grow, while the availability of land is limited. Therefore, there will be changes in land use. As a result, the problems faced by land degradation and conversion of agricultural land become non-agricultural. The objectives of this research are: (1) to determine parameter of spatial numerical classification of sustainable food agriculture in Badung Regency and Denpasar City (2) to know the projection of food balance in Badung Regency and Denpasar City in 2020, 2030, 2040, and 2050 (3) to specify of function of spatial numerical classification in the making of zonation model of sustainable agricultural land area in Badung regency and Denpasar city (4) to determine the appropriate model of the area to protect sustainable agricultural land in spatial and time scale in Badung and Denpasar regencies. The method used in this research was quantitative method include: survey, soil analysis, spatial data development, geoprocessing analysis (spatial analysis of overlay and proximity analysis), interpolation of raster digital elevation model data, and visualization (cartography). Qualitative methods consisted of literature studies, and interviews. The parameters observed for a total of 11 parameters Badung regency and Denpasar as much as 9 parameters. Numerical classification parameter analysis results used the standard deviation and the mean of the population data and projections relationship rice field in the food balance sheet by modelling. The result of the research showed that, the number of different numerical classification parameters in rural areas (Badung) and urban areas (Denpasar), in urban areas the number of parameters is less than the rural areas. The based on numerical classification weighting and scores generate population distribution parameter analysis results of a standard deviation and average value. Numerical classification produced 5 models, which was divided into three zones are sustainable neighbourhood, buffer and converted in Denpasar and Badung. The results of Population curve parameter analysis in Denpasar showed normal curve, in contrast to the Badung regency showed abnormal curve, therefore Denpasar modeling carried out throughout the region, while in the Badung regency modeling done in each district. Relationship modelling and projections lands role in food balance in Badung views of sustainable land area whereas in Denpasar seen from any connection to the green open spaces in the spatial plan Denpasar 2011-2031. Modelling in Badung (rural) is different in Denpasar (urban), as well as population curve parameter analysis results in Badung showed abnormal curve while in Denpasar showed normal curve. Relationship modelling and projections lands role in food balance in the Badung regency sustainable in terms of land area, while in Denpasar in terms of linkages with urban green space in Denpasar City's regional landuse plan of 2011-2031.

Keywords: Modelling; Numerical Classification; Sustainable Food Agriculture

1. Introduction

Increase in the number and activity of the population to meet the needs of their lives greatly affect the utilization of land resources [1–3]. Land needs for activities of the population continued to grow, while the availability of land is limited, so that there will be changes in land use [4,5]. Besides, the problems faced in the national food nowadays are the degradation of soil fertility [6], the import of rice, the competition of water use is increasing and the agricultural/rural infrastructure is still inadequate and the phenomenon of conversion of agricultural land nowadays.

The objectives of this research are (1) to determine spatial numeric parameter parameter of sustainable agriculture in Badung Regency and Denpasar City (2) to know the projection of food balance in Badung Regency and Denpasar City in 2020, 2030, 2040, and 2050 (3) to set the classification function Numerical spatial in making model of zonation of sustainable agriculture area in Badung Regency and Denpasar City (4) to determine the appropriate model of area to protect sustainable agricultural land in spatial and time scale in Badung Regency and Denpasar City.

2. Literature Review

Protection of sustainable food crops is a system and process in planning and establishing, developing, utilizing and nurturing, controlling and supervising the sustainable agriculture land of food and its area. Sustainable food crop is one of the government's policies in controlling the rate of conversion of agricultural land, especially rice fields in Indonesia. Sustainable food crops has the objective of (1) protecting sustainable agriculture and food lands, (2) ensuring the availability of sustainable food for agriculture, (3) realizing food self-sufficiency, sustainability and sovereignty, (4) protecting the ownership of agricultural land belonging to farmers (5) improving the welfare and prosperity of farmers and communities, (6) increasing the protection and empowerment of farmers, (7) increasing the provision of employment for decent living, (8) maintaining ecological balance and (9) realizing agricultural revitalization [7].

Within 14 years (1999-2013), there has been a change in the use of agricultural land to non-agricultural in Bali province of 4,906 ha. The average land use change per year occurs in Bali around 350 ha (0.41%). The highest rice field change during the fourteen years were in TabananRegency of 1,230 ha, followed by JembranaRegency of 1,078 ha, BulelengRegency of 677 ha, Badung Regency covering 672 ha, Denpasar with 659 ha, Regency Gianyar area of 497 ha and Klungkung Regency covering 173 ha. However, the addition of ricefield area occurred in 58 ha of Karangasem Regency and Bangli District (Mengani Village of KintamaniSubdistrict of 22 ha) [8]. The nine Regencies in Bali do not currently have a law on sustainable food crop protection mandated by Law 41 of 2009. This will have an impact on local food security, and the subak as a world cultural heritage will lose its existence as an irrigation system in Bali.

In terms of soil and water conservation, Subak has been in use since the seventh century with a semi-technical and simple watering system. Subakrice field also serves as flood control, rainfall catcher, especially located in the upper river. Rice crops as oxygen (O2) contributors on micro and macro scale [9]. The various requirements stipulated in Law no. 41 Year 2009, then should all Subakrice field in Bali need special attention about its existence. The existence of the need for non-agricultural development, such as housing, tourism, shops, industry and infrastructure facilities, limited land conversion is needed, especially in urban areas, government and tourism centers.

The act no. 41 of 2009 on the protection of sustainable agricultural land in Article 9 includes land suitability, availability of infrastructure, land use, technical potential of the land and the extent of the unity of land. The physical condition of the region consists of: the location position of the watershed, irrigation facilities, rainfall, the shape of the region /relief Slope, altitude, rainfall, suitability of agro-ecosystem lands, conformity to spatial planning and land use, are linked to areas that need to be protected in sustainable food agriculture [9].

3. Methodology

3.1. Area of Study

The research was conducted in Badung Regency and Denpasar City, Bali Province, Indonesia. Geographically, Badung Regency is located between $8^0$14'20 "- $8^0$50'52" South Latitude and $115^0$05'03 "- $115^0$26'51" East Longitude with an area of 418.52 km^2 (41,852 ha) or about 7.43% of Bali Island. BadungRegency is divided into 6 sub districts, namely: South KutaSubdistrict (this sub district is not included in the research because there is no rice field), Kuta, North Kuta, Mengwi, Abiansemal and Petang. From 6 sub-districts, Petang District has the largest area of 115 km^2, while Kuta District is the smallest area of 17.52 km^2. Badung Regency has 119 subak with 9,984 ha of rice field area [10]. The city of Denpasar is 127,78 km^2 wide and geographically located at 08º35'31 "- 08º44'49" South Latitude and 115º10'23 "- 115º16'27" East Longitude. Denpasar City is divided into 4 subdistricts namely North Denpasar, East Denpasar, West Denpasar and South Denpasar [11].

3.2. Research Stage

3.2.1. Preliminary Stage

This research activity began from literature study to get initial information about the condition of the research area from previous research results, either in the form of data from reports and maps that already exist. Literature studies was as a reference for field study planning. Preliminary studies include: analysis of data and information from satellite imagery and base maps (roads, rivers, irrigation canals, and administrative boundaries), land use maps, site planning observations. Interpretation of satellite imagery was for tentative landuse map making, area description, surveys and soil making sampling for agro-ecosystem land suitability requirements and for constructing thematic maps of land suitability of agro-ecosystems.

3.2.2. Data Analysis and Interpretation of Satellite Imagery

Interpretation of satellite imagery for the identification, description and classification of land use and landform analysis was done by using three analytical methods: (1) elemental analysis, (2) pattern analysis, and (3) physiography analysis. Element analysis is conducted with nine elements, namely: shape, and size, color and contrast, texture and pattern, shadow, location, and association. These nine elements are used for land use classification. Subsequently, a tentative map of landuse was made before field observation.

3.2.3. Land Resource Data Updates

Data updating focusd on map creation process on a scale of 1: 50,000, such as maps of conformity to regional landuse (strategic protected and conservation areas, agricultural cultivation areas, non-agricultural cultivation areas), land use (irrigated, mixed), watershed (upstream, middle and downstream), irrigation type (technical, semi technical, simple and rain-fed), shape / relief (flat, undulating, hilly and mountainous), slope of origin (> 40% 25-40%, and< 25%), rainfall / agroclimate zone, height (> 500, 100 - 500, and <100 m asl), land suitability agroecosystem (S1, S2, and S3), land productivity (5, 2.5 - 5 and <2.5 tons / ha / MT) and distance from the city center (> 5 km, 2.5 - 5 km, 2.5 km) and minimum area (> 5 ha, 2 - 5 Ha and <2 ha).

Analysis of spatial data and interpretation of Satellite Imagery 2015 was calculated by using Quantum GIS 2.10.1 application. Spatial data collection was in the form of satellite image in Denpasar City (Worldview Year 2015) and Badung Regency (Quick Bird Year 2013) and projecting into WGS 84 / UTM Zone 50 S coordinate system. Collecting and making vector data in Denpasar and suiting rice field with landuse plan by digitizing the regional plan of Denpasar in 2011-2031, landuse data creation by vectorisation of satellite image, watershed area by vectorisation of satellite image, irrigation field irrigation type using spatial data and attribute of subak Denpasar city, rainfall obtained from BMKG Region III Denpasar, agro ecosystem land suitability for paddy rice can be calculated from the results of the sampling point from subakin Denpasar City, land productivity obtained from subak database of Denpasar City and rice field sampling in Denpasar City. The distance from the city center was calculated by buffer method, the minimum area was calculated from the result of spatial distribution of ricefield in Denpasar city in 2015.

Collecting and building vector data in Badung regency started with suiting subakrice field with landuse plan by digitizing landuse of Badung Regency in 2013- 2033, building landuse data by digitizing satellite image, watershed location obtained from BPDAS UndaAnyar, irrigation system obtained from spatial data and attribute of subak of Badung regency, rainfall obtained from BMKG. The slope data is obtained from the topographical map, the height of the place was obtained from topographic maps. The suitability of agro-ecosystem land for ricefield was obtained from the result of sampling point of subak of Badung regency, land productivity was obtained from subak database of Badung regency and sampling of subak rice field. The distance from the city center is calculated by the buffer method (area) applied, the minimum area was calculated from the result of the width of subak area ofBadung regency of 2013. The data of each spatial per parameter was done by weighting and scoring, then all parameters were overlaid/intersected to combine spatial data values. After the overlay process then total scoring was calculated by calculating feature on the application. Population data in dbf format of overlay results was conducted to determine the class population. Then statistical analysis was done to get standard deviation, maximal, minimum, average and total value. The result of population statistical analysis obtained some modeling obtained from standard deviation [9], by formula:

$$s = \sqrt{\frac{n\sum_{i=1}^{n} x_i^2 - (\sum_{i=1}^{n} x_1)^2}{n(n-1)}}$$

s = standard deviation
xi = value of *x* number-*i*
$\bar{x}$ = average
n = number of data

Each modeling was analyzed by grouping the data of statistical analysis using select featured expression feature, so get some model that is model 1 to model 5. Each parameter and modeling was arranged with cartography rule with layout feature of composer manager then mappingper parameter in Denpasar and Badung regency as well as zonation map of subak land respectively in Badung regency and Denpasar city.

3.2.4. Establishment of Ricefield Area

The availability of image data in different time periods (2002 and 2015) makaes the land use balance was only calculated for Denpasar City area through overlay - intersect method in QGIS menu. The landuse map was generated from satellite image interpretation. Field check was conducted from the interpretation of satellite imagery for mapping of landuse in 2015.

Analysis of existing ricfield data of 2012 and landuse balance was calculated manually by comparing different year data with the same image data source. Land use classification refers to the National Land Agency classification system. This classification was based on a structured hierarchy, because the classification of cover / land use according to Bakosurtanal (2005) and the Ministry of Environment (2007) does not explain the data detail.

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3.2.5. Criteria Parameter, Classification and Mapping of Sustainable Food Crops

The criteria and mapping of GIS-based PLPPB areas refers to the classification studies, by modifying the weights and scores according to the physical condition of the region [9,12]. The 11 parameters are:

a) The suitability of paddy field location with RTRW
b) Land use
c) The position of subak rice field in watershed (DAS)
d) Type of irrigated rice field
e) Rainfall
f) Region shape
g) Elevation of the place
h) Agro-ecosystem compatibility
i) Land productivity
j) Distance from city center
k) Minimal width of subak

Criteria for Weighting and Scoring of each Parameter forClassification of Agricultural Land in Badung Regency and Kota Denpasar listed in Appendix 1. From the results of the eleventh digit digital overlay parameters in Badung regency generate a total score in each data distribution. From the distribution of data, it can be seen the maximum value, minimum, average, and standard deviation. Overlay data can be grouped or made to ring population data based on total score value, with the following classes:

A. Lestari => x (> average + 1 standard deviation)
B. Buffer = x ((average-1 standard deviation) to (Average + 1 standard deviation))
C. Converted = <x (<average - 1 standard deviation)

Based on the population rings, there are classification of subak land zoning in several models:

1) *Model 1:*
A. Subak Lestari = (> average + 1st standard deviation)
B. Subak Buffer = ((average - 1 standard deviation) Up to (> average + 1st standard deviation))
C. Subak Convert = (<average - 1 standard deviation)

2) *Model 2:*
A. Subak Lestari = (> average + ½ standard deviation)
B. Subak Buffer = ((<average - ½ standard deviation) up to (> Averages + ½ Standard deviation))
C. Subak Convert = (<average - ½ standard deviation)

3) *Model 3:*
A. Subak Lestari = (> average)
B. Subak Buffer = ((<average - 1½ standard deviation) up to (> Average))
C. Subak Convert = (<average - 1½ dot deviation)

4) *Model 4:*
A. Subak Lestari = (> average - ½ standard deviation)
B. Subak Buffer = ((<average - 2 standard deviation) up to (> Average - ½ standard deviation)
C. Subak Convert = (<average - 2 standard deviation)

5) *Model 5:*
A. Subak Lestari = (> average - 1 standard deviation)
B. Subak Buffer = ((<average - 2 ½ standard deviation) up to (> Averages - 1 stdar deviation).
C. Subak Convert = (<average - 2 ½ standard deviation)

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Based on the population ring can be made classification of subak land zonasi in some modeling that is:

1) *Model 1, consisting of sustainable subak, buffer and converted, is derived from the following formula:*
   A. Subak Lestari = (> average + 1/2 standard deviation)
   B. Subak Buffer = ((average - 1 / 2standard deviation) to (average + 1/2 standard deviation)
   C. Subak Convert = (average -1/2 standard deviation)

2) *(2) Model 2, consisting of sustainable subak, buffer and converted, is obtained from the following formula:*
   A. Subak Lestari = (> average + ½ standard deviation)
   B. Subak Buffer = ((average- ½ standard deviation) up to (Average + ½ standard deviation)
   C. Subak Convert = (average - ½ standard deviation)

3) *(3) Model 3, consisting of sustainable subak, buffer and converted, is obtained from the following formula:*
   A. Subak Lestari => x (average)
   B. Subak Buffer = ((average - 2 standard deviation) to (average)
   C. Subak Convert = (<average -2 standard deviation)

4) *(4) Model 4, consisting of sustainable subak, buffer and converted, is derived from the following formula:*
   A. Subak Lestari => x (> average + 1/2 standard deviation
   B. Subak Buffer = x ((average - 1 / 2standard deviation) to (Average + 1/2 standard deviation)
   C. Subak Convert = <x (average -1/2 standard deviation)

5) *(5) Model 5, consisting of sustainable subak, buffer and converted, is derived from the following formula:*
   A. Subak Lestari => x (> average + 1/2 standard deviation
   B. Subak Buffer = x ((average - 1 / 2standard deviation) to (Average + 1/2 standard deviation)
   C. Subak Convert = <x (average -1/2 standard deviation)

3.2.6. Food Balance Year 2020-2050 for Badung Regency and Denpasar City

The food balance was calculated based on projected population growth and land conversion. In Badung Regency the food balance is calculated for each Sub-district, while Denpasar city was calculated for whole city.

1) Projected population growth

Population projection is a scientific calculation based on certain assumptions of population growth variable. Population variables include: birth, death and migration, the three components of this variable that determine the size of the population and its characteristics in the future. Calculate the balance of food Year 2020-2050 Kota Denpasar and Badung regency. Calculate the projection of population growth by doing (1) collecting secondary data of Badung regency population per sub-district, (2) collecting secondary data of population of Denpasar City. Calculating the projection of Badung regency population was done by using Mathematical Method [13].

Formula: $Pn = Po (1 + rn)$
Namely: Pn = Population in year n
Po = Population in the early years
R = Population increase rate (%)
N = Period (time) between the initial year c

Data source of Petang sub-district using statistical data from Badung in 2006 - 2011, Abiansemal Sub-district using 2010-2015 data, Mengwi sub-district using 2010-2015 data, Kuta sub-district using data from 2012-2015, 2015. Calculating the projection of Denpasar residents by using the inter census formula [13].

Formula: Pm = Po + m / n (Pn-Po)
Namely: Pn = Number of population in year n
Po = Population in the early year
Pm = Population in estimated years
M = difference of year searched with initial year
N = year increment of 2 known censuses

For Denpasar City, data for 2000 and year 2010

2) Calculating Projection of Land Function Distribution of Badung Regency and Denpasar City

Calculating the landuse change of Badung Regency, calculated per sub-district by the formula: the area of land conversion per year = the area of land year n minus the n year land area minus 5 divided 5. The land area in the year was done by using the 2015 landuse data. The total landuse change model was calculated in 2020, 2030, 2040 and 2050. Calculation of the landuse function of Denpasar City was calculated thoroughly by using data of ricefield area of Denpasar City obtained from the digitization of Satellite Imagery of Ikonos Year 2002 and digitization of Satellite Image of Worldview Year 2015. Average land use change of Denpasar city per year was calculated by using the formula of ricefield area of 2015 minus area of rice field year 2002 divided by 13 year.

The land projection of 2020 will be calculated by subtracting the number of land use over 5 years since 2015. The land projection of 2030 will be calculated by subtracting the number of land use over 5 years, but if the land area is less than the urban green space area in the Denpasar City Spatial Plan Year 2011- 2031 (1563.62 ha), then the land area in 2030 is 1563.62 ha (equal with Denpasar City Spatial Plan Year 2011- 2031). The 2040 landuse projection is calculated by subtracting the area of urban green area with ten-year land conversion, but if the land area is smaller than the City of Denpasar (12,778 ha) multiplied by 30% or 833.4 ha then the land area in 2040 is 833.4 ha. In the law, open green space is grouped into two, namely private sector (garden / yard owned by public / private) and Public green space (managed and owned by local government). Private gren space by 10% of the total area, while Public green space is 20% of the total area. The projection for 2040 uses public green space by 30%. The land projection in 2050 is calculated by subtracting the projected 2040 results by less than ten years of landuse, but if the land area is smaller than the area of Denpasar (12,778 ha) multiplied by 20% (Public Revenue) or 555.6 ha, Land in 2050 is 555.6 ha. The description on the food balance table covers the year (2015, 2020, 2030, 2040 and 2050).

4. Results and Discussion

4.1. Result of Badung Regency

The results showed that the projection of food balance in Badung regency was in Petang District with productivity of 7 ton / ha, Abiansemal, Mengwi, Kuta Utara and Kuta respectively with productivity 8 ton / Ha, food balance condition in 2015 that is food deficit (-32843.44 ton of rice), year 2020 that is food surplus (25155.19 ton of rice), year 2030 that is food surplus (3401.79 ton of rice), year 2040 that is The food deficit (- 18434.78 tons of rice) and the year 2050 is the food deficit (-11824.82 tons of rice). The projection of food balance in Denpasar with productivity of 8 ton/ ha, food balance condition in 2015 is food deficit (-90931,35 ton rice), 2020 is food deficit (-112514.73 ton of rice) , 2030 is food deficit (-142065.17 ton of rice), 2040 is food deficit (-173229.00 ton of rice), and year 2050 is food deficit (-203716.97 ton of rice).

The area of sustainable food agriculture is the area of sustainable rice according to the projection of ricefield area with food balance. Badung regency includes:

a) Petang District by 2020, the area of sustainable rice is equal to the area of sustainable rice field in 2030, 2040 and 2050, which is 1,173 ha and entirely using model 5.

b) Abiansemal Subdistrict, area of 2020 sustainable rice field by 2,848,51 ha using model 5, year 2030 area of sawah sustainable for 2,808.80 ha using model 4, 2040 of sustainable area for 2,767,85 ha using model 1, And in 2050 the area of sawah sustainable for 2,727.52 ha using model 2.

c) Mengwi subdistrict in 2020 with area of rice field sustainable area of 4,348,05 ha using model 5, year 2030 area of sawah sustainable for 4,204.08 ha by using model 4, year 2040 area of sustainable land equal to 4,060.11 ha using model 3, And by 2050 the area of sawah is 3916.14 ha using model 1.

d) North Kuta sub-district by 2020 of sustainable area of 1,425.35 ha using model 5, 2030 of sustainable land area of 1,370.25 ha using model 4, 2040 of sustainable land of 1,315.15 ha using model 4, and In 2050 the area of sawah is 1,260.05 ha using model 4.

e) Kuta sub-districts 2020 sustainable land area of 18.5 ha using model 4, year 2030 of sustainable land area of 1.5 ha using model 3, 2040 of sustainable land for 0 ha using model 1 and 2050 Sustainable rice field of 0 ha using model 1.

Figure 1 shows the result of model 1, Figure 2 shows model 2, Figure 3 shows model 3, Figure 4 shows model 4, and Figure 5 shows model 5 for Badung Regency. Meanwhile data modeling in Badung Regency listed in Table 1, and Table 2 listed the data of suitability for rice field area in food balance by modeling in Badung Regency

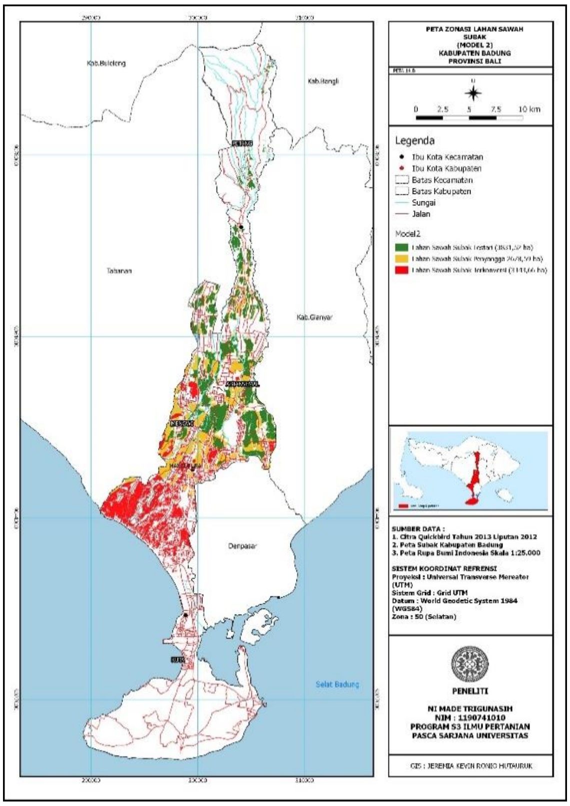

Figure 1. Model 1 Result for Badung Regency

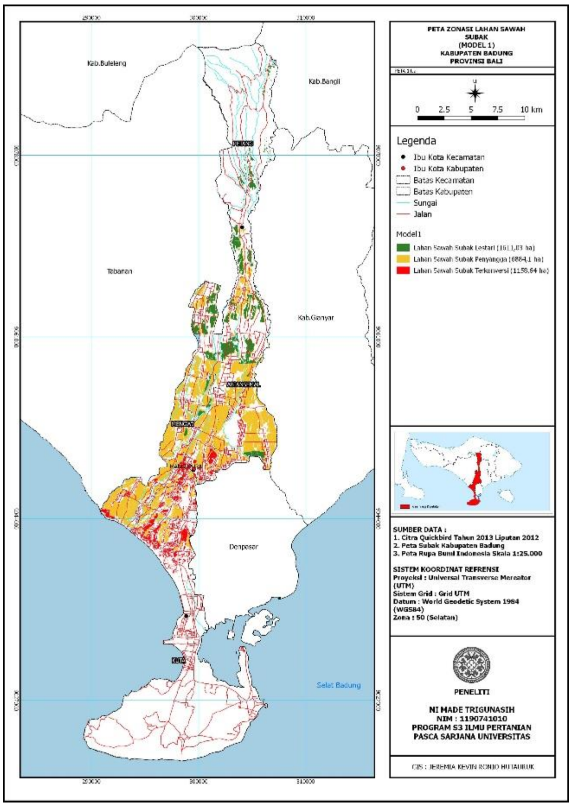

Figure 2. Model 2 Result for Badung Regency

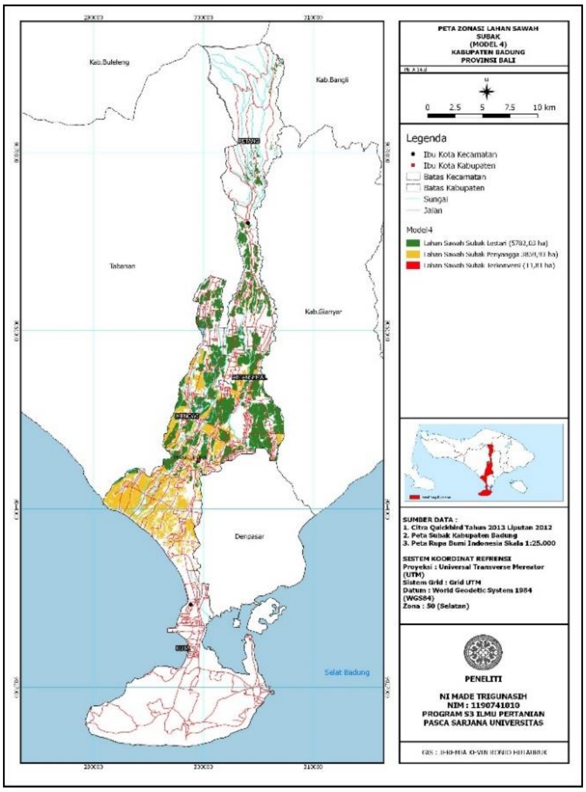

Figure 3. Model 3 Result for Badung Regency

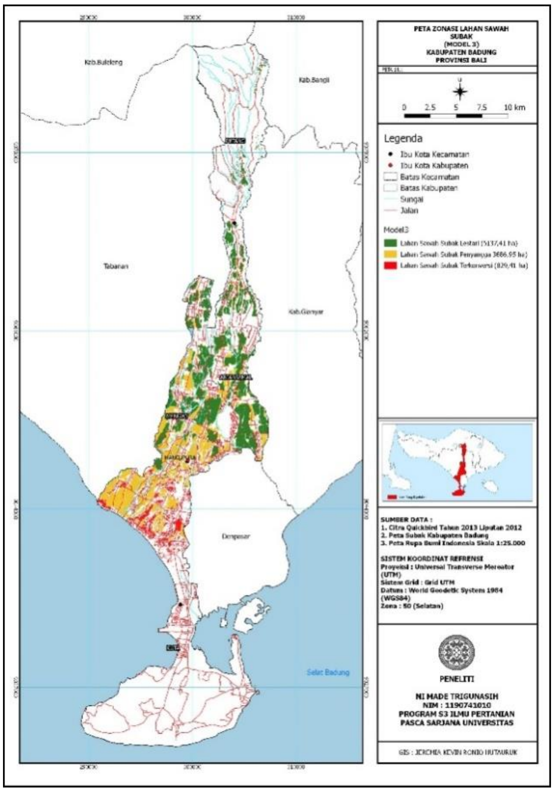

Figure 4. Model 4 Result for Badung Regency

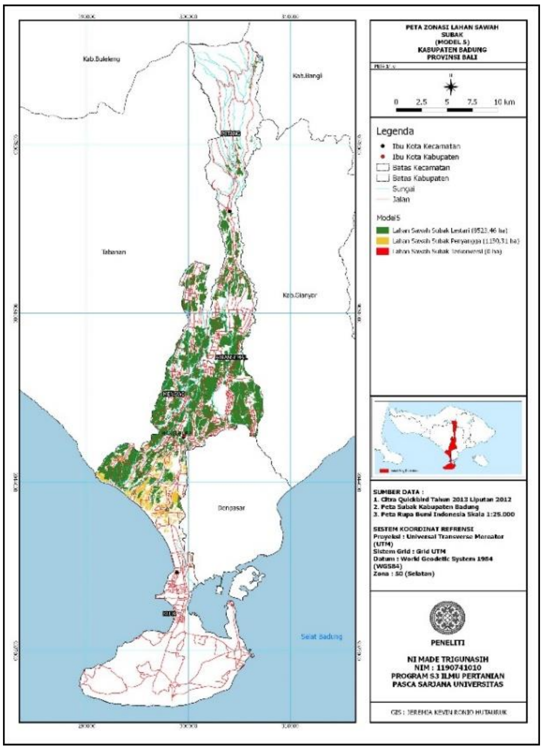

Figure 5. Model 5 Result for Badung Regency

Table 1. Area DataModeling in Badung Regency

Sub-district/ Model	Area (ha)		
	Lestari	Penyangga	Terkonversi
1	2	3	4
1. Petang			
a. Model 1	492.16	501.69	0
b. Model 2	675.83	244.07	19.19
c. Model 3	935.44	58.39	0
d. Model 4	973.75	20,09	0
e. Model 5	993.84	0	0
2. Abiansemal			
a. Model 1	705.43	2229.52	2.36
b. Model 2	1822.87	958.83	100.33
c. Model 3	2377.79	532.28	0
d. Model 4	2511.79	386.86	0
e. Model 5	2798.62	115.34	0
3. Mengwi			
a. Model 1	409.44	3530.75	359.89
b. Model 2	1332.82	1413.23	1651.76
c. Model 3	1804.36	2345.92	133.29
d. Model 4	2236.29	2061.99	0
e. Model 5	4141.34	155.31	0
4. Kuta Utara			
a. Model 1	0	637.26	728.68
b. Model 2	0	62.5	1342.91
c. Model 3	12,62	728.48	672,09
d. Model 4	64.5	1335.95	4.64
e. Model 5	647.6	758.09	0
5. Kuta			
a. Model 1	0	0	24.1
b. Model 2	0	0	24,1
c. Model 3	0	7,42	12,07
d. Model 4	0	16,93	7,17
e. Model 5	0,07	24,10	0

Table 2. Suitability for Ricefield Area in Food Balance by Modeling in Badung Regency

Sub-districts	Model - Year			
	2020	2030	2040	2050
1.Petang	Model 5	Model 5	Model 5	Model 5
2.Abiansemal	Model 5	Model 4	Model 1	Model 2
3.Mengwi	Model 5	Model 4	Model 3	Model 1
4.Kuta Utara	Model 5	Model 4	Model 4	Mode 4
5.Kuta	Model 4	Model 3	Model 1	Model 1

4.2. Denpasar City

City of Denpasar (urban), in 2020 the area of sawah sustainable is 1705,21 ha using model 5, year 2030 wide of sawah sustainable by 1563,62 ha using model 4, year 2040 sustainable area of 964,22 ha using model 3, And by 2050 the area of sawah is 556,6 ha using model 2. Factors affecting sustainable area, buffer and convert in Badung regency is suitability of paddy field with RTRW, watershed position, rainfall, place height, and shape of area (slope) whereas in Denpasar influence factor is suitability of paddy field with RTRW and paddy field position in the watershed.

Figure 6 shows model 1 result for Denpasar City, Figure 7 shows model 2 result for Denpasar City, Figure 8 shows model 3 result for Denpasar City, Figure 9 shows model 4 result for Denpasar City, and Figure 10 shows model 5 result for Denpasar City. Table 3 listed the data for area in modeling for Denpasar City. Meanwhile Table 4 listed the data of suitability of ricefield area in food balance by modeling in Denpasar City.

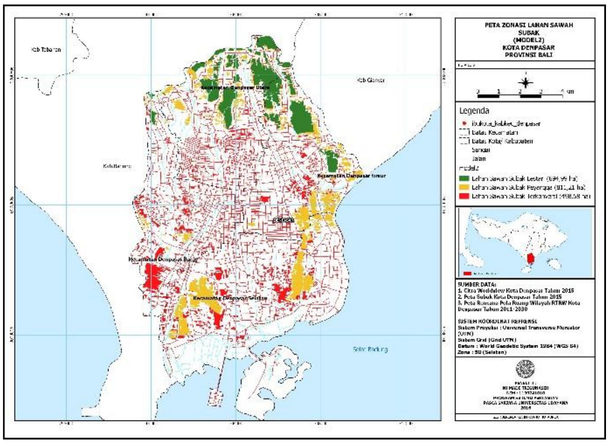

Figure 6. Model 1 Result for Denpasar City

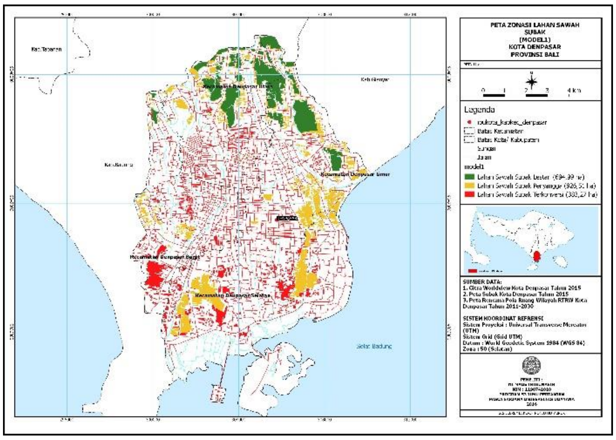

Figure 7. Model 2 Result for Denpasar City

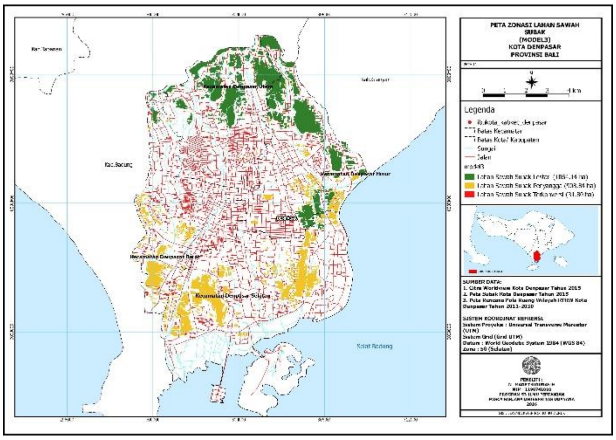

Figure 8. Model 3 Result for Denpasar City

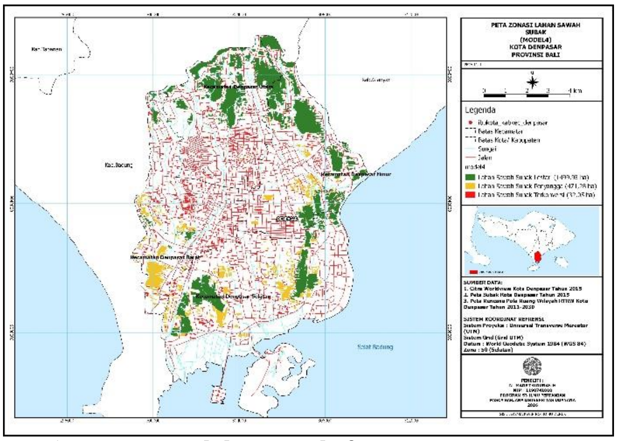

Figure 9. Model 4 Result for Denpasar City

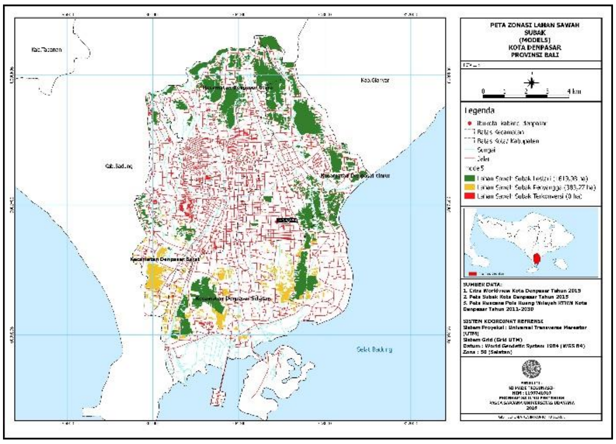

Figure 10. Model 5 Result for Denpasar City

Table 3. Data for Area in Modeling for Denpasar City

Model	Area (ha)		
	Sustainable	Buffer	Converted
Model 1	695,09	926,59	383,28
Model 2	695,05	811,30	498,61
Model 3	1064,28	908,88	31,80
Model 4	1500,80	472,11	32,05
Model 5	1621,58	383,38	0

Table 4. Data of Suitability of Rice field Area in Food Balance by Modeling

City	Model - Year			
	2020	2030	2040	2050
Denpasar	Model 5	Model 4	Model 3	Model 2

5. Conclusions

Based on the results and discussion can be concluded:

a) Classification parameter for rural area (Badung Regency) in the form of: suitability of paddy field with landuse plan, landuse, rice field position in watershed, type of irrigated ricefield, rainfall, area, height of place, suitability of agro-ecosystem land, ricefield production, Cities and minimal area of ricefields. Denpasar City Parameter same with Badung regency except parameter of area and height of place.

b) Projection of food balance at:
   1) Badung Regency has food deficit in 2015, 2040 and 2050, but in 2020 and 2030 experienced food surplus.
   2) Denpasar City 2015, 2020, 2030, 2040 and 2050 each experienced food deficit.

c) The numerical classification model for the KLP2B zonation
   Zoning area of Badung Regency in the form of:
   1) Subak sustainable in models 1, 2, 3, 4, and 5 each have an area of 1611.03 ha; 3831.52 ha; 5137.41 ha; 5782.03 ha and 8523.46 ha
   2) Subak buffer in models 1, 2, 3, 4 and 5, each has an area of 6884.1 ha; 2678.59 ha; 3686.95 ha; 3859.93 ha and 1130.31 ha.
   3) Subak converted on models 1, 2, 3, 4, and 5 each have an area of 1158.64 ha; 3143,66 ha; 829.41 ha; 11,81 ha and 0 ha.

   Zoning area for Denpasar City in the form of:
   1) Subak sustainable in models 1, 2, 3, 4, and 5 each have an area of 695.09 ha; 69505 ha; 1064.28 ha; 1500.8 ha and 1621.58 ha.
   2) Subak Buffers in models 1, 2, 3, 4 and 5 each have an area of 926.59 ha; 811.30 ha; 908.88 ha; 472.11 ha and 383.38 ha.
   3) Subak converted on models 1, 2, 3, 4, and 5 each have an area of 383.28 ha; 498.61 ha; 31.8 ha; 32.05 ha and 0 ha.

d) Sustainable agriculture model:
   The Regency of Badung includes:
   1) Petang sub-districts in 2020, 2030, 2040 and 2050 have a sustainable area of sawah equal to 1,173 ha and use model 5.
   2) Abiansemal sub-districts have sustainable paddy fields in 2020, 2030, 2040 and 2050 with area and model respectively of 2,848.51 ha (model 5), 2,808.80 ha (model 4), 2,767.85 ha (model 1), and 2,727.52 ha (model 2).

3) Mengwi sub-district has a sustainable rice field area in 2020, 2030, 2040 and 2050 with area and model respectively 4,348.05 ha (model 5), 4,204.08 ha (model 4), 4,060.11 ha (model 3), and 3916.14 ha (model 1).
4) North Kutasubdistrict has 2050 sustainable rice fields in 2020, 2030, 2040 and 2050 with area and model of 1,425.35 ha (model 5), 1,370.25 ha (model 4), 1,315.15 ha (Model 4), and 1,260.05 ha (model 4).
5) Kuta sub-districts have widespread sawah in 2020, 2030, 2040 and 2050 with the width and model of 18.5 ha (model 4), 1.5 ha (model 3), 0 (model 1), respectively, and 0 ha (model 1),
6) Denpasar city with sustainable rice field area of 2020, 2030, 2040 and 2050 respectively have wide and model of 1,705.21 ha (model 5), 1,563.62 ha (model 4), 964.22 ha (model 3) and 556.6 (model 2).

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Appendix
Appendix 1

Criteria for Weighting and Scoring of each Parameter
for Agricultural Land Classification in Badung Regency

No.	Parameter		Weight	Rating Score	Value
1	Ricefield suitability with landuse planning		11		
	a.	Strategic and protected areas		3	33
	b.	Agricultural Cultivation Area		2	22
	c.	Non-agricultural areas		1	11
					66
2	Penggunaan lahan :		10		
	a.	Irrigated ricefield		3	30
	b.	Moor		2	20
	c.	Mixed plantation		1	10
					60
3	Subak location in the Watershed area		9		
	a.	Upstream		3	27
	b.	Middle		2	18
	c.	Downstream		1	9
					54
4	Irrigation system		8		
	a.	Technical-semi technical irrigation		3	24
	b.	Simple irrigation/ non technical		2	16
	c.	Rain-fed		1	8
					48
5	Rainfall		7		
	a.	> 2500 mm/yr		3	21
	b.	2000 – 2500 mm/yr		2	14
	c.	< 2000 mm/yr		1	7
					42
6	Topography :		6		
	a.	Hilly to mountainous with slope> 40 %		3	18
	b.	Undulating to wavy with slope 25-40%		2	12
	c.	Flat to undulating with slope< 25 %		1	6
					36
7	Height:		5		
	a.	>500m asl		3	15
	b.	100 – 500 m asl		2	10
	c.	<100 m asl		1	5
					30
8	Agro ecosystem land suitability for ricefields		4		
	a.	High suitability (S1)		3	12
	b.	Medium suitability (S2)		2	8
	c.	Marginal suitability (S3)		1	4
					24
9	Productivity		3		
	a.	>5 ton/ha/MT		3	9
	b.	2,5 - 5 ton/ha/MT		2	6
	c.	< 2,5 ton/ha/MT		1	3
					18
10	Distance from city center :		2		
	a.	> 5km		3	6
	b.	2,5 – 5 km		2	4
	c.	< 2,5 km		1	2
					12
11	Minimum area		1		
	a.	> 10 ha		3	3
	b.	5-10 ha		2	2
	c.	<5 ha		1	1
					6

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Appendix 2

Criteria for Weighting and Scoring of each Parameter
for Agricultural Land Classification in Denpasar City

No	Parameter		Rating		
			Weight	**Score**	**Value**
1	Land suitability with landuse plan		9		
	a.	Urban green space		3	27
	b.	Agricultural land		2	18
	c.	Non-agricultural land		1	9
					54
2	Land use		8		
	a.	Irrigated ricefield		3	24
	b.	Moor		2	16
	c.	Mixed plantation		1	8
					48
3	Subak location in the Watershed area		7		
	a.	Upstream		3	21
	b.	Middle		2	14
	c.	Downstream		1	7
					42
4	Irrigation system		6		
	a.	Technical-semi technical irrigation		3	18
	b.	Simple irrigation/ non technical		2	12
	c.	Rain-fed		1	6
					36
5	Rainfall		5		
	a.	> 2500 mm/yr		3	15
	b.	2000 – 2500 mm/yr		2	10
	c.	< 2000 mm/yr		1	5
					30
6	Agro ecosystem land suitability for ricefields		4		
	a.	High suitability (S1)		3	12
	b.	Medium suitability (S2)		2	8
	c.	Marginal suitability (S3)		1	4
					24
7	Productivity		3		
	a.	>5 ton/ha/MT		3	9
	b.	2,5 - 5 ton/ha/MT		2	6
	c.	< 2,5 ton/ha/MT		1	3
					18
8	Distance from city center :		2		
	d.	> 5km		3	6
	e.	2,5 – 5 km		2	4
	f.	< 2,5 km		1	2
					12
9	Minimum area		1		
	a.	> 10 ha		3	3
	b.	5-10 ha		2	2
	c.	<5 ha		1	1
					6