

# Potential Land Mapping for Agricultural Extentification in Mengwi Sub-district to Support Food Balance in Badung Regency, Indonesia

Ni Made Trigunasih<sup>2\*</sup>, Indayati Lanya<sup>1</sup>, I.G.P Ratna Adi<sup>1</sup>, JeremiaHutauruk<sup>2</sup>, Feronika<sup>2</sup>

<sup>1</sup>Study Program Agroecotechnology, Faculty of Agricultural, Udayana University, Indonesia

<sup>2</sup>Center for Spatial Data Infrastructure Development (PPIDS) Universitas Udayana, Bali, Indonesia

tri5963@yahoo.com

**Abstract.** The availability of agricultural land for food crops, especially in Bali, is rapidly declining every year. The availability of rice fields in Badung regency, especially in Mengwi Sub-district until 2040 is no longer exist, this means that Mengwi Sub-district has lost the rice fields. The existence of land conversion will affect food availability for the country, so there will be food deficit. The food balance in Badung Regency in 2015 with Cultivation Index (IP) and initial productivity in each Sub-district showed a food deficit of 32,843.44 tons, then after increasing IP of 2,5 the productivity in Kecamatan Petang and Kuta at 7 tons / ha, and Abiansema, Mengwi and North Kuta Sub-districts with 8 tons / ha which indicate a surplus in 2020 and 2030 respectively of 25,155.19 tons, and 3,401.79 tons. But in 2040 and 2050 there was a food deficiency of 18,434.78 tons and 11,824.82 tons respectively. Considering that productivity improvement efforts cannot rely solely on intensification approaches, but also need to be done with extensification or expansion of agricultural areas to support food production. This research was conducted in Mengwi Sub-district, Badung Regency. Mengwi Sub-district consists of 20 villages. The objectives of this research are: (1) to map potential land that can be converted to agricultural land of food crops, and (2) to know the amount of food demand to supply food balance in Badung Regency in 2040. Research methodology includes (1) preliminary study, (2) interpretation of satellite images, (3) mapping and measurement of land area, and (4) calculation of additional food availability. The results indicate that the potential land that can be converted to agricultural land for food crops is 132 ha, consists of 128.51 ha of mixed plantation and 3.49 ha of bare land/ bush. The result of additional land produced 1601.73 tons of rice that increased the food availability in Mengwi Sub-district to 45425.7 tons. The addition of surplus in 2040 in Mengwi sub-district amounted to 21669.23 tons but did not cover the food deficit in Badung regency in 2040.

**Keywords:** Extensification, Food Crop Agriculture, Food Balance

## 1. Introduction

The availability of agricultural land for food crops, especially in Bali, is rapidly declining every year. The availability of rice field in Badung regency, especially in Kuta Sub-district until 2040 is no longer exist, this means that Kuta has lost its traditional Subak rice field [1]. Subak is an irrigation organization in Bali that is very famous in the eyes of the world. The declining of the availability of

land is not only caused by the increase in population, but also because of the conversion of cropland in relation to the widespread of urbanization [2]. The existence of land conversion will affect food availability for the country, so there will be food deficit. Food balance in Badung Regency in 2015 with Cultivation Index (IP) and initial productivity in each sub-district showed a food deficit of 32,843.44 tons, then after increased IP to 2,5 the productivity in Petang Sub-district and Kuta Sub-district for 7 tons / ha, and Abianse-mal, Mengwi and Kuta Utara sub-districts of 8 tons / ha which indicate a surplus in 2020 and 2030 respectively of 25,155.19 tons, and 3,401.79 tons. But in 2040 and 2050 there was a food deficit of 18,434.78 tons and 11,824.82 tons respectively [1].

Avoiding the occurrence of food deficits, regional production capacity in the long run needs to be increased through intensification. Considering that productivity improvement efforts cannot rely solely on intensification approaches, but also need to be done with extensification or expansion of agricultural areas to support food production. However, it is not easy to establish areas that can be reserved for agricultural expansion due to the complexity of the problems encountered in land governance. The pressure of development and population also demands easier access to land, through the expansion of other food areas.

One of the efforts to increase land production in Badung Regency is by extensification of agriculture as it has done in Petang Sub-district of 100 ha. In this case extensification can be done through monitoring and mapping of potential land that can be converted to agricultural land for food crops such as: bare land, bush, swamp, moor, and mixed plantation. This mapping is based on remote sensing and Geographic Information System (GIS).

The aims of this research are (1) to map potential land that can be converted to agricultural land of food crops, (2) to know the amount of food demand to supply food balance in Badung regency in 2040.

## 2. Literature Review

### 2.1 Food Balance in Badung Regency

Food balance in Badung Regency is calculated based on projection of population growth and projection of land function in every sub-district. Modeling by increasing IP or crop index of 2.5 and productivity up to 7-8 tons hence resulted food balance data of 2020, 2030, 2040 and 2050 shown in Table 1.[1]

**Table 1.** Food Balance Data in Badung Regency Year 2015, 2020, 2030, 2040 and 2050

Years	Petang	Abianse-mal	Mengwi	Kuta Utara	Kuta	Kuta Selatan	Total	Information
2015	196	-371,13	778,06	-8501,85	-11022,8	-13921,73	-32843,44	Defisit
2020	6096,77	19533,37	30807,11	-151,62	-12286	-18844,49	25155,19	Surplus
2030	5908,62	17076,07	25437,36	-4803,49	-15296,9	-24919,87	3401,79	Surplus
2040	5679,73	14618,77	20067,5	-9454,57	-18161,6	-31184,64	-18434,78	Defisit
2050	5532,43	12161,47	14697,76	-14105,77	-21012,1	-37310,18	-11824,82	Defisit

### 2.2 Agricultural Extensification

Potential land resources for agricultural expansion are possible. Nevertheless, taking into consideration: (a) tenure status, (b) administrative area (location), (c) availability of manpower, and (d) availability of infrastructure. For the procurement of inputs and distribution of agricultural output, and (e) the opportunity to be converted to agricultural land for food crops in relation to spatial planning (land use for settlement, urban development, forest conservation, etc.); then in the short - medium term that can be utilized for the expansion of agricultural areas is estimated at about 20-25 percent of the figure. But this number is still more than enough to meet the target of 2 million hectares. Especially for rice fields, it is estimated more than 650 thousand hectares (greater than the target of 250 thousand hectares of rice field expansion) [4].

### 2.3 Geography Information System (GIS)

Geography Information System (GIS) is one of many information technologies that have transformed the ways geographers conduct research and contribute to society. In the past two decades, these information technologies have had tremendous effects on research techniques specific to geography, as well as on the general ways in which scientists and scholars communicate and collaborate [3].

A geographic information system in the wider sense consists of software, data, people, and an organization in which it functions. In the narrow sense, we consider a GIS as a software system for which we discuss its architecture and functional components. According to the definition, a GIS always consists of modules for data capture (input) and preparation, data storage, data analysis, and presentation (output) of spatial data. For a particular GIS, each of these modules may provide many or only a few functions. However, if one of these functions would be completely missing, the system should not be called a geographic information system. The same function may be offered by different modules: for instance, data capture and data storage may have functions in common, and the same holds for data preparation and data analysis. An explanation of the various functions of the four modules provide a functional description of a GIS. Here, we only briefly describe them in the following sections. A more detailed treatment can be found in follow-up chapters. Beside data capture, storage and maintenance, analysis and output, geo-information processes also involve exchange of information, as well as issues of embedding the spatial data handling process efficiently in the organizational context. These issues define the context and rules according to which geo-information is acquired and processed [4].

### 2.4 Extensification of Agriculture

Decreasing of natural resources and the environmental impacts the food production per hectare. This objective translates to reducing external inputs, such as livestock densities while minimizing food loss [5]. Extensification programs should consider land suitability for agriculture. otherwise, it will face obstacles in its development [6].

In the agricultural development of Indonesia, agricultural extensification is the extension of agricultural areas to areas previously untapped by humans. The goal is to forest land, steppe meadow, peatland, or other forms of marginal land (marginalized). This term in Indonesian has no direct relationship to extensive agriculture; and in the international terminology the program is better known as agricultural (land) expansion ("expansion of agricultural land") [4].

Expansion of agricultural areas is necessary when available agricultural land is deemed incapable of supporting the expected supply of production (e.g. to provide food for the population of a region / country). The risks to be taken are the disruption of native natural ecosystems [7] and the potential for indigenous cultural destruction due to competition with outsiders [8].

## 3. Methodology

### 3.1. Area of Study

This research was conducted in Mengwi Subdistrict, Badung Regency. Mengwi sub-district consists of 20 villages, and the total area of rice field is covering 4366.03 ha [10].

### 3.2 Tools and Material

While the tool used are:

- *Computer*
- *Software (Qgis 2.10.1),*

The material used in this research are spatial data as follows:

- Quickbird satellite Image of Badung Regency, 2013
- Indonesia Topographic Map 2002

### *3.3 Research Procedures.*

Phase of the research include:

#### *3.3.1. Preliminary studies*

Preliminary study is done through stages such as collecting and studying literature review from various sources. Collecting data used in research, identification of research area.

#### *3.3.2 Interpretation of satellite images*

Interpretation of orthorectification satellite images, compilation of reference coordinate system using Transverse Mercator (UTM) projection system, development of raster and vector data.

#### *3.3.3 Mapping and Measurement of Land Area*

Mapping is done with image interpretation and digitization on screen. Objects observed and mapped are bare land, shrubs, swamps, moorlands and mixed plantations. After mapping the area is calculated using GIS applications.

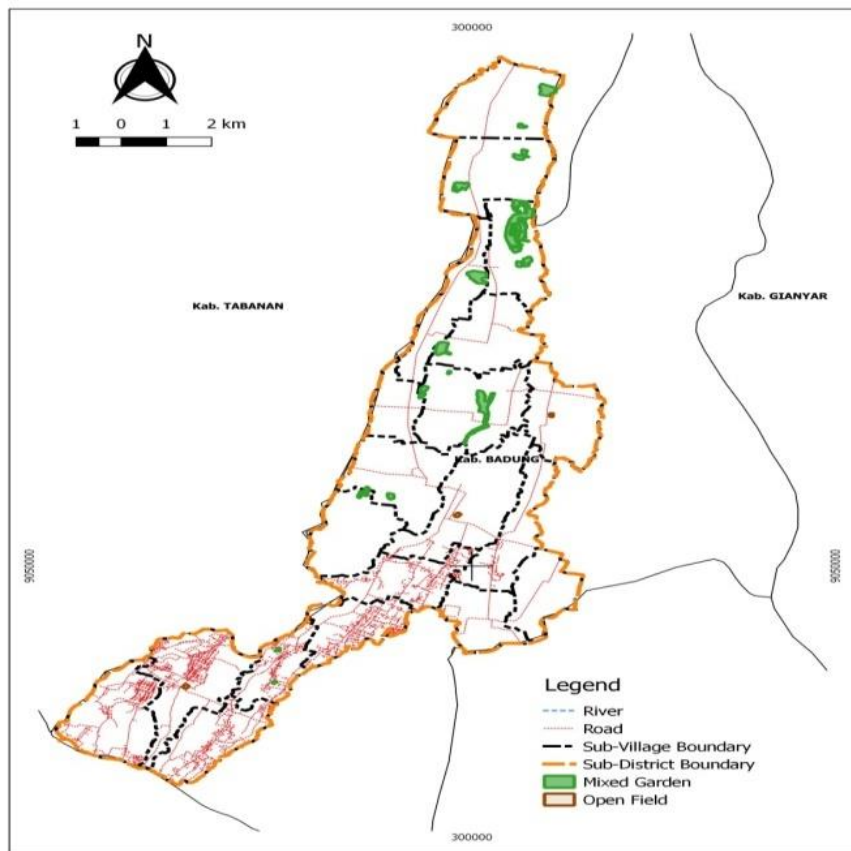
#### *3.3.4 Calculation of Increasing Food Availability*

Calculate the addition of food availability starting from the calculation of the addition of land area in 2040. The area of land projection in 2040 added with the area of potential land mapping. From the new land area obtained the availability of food is by multiplying the new land area with a maximum IP of 2.5 and maximum productivity of 8 tons / ha. Data of dry grain harvest is converted to dry grind mill multiplied by 0,86 and for Rice multiplied 0,63 of Daily Power Off (THL) - Agricultural Extension Aid (TBPP) of agricultural depart.

From the results of additional food availability reduced by the needs of residents in Mengwi District Year 2040, it will be seen the value of surplus or deficit. Then supply supply of food to scale badung district in 2040 to know the value of surplus or deficit.

## **4. Result and Discussion**

The results of satellite image interpretation in Mengwi Sub-district obtained potential areas that can be converted to agricultural land for food crops, shown in Figure 1.



**Figure 1.** Potential Land Map

The above mapping results indicate the potential land of mixed plantation area of 128.51 ha and bare land / shrubs of 3.49 ha. Potential land in the form of dominant mixed plantation was found in Sobangan Village (50.07 ha), Gulingan Village (22.5 ha), and Sembung Village (11.97 ha) while potential land in the form of bareland/ bush was found in the Village Munggu (1.27 ha), Kapal Village (1.3 ha) and Desa Baha (0.92 ha). The result of bare land and mixed plantation are shown in figure 2 and figure 3.



**Figure 2.** Bareland



**Figure 3.** Mixed Plantation

Projection of Food Balance in Kecamatan Mengwi is calculated using projection of population growth and projection of land conversion to non agriculture. data on population projection in Badung Regency is shown in Table 2.

**Table 2.** Projection Data of Population of Sub-District in Badung Regency in 2020, 2040 and 2050

No.	Districts	An Area (km <sup>2</sup> )	Population *)	Growth Rate	Population Density (people/km <sup>2</sup> )	Total Population				
						2015	2020	2030	2040	2050
1	Petang	115,00		0,6	226,97	26.100	29.953	31.611	33.628	35.590
2	Abiansemal	69,01		2,2	412,85	90.600	98.809	116.627	134.445	152.265
3	Mengwi	82,00		3,14	1562,20	128.100	142.094	175.719	209.345	242.970
4	Kuta Utara	33,86		3,3	3.358,10	119.800	136.916	172.662	208.407	244.153
5	Kuta	17,52		2,8	5.576,48	97.700	109.805	134.923	160.042	185.161
6	Kuta Selatan	101,13		4,42	11.142,09	122.680	166060	219597	274803	328782

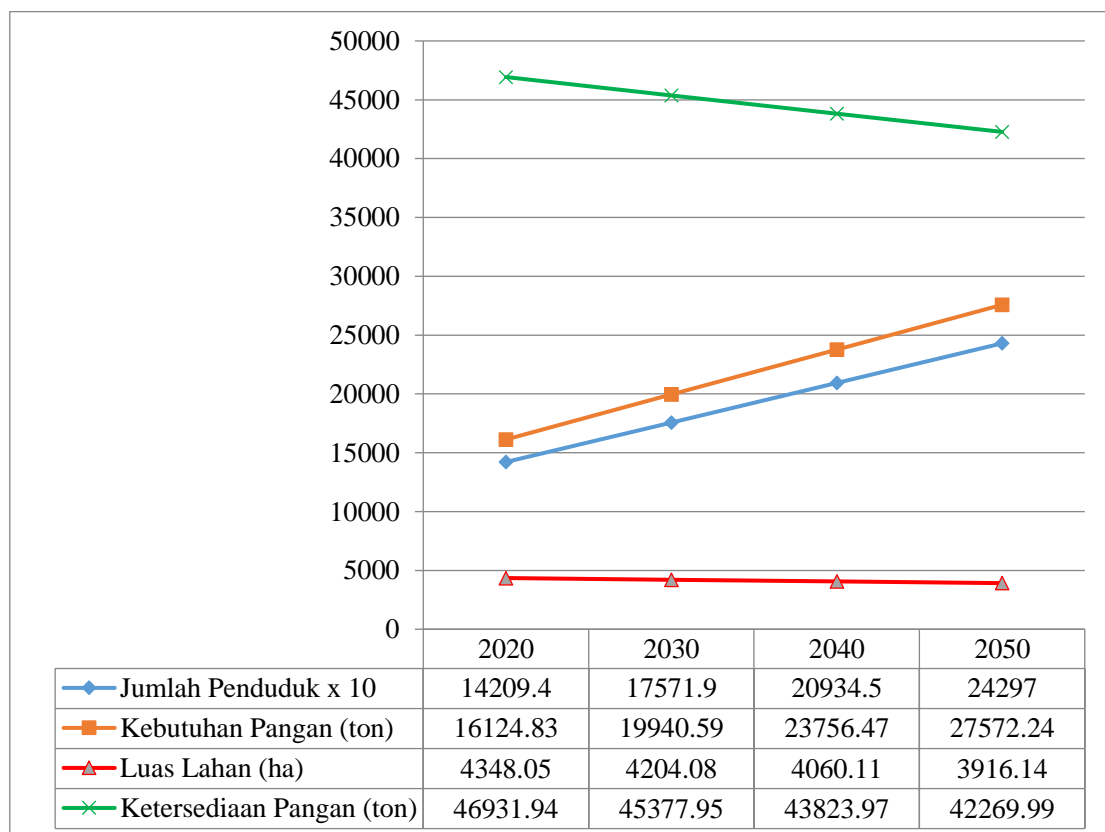
Description: \*) = Central Bureau Statistics of Badung Regency [10]

**Table 3.** Projection Data of Rice Field Change in Badung Regency

No.	Districts	An Area (ha)	Rate of Land Fuction (ha/y)	Paddy Field Area (ha) [1]				
				2015*	2020**	2030**	2040**	2050**
1	Petang	11.500	0	1.173,00	1173,00	1173,00	1173,00	117300
2	Abiansemal	6.901	4,033	2.868,67	2848,51	2808,18	2767,85	2727,52
3	Mengwi	8.200	14,40	4.420,03	4348,05	4204,08	4060,11	3916,14
4	Kuta Utara	3.386	5,51	1.452,90	1425,35	1370,25	1315,15	1260,05
5	Kuta	1.752	1,7	27,00	18,50	1,50	0	0
6	Kuta Selatan	10.113	0	0	0	0	0	0

Description: \*) = Central Bureau Statistics of Badung Regency [10]

The relation of population, food requirement, land area and availability of food in Mengwi Sub-district with IP 2.5 and productivity of 8 ton / ha are presented in Figure 4.

**Figure 4.** Graph of Food Balance Projection in Mengwi Sub-district



To increase availability in 2040 food in Kecamatan Mengwi from the addition of potential land area that can be converted to agricultural land of food crops, the calculation is as follows:

$$\begin{aligned}\text{New Land Area} &= \text{Land Area Year 2040} + \text{Potential Land Area} \\ &= 4060,11 \text{ ha} + 132 \text{ ha} \\ &= 4192.11 \text{ ha}\end{aligned}$$

$$\begin{aligned}\text{Food Availability (GKP)} &= (\text{New Land Area} \times 2.5 \text{ (IP)}) \times 8 \text{ (ton / ha)} \\ &= 4192.11 \text{ ha} \times 2.5, 8 \\ &= 83842.2\end{aligned}$$

$$\begin{aligned}\text{Food Availability (GKG)} &= 83842.2 \times 0.86 \\ &= 72104.29\end{aligned}$$

$$\begin{aligned}\text{Availability of Food (Rice)} &= 72104.29 \times 0.63 \\ &= 45425.7\end{aligned}$$

From the result of the addition of potential land that can be converted as wetland (132 ha) then calculated the addition of food availability that is:

$$\text{Availability of new food in 2040} - \text{availability of old food year 2040} = 45425.7 \text{ tons} - 43823.97 \text{ tons} = 1601.73 \text{ tons.}$$

Projection of food balance in 2040 with productivity and maximal IP in Badung regency has a food deficit of 18434,78 tons [1], while from the addition of food availability in Mengwi District only 1601,73 tons. Therefore, this condition can not cover the food deficit condition of Badung Regency in 2040 but for Mengwi sub-district has a food surplus of 21669.23 tons, obtained from the reduction of food availability in Mengwi Subdistrict (45425,7 tons) reduced by food requirement in Mengwi Subdistrict 23756.47 tons.

With the extensification of agriculture in District Mengwi can increase the availability of food for 1601.73 so Mengwi Sub-district can supply food availability for other districts in Badung regency of the year. But for the entire Badung regency in 2040 still need food supplies from other regions to meet the needs of food.

## 5. Conclusions and Recommendations

### 5.1 Conclusions

1. Mapping of potential land that can be converted to agricultural land of food crops obtained by 132 ha consists of 128.51 ha of mixed plantation/ garden and 3.49 ha of open land / shrubs.
2. From the results of additional land produced 1601.73 tons of rice that supplies food availability in Mengwi Sub-district to 45425.7 tons. With the addition of surplus in 2040 in Mengwi sub-district amounted to 21669.23 tons but did not cover the food deficit in Badung Regency in 2040.

### 5.2 Rekomendations

1. Agricultural extensification potential can be done in other sub-districts in Badung Regency such as Abiansema and North Kuta Sub-districts.
2. Potential mapped potentials may be further adjusted to the Spatial Plans of Badung Regency Year 2013-2033, in particular additional lands in accordance with the zoning / designation of the agricultural crops area.

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