Role of Remote Sensing and Geographic Information System Mapping for Protected Areas Land Rice Field Subak, Buffer Zones, and Area Conversion (Case Studies In Gianyar Regency, Bali Province)

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Abstract. Conversion of rice fields in Bali 2579 ha/year, Law Number 41 of 2009 [1] and five of Government Regulation (GR), mandates the Local Government (LG) has a Regional Regulation (RR) or Rule Regent/Mayor, on the protection of agricultural land sustainable food (PALSF). Yet none provincial government of Bali has PALSF; although Subak as world cultural heritage. Similarly, Gianyar regency development strategy directed to integrate agriculture with tourism. Landsat 8 images, Word View Coverage 2015 Gianyar district and ArcGIS 10.3 software used for of rice field mapping and zoning of land protection Subak. Ten thematic maps (watersheds, land use, irrigation, relief/slope, rainfall, spatial planning, land suitability, productivity, the distance from downtown) as a variable parameter, weighted and balanced numerically. Numerical classification agriculture land using for the overlay menu and reselek.

The total value of >125 as rice need to be protected, 100-125 value for buffer zone, and the value of <100 rice fields can be converted to 40 next year. For the 20 next year, the total value of >100, 50-100 and <50 respectively to rice fields that need to be protected, wetland buffer, and rice fields can be converted. Region Subak sustainable of rice field protection, buffer and can be converted in a row for the next 20 years is 10973 ha, 3855 ha and 311 ha. For the next 40 years Subak conserved of rice field (8019 ha), buffer (5855 ha), and can be converted (3124 ha). Subak land pattern of spread can be converted to an supply of land for non-agricultural development of the region downstream to the access road Ida Bagus Matera (Jln. Province / national) in the coastal areas of Gianyar.

Keywords: Remote sensing, thematic map, protected areas, buffers, paddy field, land conversion, Subak
1. Introduction

Gianyar regency is one area of the National Tourism Development Sarbagita (Denpasar, Badung, Gianyar and Tabanan) in Presidential Regulation No. 51 of 2014 [2]. Research 2014 [3] produce data and information, that: development of tourism in Bali negative impact on rice field function transfer 800 ha year\(^{-1}\). Conflicts of interest between agriculture and tourism continues, consequently wetland continuously pressured by the interests of non-agricultural development, both for residential as well as for infrastructure objects and tourist destinations. Conversion of agricultural land have occurred because the supply of land in Bali Generally, and Gianyar especially is a rice field.

Development of tourism in Gianyar very rapidly, particularly in tourism centers, such as coastal areas and tourism infrastructure. Rice fields in Bali Subak incorporated in the territory. Therefore, Subak rice fields not only as agricultural resources, but contain the environmental balance function, social and agrarian culture that is very noble. Subak agreed as local wisdom of Bali, a nationally recognized, and as a world cultural heritage [4], which is able to implement the philosophy of Tri Hita Karana (THK).

Along with advances in the tourism sector, and the development of population in urban areas is a conflict of interest utilization of water resources. Originally springs as a source of irrigation water, has changed functions for household needs, hotel, restaurant and other tour industry which have an impact on the lack of irrigation water and rice field function transfer. The existence of rice fields as well as a basic component in food production, the loss of rice paddies have a negative impact on food security. For the existence rice paddies need to be protected by law such as the Regional Regulation (Perda), to be used as agricultural land resources in a sustainable manner.

The preparation of Regional Regulation has been mandated by the Act, the Government Regulation (PP) and the Regulation of the Minister of Agriculture (Permentan), relating to the Protection of Land Pertanian sustainable Food (PLP2B). PLP2B legal products, needs to be supplemented with spatial data that is accurate and timely, and accessible to stakeholders through information technology, for ease in implementation. The use of high resolution satellite imagery that can record any objects on the Earth's surface, and software Geographical Information System (GIS) is able to answer the needs mentioned above.

Research the role of remote sensing and GIS for mapping of rice field zoning as LP2B (sustainable Subak rice field, buffer, and can be converted) very urgent to protect of Subak rice field. Paddy fields as a determinant component of food sovereignty, culture and nature conservation, normasilasai ecosystems, as well as maintain world heritage, and is able to apply the Balinese philosophy of THK namely: the balance between nature, man and God.

The research objective is: (1) make a zonation map paddy fields (zoning map) through classification of numerical-based remote sensing and Geographic Information Systems (GIS), (2) get food balance, and (3) criteria for Subak land management in each zone area (sustainable/ protection, buffer, and converted).

2. Material and Methods

The research location in the district of Gianyar, Is one of eight districts in the regency of Bali Province. Located between 08°8'48"-08°38'58" south latitude and 115°13'29"-115°22'23" east longitude. Its borders by Denpasar and Badung regency in West side, Bangli Regency in the north side, Bangli and Klungkung Regency at eastward, then Badung Strait and Ocean Indonesia in the southern (Figure 1). Satellite Imagery WorldView Gianyar District 2015 is presented in Figure 2. Is located at altitude of 250-950 meters above sea level. The area of Gianyar Regency 368 km\(^2\) or 6.53% of the Bali Province. Land Area 2.540 hectares of rice fields and agricultural land 1039.00 hectares of non-rice fields. Rainfall in the area ranges from 1,900 -2,500 mm/th (Gianyar Central Bureau of Statistics, 2013) [5]. There is a tourism center on the south coast, the area of Ubud, Sukawati, and Tampak Siring, as well as natural and cultural attractions other. Gianyar Regency was divided into 7 districts, that is Sukawati District (12 villages, 111 villages/banjar), Blahbatuh District (9 villages, 67 banjar), Gianyar District (17 villages, 96 banjar), Tampaksiring District (8 villages, 70 banjar), Ubud District (8 villages, 80 banjar), Tegallalang District (7 villages, 65 banjar), and Payangan District (9 villages, 59 banjar).
Materials used include: topographic maps (Bakosurtanal, 2002) [6] for the analysis: watershed, high places, relief, distance from the town center, and irrigation canals. Thematic maps (land suitability, rainfall map, map of rice production, the distance from the city center) and maps of Gianyar Regional Spatial Plan (RTRW) 2012-2032 (Local Regulation/Perda No. 16 of 2012) [7]. Satellite images World View Gianyar Coverage 2015. Remote sensing technology is used to create spatial maps of land use. This research tool in the form of specific set of computers with the ArcGIS 10.1 program, is used for the digitization and analysis of thematic maps.

Methods used include: (1) the interpretation of satellite imagery for mapping land use, (2) field survey, (3) digital mapping thematic maps based on GIS, (4) analisis statistik neraca pangan, (5) the classification of numerical paddy fields, conducted through weighting 1-10 and scores 1-3, each parameter to get a zoning map using ArcGIS 10.1 program using the overlay method, intersect and query analysis, (6) the preparation of paddy fields classification criteria (sustainable, buffer, and can be converted).

3. Result and Discussion

3.1. Thematic Map
Interpretation of satellite imagery and topographic maps by using software ArcGIS 10.1 produces 10 kinds of thematic maps, namely: 1) land use maps, (2) map suitability of land with a map RTRW (protected areas and agriculture), (3) map the morphology of Regions watershed, (4) the height of the map, (5) relief map, (6) the rainfall map, (7) irrigation map, (8) agroekosistem land suitability maps, (9) a map of rice production, and (10) map distance from the city center.

Land use maps obtained from the analysis of satellite imagery and field observations are presented in Figure 3. The level of accuracy of the identification rice fields reached 98%, due to the fallow rice fields. Figure 4 overlay between rice fields map (Figure 3)
Figure 3. Land use map (analysis, 2015).

Figure 4. Land suitability map of rice field, with RTRW Map (analysis, 2015).

Figure 5. Morfologi Watershed Map (analysis, 2015).

Figure 6. Elevation Map (analysis, 2015).

Figure 7. Peta reliief (analysis, 2015).

Figure 8. Peta Curah hujan tahunan (analysis, 2015).

Figure 9. Map of the area irrigated (analysis, 2015).

Figure 10. Agroekosistem land suitability maps (analysis, 2015).
with a map of the RTRW, generate suitability maps of rice field with green open space (RTH) and the farm area. Figure 5 maps the morphology of the Watershed is the result of the analysis of topographic maps with satellite imagery. Figure 6 (a map of high places) and 7 (relief map) obtained from the analysis of topographic maps; Figure 8 (precipitation map) the results of the analysis of rainfall data of the last 10 years; Figure 9 (a map of the region irrigated) the results of the analysis of of rice field with irrigation networks; Figure 10 (a map of the agro-ecosystem land suitability for paddy rice) the results of the field survey and soil analysis of land suitability classification of agro-ecosystem; Figure 11 (a map of rice production results of field survey and analysis of statistical data), and Figure 12 is a map of the distance from urban centers, the results of the analysis of topographic maps and satellite imagery.

Based on the maps above show that: the upstream area is dominated by the dry land, while the middle and downstream are dominated by rice fields. The use of rice field consistent with the high point, the area of irrigation, and agro-ecosystem land suitability. The higher and the more upstream, as well as diminishing returns of rice field area. The lower the level of the land suitability result of factors limiting the temperature decreases. The upstream is dry land farming and mixed farms, generally found at an altitude of more than 500 m asl. Based on environmental sustainability factors, the upstream part is necessary to land conservation as rain water catchment and water supply downstream. Their irrigation channels are still good, then the use of rice field still exist, in all regions of the Gianyar Regency. Rice production data is quite high, averaging 6 ton ha\(^{-1}\) crop\(^{-1}\). The challenge remains the development of housing and urban infrastructure that interfere with irrigation channels.

3.2. Supplies and Needs Food (Food Balance Sheets)
Inventory analysis and food needs based on projected population and of rice field, as well as the rate of land conversion. Figure 13 the population projection data, the need for food, rice field area, and food supplies for 2015, 2020, 2030, 2040, and 2050. Results of regression analysis needs and food supply (Graph food balance sheet) are presented in Figure 14. The figures show a spacious rice field and food supplies inversely proportional to population growth and food needs. The higher the food needs followed the lower the food supply. Rice field area decreased 34, 61 ha yr\(^{-1}\), followed by a decline in food supply 1.730 tons of rice yr\(^{-1}\). While the population increased by 12,560 people by the year \(^{-1}\) and increased food needs tons of rice 1.6328 tons year \(^{-1}\). This data is used as a basis in determining the zoning classification of of rice field.
3.3. **Numerical classification (Zoning Map) PLP2B.**

Numerical classification using the ArcGIS 10.1, the results of the overlay 10 thematic maps, which have been weighted and do the scoring as parameters in accordance with its role in the conservation of agricultural land resources based environment. The method uses intersect menu and query analysis, produced maps of rice field Subak zoning (zoning map) sustainable, buffer (limited conversion). Paddy field that can be converted to 20 years or 1x Long Term Development Plan (RPJP) forwards included in Figure 15 and for the next 40 years (2 x RPJP) in Figure 16.

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**Figure 13.** The relationship between population projections, food needs with rice area and food supplies.

**Figure 14.** The relationship between population projections, food needs with rice area and food supplies.
Region Subak sustainable of rice field protection, buffer and can be converted in a row for the next 20 years is 10,973 ha, 3,855 ha and 311 ha. For the next 40 years Subak conserved of rice field (8019 ha), buffer (5,855 ha), and can dikonvers (3,124 ha). Subak land pattern of spread can be converted to an inventory of land for non-agricultural development of the region, downstream, with an access road Ida Bagus Matera (Jln. Provincial / national), the coastal areas and the tourist area of Ubud Gianyar.

Results of numerical classification using the ArcGIS 10.1 overlay 10 thematic maps which have been weighted and scored as parameters in accordance with its role in conservation of agricultural land resources based environments, using menu intersect and query analysis, produced maps paddy field Subak zoning (zoning map) Lestari, buffer (limited conversion). Figure 13 shows the of rice field that can be converted much less than rice field area in Figure 14, the result of numerical classifications are different according to the needs of land in the development. Classification of rice fields for the next 20 years, it was determined the total value of ≥ 100 (sustainable rice fields), the total value of 75-100 (buffer rice fields), and the total value <75 (rice fields can be converted). As for the 40 years to come, the total value of ≥ 125 (sustainable rice fields), the total value of 100-125 (rice fields buffer), and the total value of <100 (rice fields can be converted).

Zonation mapping rice fields for the next 20 years the fields available to most sustainable paddy fields except in coastal areas. Coastal areas are around the way Ida Bagus Mantra (national road) classified rice fields buffer. The existence of this buffer rice fields for the next 40 years of development needs changed into land that can be converted to non-agricultural development. Rice fields that can be converted are in the border city of Denpasar, and access roads Ida Bagus Spells as a national road. This area experienced many non-agricultural development. In other words, the results Rice fields zoning classification in accordance with the needs of development. Development needs will increase with time. For the total value of the classification to be improved, so get rice area that can be converted bigger and smaller sustainable rice fields.

Location rice fields sustainable for the next 40 years there is a need in the upper and eastern, which is bordered by Klungkung Regency. While the bordering city of Denpasar as buffer rice fields. Rice fields around the national road access can be converted. Based on the results of the zoning classification rice fields, both for the construction of the next 20 years or RTRW 1x and 2x RTRW can be used as a basis in the preparation or revision of the RTRW or Detailed Spatial Plan.
4. Conclusions

Word View satellite imagery can be used for mapping of rice field with 99% accuracy rate. Paddy field conversion is caused by allocation of space for non-agricultural cultivated area and the pressure development in growth centers.

Land use change and food supply is inversely proportional to the rate of population growth and food needs. The population is increasing, but the area of rice field decline. Paddy fields decreased -34.61 ha yr\(^{-1}\) and food supplies decreased by -1.7 tonnes yr\(^{-1}\). In contrast, the population increased by +12 560 people and increased food needs of +1,632 tons year\(^{-1}\).

Classification zoning of rice field water control system using 10 parameters: (1) land use maps, (2) map suitability of land with a map RTRW (protected areas and agriculture), (3) map the morphology of Regions watershed, (4) the height of the map, (5) relief map, (6) the rainfall map, (7) irrigation folder, (8) agroekosistem land suitability maps, (9) a map of rice production, and (10) map distance from the city center. Then performed weighting of 1-10, and scoring 1-3, in accordance with its role in preserving the environment, generating group: sustainable rice field, rice field rice buffer and can be converted according to the needs of development in a period of 20 years and 40 years to come.

Rice fields need to be protected (10,973 ha), as a buffer (3,855 ha ha) and can be converted (311 ha) for the next 20 years of development needs. For the next 40 years of development, rice field that need to be protected (8,019 ha), as a buffer (5,855 ha), and which can be converted to non-agricultural construction area of 3,124 ha.

Remote sensing and GIS technology, as well as a numerical classification can be used for the establishment of Subak rice field area as LP2B within a certain period, and is able to inform the geographic locations (spatial) is appropriate, in accordance with the needs of development time.

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